REAL CONVERGENCE IN OPEC COUNTRIES

J. Cuñado and F. Pérez de Gracia
Universidad de Navarra

ABSTRACT

This article examines the real convergence hypothesis in 13 OPEC countries (Algeria, Angola, Ecuador, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela) towards the U.S. economy by means of using time series techniques. The results show the existence of structural breaks in the convergence process, most of them occurring around 1979-81, which suggests that this convergence process is related to the evolution of the oil price. Furthermore, when applying unit root tests allowing for structural breaks, we only find evidence of conditional catch-up towards the U.S. economy for the case of Indonesia, and for Angola in the last period of the sample.

Keywords: Real convergence; Unit root tests; OPEC countries.

JEL classification: C32; O41.

*Correspondence author: Fernando Pérez de Gracia
Universidad de Navarra
Campus Universitario
Facultad de Ciencias Económicas
Edificio Biblioteca, Entrada Este
E-31080 Pamplona
SPAIN
Phone: 00 34 948 425625
Fax: 00 34 948 425626
E-mail: fgracia@unav.es

1. Introduction

There has been in recent years an emerging body of empirical literature on convergence in per capita output across different economies. The interest on this subject may be explained, at least in part, as a prediction test of the neoclassical growth model (Solow, 1956) as opposed to the "new" endogenous growth models (Romer, 1986; Lucas, 1988). As it is well known, the neoclassical model predicts (under some assumptions) that per capita output will converge to each country's steady-state (conditional convergence) or to a common steady-state (unconditional convergence), regardless of its initial per capita output level. On the contrary, in endogenous growth models there is no tendency for income levels to converge, since divergence can be generated by relaxing some of the neoclassical assumptions (e.g., incorporating non convexities in the production function).

Furthermore, the great differences observed in per capita output and in growth rates across countries justify a deeper study on convergence. However, among the great number of empirical papers which studies convergence, no attention has been paid to the OPEC experience. The Organization of Petroleum Exporting Countries (OPEC) is a cartel of 12 countries made of Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela[1]. OPEC nations still account for two-thirds of the world's oil reserves, and, as of March 2008, 35.6% of the world's oil production, affording them considerable control over the global oil market.

Until World War II, economic literature believed that natural resources were an important factor affecting economic growth, while recent evidence has found that countries

[1] Indonesia´s membership from OPEC was voluntarily suspended recently as it became a net importer of oil.

rich in natural resources grow slower on average than natural resource poor countries (Sachs and Warner, 1999, 2001; Mehlum et al., 2006; Sala-i-Martin, 1997). This article examines the real convergence hypothesis in 13 OPEC countries during the second half of the twentieth century. Although all the analyzed countries are rich in natural resources, oil, there are great differences among them: first, from the 13 countries belonging to the OPEC, seven are situated in the Middle East, four in Africa and two in South America; second, there are great differences in the year they joined the OPEC organization, and the size of the country; third, there are also great differences in the quotas of each of the countries (for example, while Saudi Arabia produces 10,000 thousands of barrels of oil per day, Ecuador only produces 500).

The evolution of oil prices in the last fifty years has been subject to many changes: after the 1973 and 1979 oil crisis, oil prices experienced an increase until mid-80´s, and then they started to decrease. As shown in Table 1, average growth rates of analyzed countries seem to be related to the evolution of oil prices. However, there has been substantial diversity across countries (see Table 1). As shown in this table, while the average growth rate of per capita GDP series were negative for many OPEC countries during the period 1971-1990, the average growth rate for Indonesia was 3.7% and 1.6% and 1.4% for Ecuador and Algeria. However, average growth rates are higher for the last period of the sample (2.6% average growth rate for Angola, 3.2 for Indonesia, 3.4% for Iran and Qatar, etc.).

(Insert Table 1 about here)

The differential behaviour of the growth rates of these countries, their difficulties to converge to real per capita GDP levels of developed countries and the little research found

in the literature regarding this group of countries motivates the analysis on real convergence made in this paper. In this paper we examine the real convergence hypothesis for 13 OPEC economies towards the US.

