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STRUCTURAL BREAKS AND REAL CONVERGENCE IN OPEC COUNTRIES

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This article examines the real convergence hypothesis in OPEC countries (Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela) using time series techniques and allowing for structural breaks. The main results show lack of support for income convergence in OPEC countries. We only find evidence of catch-up with the U.S. economy for the case of Indonesia, and for Angola in the last years of the sample. These findings are in line with the "resource curse" literature, which suggests that natural resource dependence inhibits economic growth. Furthermore, the results suggest that the country's oil export dependence is negatively related with its per capita GDP growth rate.

JEL classification codes: C32; O41
Key words: real convergence; unit root tests; OPEC countries; structural breaks

I. Introduction

In recent years there has been 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 test for the predictions of the neoclassical growth model (Solow 1956) as opposed to the "new" endogenous growth models (see, for example, Romer 1986 and Lucas 1988). As it is well known, the neoclassical model predicts (under some assumptions) that per capita output will converge to either the steady-state of the individual countries (conditional convergence) or to a common steady-state (unconditional convergence), regardless of initial per capita output

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levels. On the other hand, 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, no attention has been paid to the OPEC experience in the large number of empirical papers that study convergence. The Organization of Petroleum Exporting Countries (OPEC) is currently a cartel of 12 countries, including 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, which gives them considerable control over the global oil market.

Until World War II, the economic literature believed that natural resources were an important factor favoring economic growth, while recent evidence has found that countries rich in natural resources grow slower on average than natural resource poor countries (see, for example, Sala-i-Martin 1997; Sachs and Warner 1999, 2001; and Mehlum et al. 2006, among others). This article examines the real convergence hypothesis in 14 OPEC countries during the second half of the twentieth century. Although all the analyzed countries are rich in a natural resource, oil, there are great differences among them. First, among the 14 countries belonging to the OPEC, seven are located in Asia, five in Africa, and two in South America. Second, they joined the OPEC at very different times. Third, there is a wide variety in size. Fourth, there are great differences in the quotas of each of the countries (for example, Saudi Arabia produces 10,000 thousands of oil barrels per day while Ecuador only produces 500). Fifth, oil export dependency varies among the OPEC countries (for example, Qatar and Kuwait are the most oil dependent countries, with per capita net oil export revenues of U.S. $ 26,151 and 19,685 respectively, while Indonesia, Nigeria and Ecuador are the least dependent countries).

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 increased until the mid-80´s, and then they started to decrease. As shown in Table 1, average growth rates of the analyzed countries seem to be related to the evolution of oil prices. However, there has been

[1] In this paper, two former OPEC members are included, Gabon and Indonesia. Indonesia´s membership from OPEC was voluntarily suspended in 2008 as it became a net importer of oil. Gabon left the OPEC in 1994.

substantial diversity across countries (see Table 1). As shown in this table, while the average growth rate of per capita series was negative for many OPEC countries during the period 1971-1990, the average growth rate for Indonesia was 3.7% and the figures for Ecuador and Algeria are 1.6% and 1.4% respectively. However, average growth rates are higher for the last period of the sample (2.5% average growth rate for Angola, 3.2% for Indonesia, 3.5% for Iran, 3.7% for Qatar, etc.). It is also interesting to note (see Table 1) that the countries with the lowest growth rates for the whole period (Qatar, Kuwait and United Arab Emirates) are also the most oil export dependent countries.[2]

Table 1. Average growth rates (different periods) and oil export dependency

	Average growth rates				Oil dependency
	1950-1970	1971-1990	1991-2006	1950-2006	2006
Algeria	0.025	0.014	0.010	0.017	1,305
Angola	0.026	-0.036	0.025	0.004	2,494
Libya	0.118	-0.054	-0.009	0.020	5,769
Gabon	0.032	-0.010	0.015	0.003	–
Nigeria	0.019	0.001	0.015	0.011	380
Ecuador	0.021	0.016	-0.002	0.012	505
Venezuela	0.018	-0.012	0.009	0.004	1,584
Indonesia	0.018	0.037	0.032	0.029	–
Iran	0.044	-0.009	0.035	0.023	806
Iraq	0.047	-0.017	-0.034	0.001	1,118
Kuwait	**0.003**	**-0.080**