Empirical testing of the convergence hypothesis provides several definitions of convergence and thus, different methodologies to test it. In a cross-section approach, a negative (partial) correlation between growth rates and initial income is interpreted as evidence of unconditional (conditional) beta-convergence. In this context, one of the most generally accepted results is that while there is no evidence of unconditional convergence among a broad sample of countries, the conditional convergence hypothesis holds when examining more homogenous groups of countries (or regions) or when conditioning on additional explanatory variables. Examples in this context are Baumol (1986), De Long (1988), Dowrick and Nguyen (1989), Grier and Tullock (1989), Barro (1991), Barro and Sala-i-Martin (1991, 1992, 1995), Mankiw, Romer and Weil (1992), etc. In a time series approach, stochastic convergence asks whether permanent movements in one country's per capita output are associated with permanent movements in another countries' output, that is, it examines, whether common stochastic elements matter, and how much persistent the differences among countries are. Thus, stochastic convergence implies that output differences among economies cannot contain unit roots. Empirical tests on this hypothesis have been carried out by Campbell and Mankiw (1989), Cogley (1990), Bernard (1991), Carlino and Mills (1993), Bernard and Durlauf (1995), Cunado et al. (2003), Beliu et al. (2004), and, in general, they do not find evidence of convergence. However, when the convergence tests take into account the possibility of structural breaks, the evidence of convergence is reinforced. Greasley and Oxley (1997) found evidence of bivariate

convergence between Belgium and Netherlands, France and Italy, Australia and the UK, and Sweden and Denmark. St. Aubyn (1999) finds evidence of convergence between US and each of the UK, Australia and Japan, using the Kalman filter methodology. Cellini and Scorcu (2000) detect stochastic convergence only for the US and Canada, and the US and the UK when they allow for structural breaks. Strazicich, Lee and Day (2003) examine the differences in per capita incomes of fifteen OECD countries with the US economy over the period 1870-1994 allowing for two structural breaks and they reject the unit root null hypothesis in eleven of the fifteen countries, thus supporting the stochastic convergence hypothesis.

In this paper, we apply time series convergence tests allowing for structural breaks to the differences in per capita output for 13 OPEC countries to the US using data for the period 1950-2007. The outline of the paper is as follows. Section 2 describes the methodology employed in the article to test for convergence. Section 3 covers the empirical analysis and Section 4 offers some conclusions.

2. Time Series Convergence Tests

In a time series testing framework, countries *i* and *j* convergence if their outputs are cointegrated with cointegrating vector [1,-1], that is, the difference $y_{i,t+k} - y_{j,t+k}$ must be a stationary I(0) process with no deterministic components (unconditional convergence), where y_i is the log real GDP per capita in country *i* and likewise y_j for country *j*.

Since most of the procedures for testing the unit root hypothesis include the cases of no regressors, an intercept, and an intercept and a linear trend, we can distinguish between

long-run convergence (unconditional or conditional[2] depending on the significance of the intercept, α_0 in equation (1)) and convergence as a catch-up (if the log of relative output is trend stationary, $\alpha_1>0$ in equation (1)). Although this last definition[3] may be open to criticism because the presence of a time trend allows for permanent per capita output differences, it might be appropiate in a context in which convergence is an on-going process (Bernard and Durlauf, 1995; Oxley and Greasly, 1995), as the one observed for less developed countries, such as some of the OPEC countries analyzed in this paper. In this context, we will test for convergence analyzing the integration order of the relative incomes using the following equation:

$$\Delta RI_t = \alpha_0 + \alpha_1 t + \beta RI_{t-1} + \sum_{j=1}^{p} c_j \Delta RI_{t-j} + e_t, \qquad (1)$$

where $RI_t = \ln(y_t^{US}) - \ln(y_t^i)$, the p extra regressors, ΔRI_{t-j} are added to eliminate possible serial correlation in the error terms.

However, these types of unit root tests may fail to recognise convergence when structural breaks are present. For example, St. Aubyn (1999), Cellini and Scorcu (2000) show that the introduction of structural breaks makes the existence of convergence across countries more clear.

For the OPEC economies, we could think in the existence of one or more breaks in the convergence process during the period 1950-2007. As Perron (1989) pointed out, these tests perform poorly when there is a break in the constant or deterministic trend function.

[2] According to neoclassical models, unconditional or absolute convergence holds when per capita GDP of the different countries convergence to the same steady state. In contrast, conditional convergence applies when per capita GDP of each economy converge to its own steady state. In this last case, the constant α_0 measures the differences in the steady state of each of the economies.

[3] Carlino and Mills (1993), for example, use this methodology in order to allow initially low income countries to grow faster than higher income countries.

However, Perron's method has been criticized on the grounds that the break point is chosen exogenously. Several authors, such as Christiano (1992), Perron and Vogelsang (1992) or Zivot and Andrews (1992) have developed methods to endogenously search for a break point and test for the presence of a unit root when the process has a broken constant or trend and have demonstrated that their test are robust and more powerful than the augmented Dickey-Fuller (1979) and Phillips-Perron (1988) tests[4]. However, these last procedures have also been critized in the literature (Nunes, Newbold and Kuan, 1997; Lee and Strazicich, 2001, 2003), since these type of tests derive their critical values assuming no breaks under the null, so that, in the presence of a unit root with break, these tests will tend to reject the null hypothesis suggesting that the time series is stationary around a break when it is nonstationary with a break. In order to solve this problem, we will use the endogenous two-break[5] LM unit root test proposed by Lee and Strazicich (2003) which is unaffected by breaks under the null. Following these authors, a unit root test statistic can be obtained by estimating the following model:

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta \tilde{S}_{t-i} + e_t, \qquad (2)$$

where Z_t reflects the deterministic components, $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}$, t=2,3,…,T. $\tilde{\delta}$ is a vector of coefficients in the regression of Δy_t on ΔZ_t and $\tilde{\psi}_x = y_1 - Z_1 \tilde{\delta}$, where y_1 and Z_1 denote the first observations of y_t and Z_t, respectively. e_t is the contemporaneous error term and is assumed independent and identically distributed with zero mean and finite variance. ΔS_{t-i} are added to eliminate possible serial correlation. When $Z_t = \{1, t\}$, we have the

[4] Recent empirical application of these tests can be found in Leybourne et al. (2003), Atkins et al. (2004), Sen (2004) or Narayan (2005a,b), among others.

statistic proposed in Schmidt and Phillips (1992). If we want to account for some structural breaks, we can extend the models A (which allows for a one-time change in level) and C[6] (which allows for a change in both the level and trend) considered by Perron (1989) and define Z_t in the following ways: $Z_t = \{1, t, D_1, D_2\}'$ for model A and $Z_t = \{1, t, D_1, D_2, DT_1, DT_2\}'$ for model C, where D_j=1 for t $\geq T_{Bj}$+1 and zero otherwise, DT_j=t for t $\geq T_{Bj}$+1 and zero otherwise, and T_{Bj} are the date of the breaks.

The unit root null hypothesis is described by ϕ=0 and the LM test t-statistic is defined by:

$\tilde{\tau}$ =t-statistic for the null hypothesis ϕ=0. (3)

To implement the test, the number of augmentation terms $\Delta\tilde{S}_{t-i}, i = 1,...,k$ that correct for serial correlation in equation (2) must be determined. At each combination of break points, k is determined by following the general to specific procedure suggested by Perron (1989). The procedure begins with a maximum number of lagged first-differenced terms (k=8) and examines the last term to see if it is significantly different from zero at the 10% level. If it is insignificant, the maximum lagged term is dropped and the model is reestimated with k=7 terms and so on, until either the maximum term is found or k=0. After determining the "optimal" number of k, the unit root test statistic is estimated using

[5] We use this two-break LM unit root test and not the one-break LM test because an examination of the empirical results reveals that the two structural breaks included in the model were significant in all the five analyzed countries for the period 1950-2003.

[6] In the empirical analysis, and as in Lee and Strazicich (2003), we consider Model C which allows for two changes in level and trend.

equation (3). The process is repeated for each λ, to determine the LM test statistic with the minimum t-value.[7]

3. Empirical Analysis

The data used in this section are annual log real GDP per capita in 1990 Geary-Khamis PPP-adjusted dollars. The series runs from 1950 to 2007 for 13 OPEC countries (Algeria, Angola, Ecuador, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela) and the US. All the variables have been obtained from Maddison (2001). First, we carry out ADF unit root tests to each of the series in order to obtain the integration order of each of the series (see Table 2). As convergence measure, we define the differences of each of the log real per capita GDP series with respect to the US.

The results from the augmented Dickey Fuller (ADF) tests to the differences of each of per capita GDP series with respect to the US are reported in Table 3. We are unable to reject the unit root hypothesis in favor of unconditional convergence for any of the OPEC countries.

(Insert Tables 2 and 3 about here)

When we include an intercept and a time trend in the model, we are also unable to reject the unit root hypothesis in favor or conditional convergence or cath-up.

The little evidence of convergence or catch-up among this group of countries could be due to the existence of different convergence speeds in the convergence process or the

[7] See Lee and Strazicich (2003) for a more detailed description of the test. The computation of the LM unit root test statistic has been carried out using the Gauss codes provided by Junsoo Lee and available on the web

case in which countries pass through convergence to nonconvergence processes (or viceversa), two possibilities which will be studied while allowing for structural breaks when applying the miminum Lagranger Multiplier statistic suggested by Lee and Strazicich (2003). In Table 4 we report the minimum LM statistic and the date of the break when we allow for only one break, while Table 5 reports the minimum LM statistic and the date of the breaks when the possibility of two structural breaks is included.

(Insert Tables 4 and 5 about here)

The main results presented in these tables may be summarized as follows: First, a broad examination of the significance of the dummy variables indicate that the convergence processes of the different OPEC countries have experienced structural changes which should be taken into account when analyzing the order of integration of relative incomes. For example, when we allow for a break, this occurs for most of the countries in 1979-1981, coinciding with the end of the 1979 oil crisis, when oil prices start increasing. When we include the possibility of two structural breaks, the results suggest the existence of a break at the end of sixties or beginning of seventies, before the 1973 oil crisis, and a second one at the end of eighties-beginning of nineties. Second, we can reject the unit root null hypothesis (in model C) in only three cases (Indonesia, Iraq and Saudi Arabia) when allowing for a structural break and in 6 cases when including two structural breaks (Angola, Indonesia, Iraq, Kuwait, Libya and Saudi Arabia). Following Tomljanovich and Vogelsang (2002) and Nieswiadomy and Strazicich (2004), we must study if there has been a catch-up process in per capita output after the structural break for all these cases, so that we run the following regression:

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site http://www.cba.ua.edu/~jlee/gauss.

$$RI_t = \mu_1 + \mu_2 + \mu_3 + \beta_1 t_1 + \beta_2 t_2 + \beta_3 t + u_t, \quad (5)$$

where μ_1 and β_1 are the intercept and the slope before the first break, μ_2 and β_2 the intercept and the slope after the first break and μ_3 and β_3 the intercept and the slope after the second break. Testing for converge for the last period is equivalent to testing whether the parameters μ_3 and β_3 are different from zero and negatively related. The last columns in Tables 4 and 5 summarize the results found in this analysis. In this case, and following Tomljanovich and Vogelsang (2002) and Nieswiadomy and Strazicich (2004), C denotes catch-up (those cases in which the unit root hypothesis was rejected in favor of stationarity around different time trends and satisfy the β-convergence hypothesis in equation (5), D denotes divergence (stationarity around different time trends which do not satisfy the above β-convergence condition), and U denotes unit root (we did not find evidence to reject the unit root null hypothesis). We find evidence of a catch-up process after the break for Indonesia towards the US economy when we allow for only a break and for Angola and Indonesia when we allow for two possible breaks.

4. Concluding Remarks

In this article we have examined the real convergence process for 13 OPEC countries by means of using time-series tests over the period 1950-2007. In particular, we have analyzed the convergence process for the 13 OPEC countries towards the US economy, first based on ADF unit root tests and then allowing for structural breaks.

Using the first tests, we find no evidence of unconditional convergence for any of the OPEC countries analyzed. When we include an intercept and a time trend, we cannot again reject the unit root null hypothesis for any of the countries.

However, when we analyze the possibility of structural breaks, we find significant evidence of a structural break in the convergence process of these countries, with the break occurring in many cases 1979-1981. We interpret this result indicating that the relative performance of these countries is related to the oil price, which after the 1979 crisis, experienced an increase. When we allow for this break, we find evidence of a catch-up process for Indonesia towards the US.

When we apply unit root tests allowing for these two structural breaks, we find evidence of a catch-up process during the last period, the nineties-2007, for two of the countries (Indonesia, Angola) towards the US economy.

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FIGURE 1. Real per capita GDP (in logs), 1950-2007

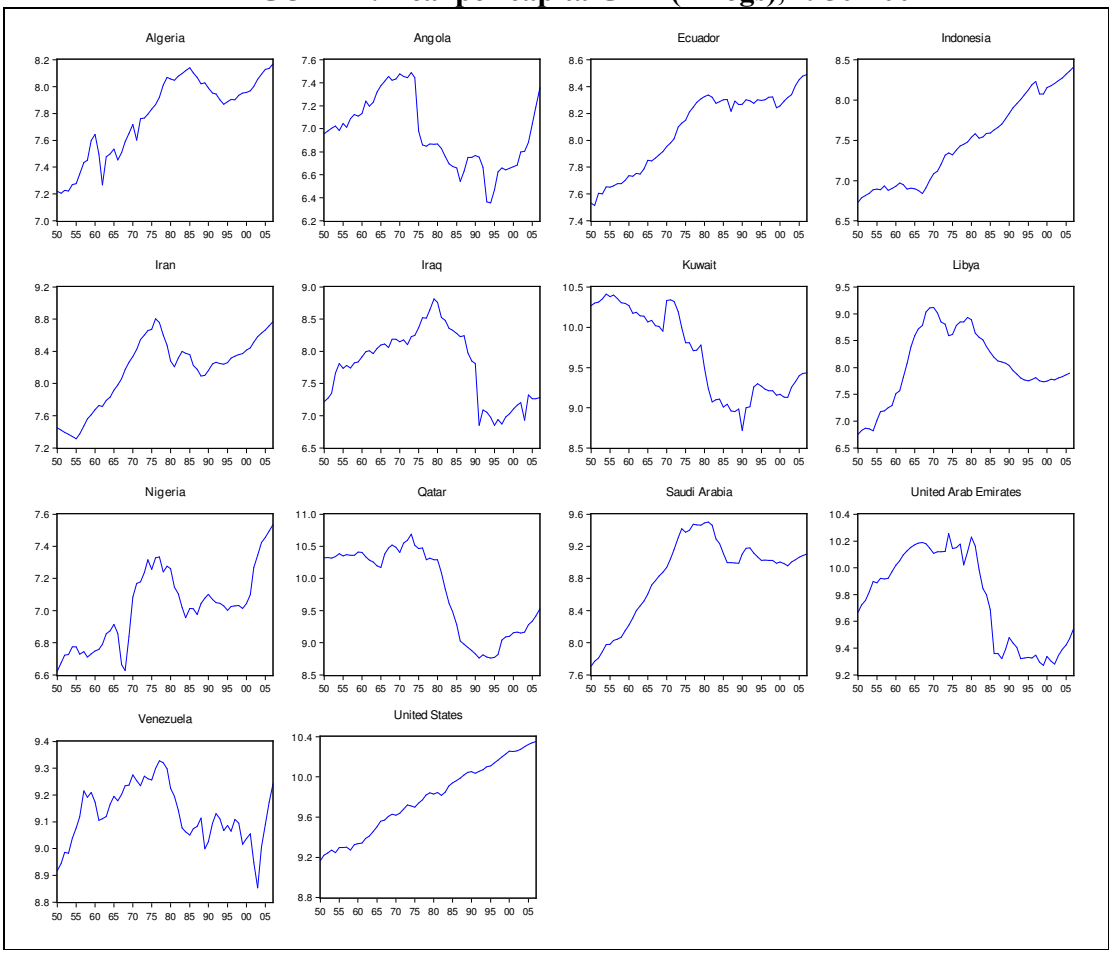

FIGURE 2. Real per capita GDP differences with the US economy (in logs)

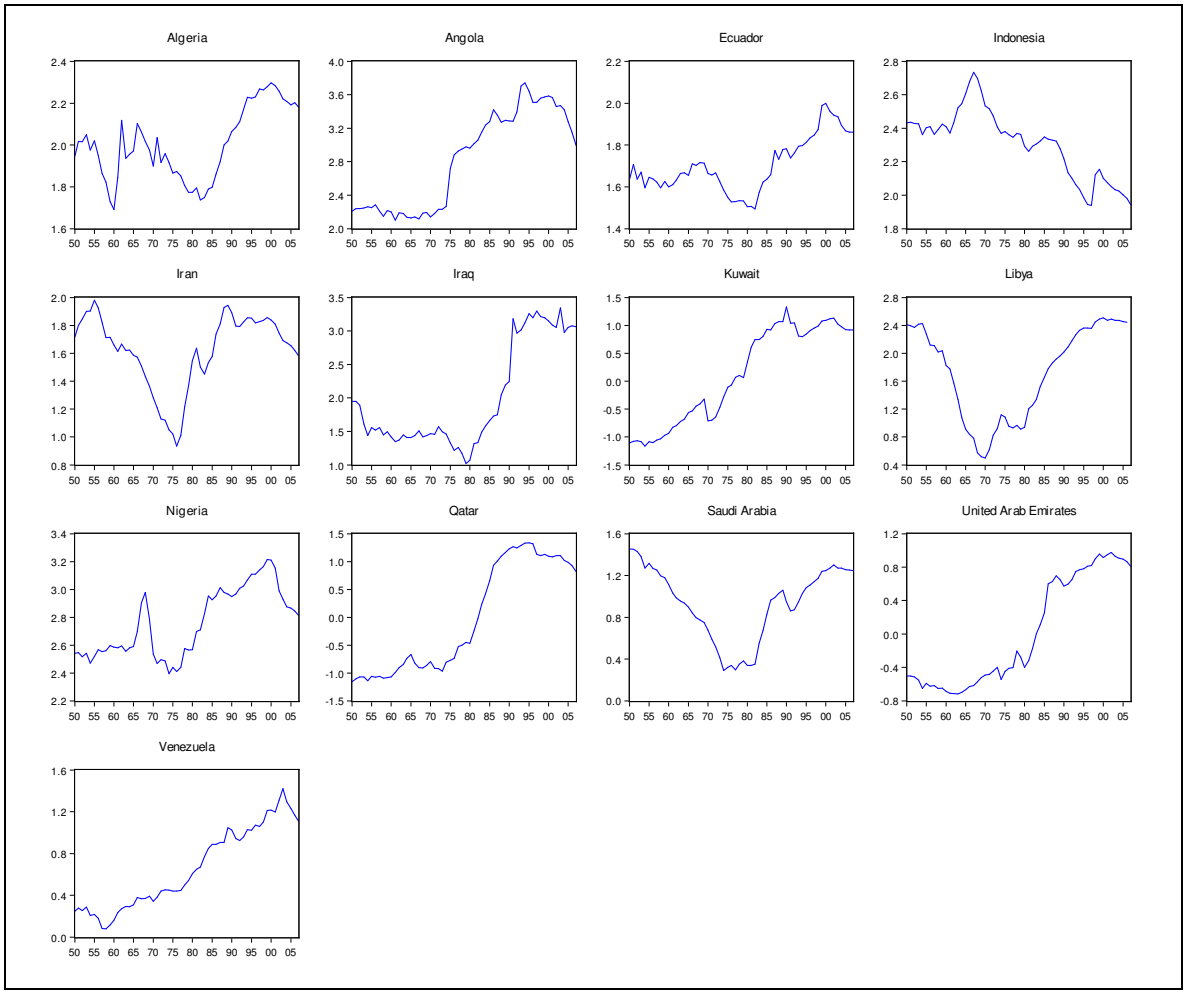

TABLE 1. Average growth rates, different periods

Average growth rates of per capita GDP series				
	1950-2005	**1950-1970**	**1971-1990**	**1991-2005**
Algeria	0.016	0.025	0.014	0.009
Angola	0.004	0.026	-0.036	0.026
Ecuador	0.017	0.021	0.016	0.012
Indonesia	0.029	0.018	0.037	0.032
Iran	0.023	0.044	-0.009	0.034
Iraq	0.001	0.047	-0.017	-0.036
Kuwait	-0.015	0.003	-0.080	0.045
Libya	0.020	0.118	-0.050	-0.011
Nigeria	0.016	0.023	0.001	0.024
Qatar	-0.016	0.004	-0.079	0.034
Saudi Arabia	0.025	0.061	0.008	-0.003
United Arab Emirates	-0.003	0.022	-0.032	-0.004
Venezuela	0.005	0.018	-0.012	0.004
US	0.021	0.023	0.022	0.018

TABLE 2. ADF unit root tests

Testing the integration order of the log real per capita GDP series			
	With no regressors	With an intercept	With an intercept and a linear time trend
Algeria	1.81	-0.89	-1.52
Angola	0.03	-1.43	-1.18
Ecuador	3.14	-0.47	-1.42
Indonesia	5.04	2.31	-0.85
Iran	0.54	-1.41	-2.16
Iraq	-0.47	-1.09	-1.60
Kuwait	-1.49	-1.12	-1.30
Libya	-0.77	-1.91	-1.92
Nigeria	0.95	-0.81	-1.80
Qatar	-1.18	-0.71	-1.22
Saudi Arabia	0.04	-1.87	-1.59
United Arab Emirates	-0.4	-0.79	-2.15
Venezuela	0.62	-2.47	-2.61
US	8.31	1.83	-2.35

The 10%, 5% and 1% critical values are: Model with no regressors: -1.61, -1.95, -2.61; Model with an intercept:-2.60, -2.92, -3.57; Model with an intercept and a linear time trend: -3.18, -3.50, -4.16
* indicates significant at the 10% level.

TABLE 3. ADF unit root tests

Testing the integration order of the differences of log real per capita GDP series with the US				
	With no regressors	With an intercept	With an intercept and a linear time trend	Converging?
Algeria	0.32	-1.39	-1.96	U
Angola	0.32	-1.19	-1.07	U
Ecuador	0.70	-0.85	-1.63	U
Indonesia	-1.00	-0.75	-2.40	U
Iran	-0.68	-2.08	-2.13	U
Iraq	0.70	-0.26	-2.04	U
Kuwait	-0.77	-1.07	-0.86	U
Libya	-0.41	-1.22	-1.91	U
Nigeria	0.13	-1.86	-2.53	U
Qatar	-0.99	-0.95	-1.20	U
Saudi Arabia	-0.78	-1.67	-1.74	U
United Arab Emirates	-0.34	0.04	-2.18	U
Venezuela	1.59	-0.38	-3.01	U

The critical values are: Model with no regressors: -1.61, -1.95, -2.61. Model with an intercept:-2.60, -2.92, -3.57. Model with an intercept and a linear time trend: -3.18, -3.50, -4.16. *, ** and *** indicate signficant at the 10%, 5% and 1% levels respectively. U denotes unit root.

TABLE 4. LM unit root tests

Testing the integration order of the differences of log real per capita GDP series with the US						
	Change in the intercept			Change in both the intercept and the linear time trend		
	LM stat	T_B	Converging?	LM stat	T_B	Converging?
Algeria	-2.85	1961	U	-3.48	1961	U
Angola	-2.14	1992	U	-3.22	1973	U
Ecuador	-2.93	1986	U	-4.16	1981	U
Indonesia	-2.78	1970	U	-4.46*	1963	C
Iran	-3.14	1981	U	-3.33	1984	U
Iraq	-2.15	1997	U	-4.63*	1989	D
Kuwait	-1.89	1989	U	-4.12	1979	U
Libya	-1.91	1974	U	-2.41	1979	U
Nigeria	-2.66	1977	U	-3.97	1981	U
Qatar	-2.81	1997	U	-4.09	1981	U
Saudi Arabia	-2.59	1989	U	-4.49*	1981	D
United Arab Emirates	-1.84	1988	U	-3.96	1991	U
Venezuela	-1.68	1995	U	-3.54	1981	U

The 10%, 5% and 1% asymptotic critical values have been obtained from Lee and Strazicich (2001). *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively. C denotes catch-up (with both μ_2 and β_2 are significant), c denotes catch-up (with only one coefficient statistically significant at 10%), D denotes divergence (stationarity around two time breaks which do not satisfy the above β-convergence condition), d denotes divergence (with only one coefficient statistically significant at 10%), and U denotes unit root (we did not find evidence to reject the unit root null hypothesis).

TABLE 5. LM unit root tests

Testing the integration order of the differences of log real per capita GDP series with the US								
	Change in the intercept				Change in both the intercept and the linear time trend			
	LM stat	T_{B1}	T_{B2}		LM stat	T_{B1}	T_{B2}	
Algeria	-2.85	1960	1976	U	-4.47	1959	1963	U
Angola	-2.15	1973	1995	U	-5.42*	1973	1997	C
Ecuador	-3.01	1986	1998	U	-5.30	1971	1991	U
Indonesia	-3.28	1978	2001	U	-5.58*	1962	1991	C
Iran	-3.17	1976	1980	U	-4.97	1971	1989	U
Iraq	-1.94	1978	1998	U	-7.02**	1970	1989	D
Kuwait	-2.50	1968	1998	U	-5.62*	1977	1982	D
Libya	-1.96	1972	1979	U	-5.41*	1968	1998	D
Nigeria	-2.94	1976	1979	U	-4.57	1968	1988	U
Qatar	-2.81	1997	2000	U	-4.94	1978	1994	U
Saudi Arabia	-2.90	1982	1986	U	-6.62**	1970	1981	D
United Arab Emirates	-1.92	1972	1976	U	-5.02	1968	1983	U
Venezuela	-2.03	1988	1995	U	-5.23	1980	1995	U

The 10%, 5% and 1% asymptotic critical values have been obtained from Lee and Strazicich (2001). *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively. C denotes catch-up (with both μ_2 and β_2 are significant), c denotes catch-up (with only one coefficient statistically significant at 10%), D denotes divergence (stationarity around two time breaks which do not satisfy the above β-convergence condition), d denotes divergence (with only one coefficient statistically significant at 10%), and U denotes unit root (we did not find evidence to reject the unit root null hypothesis).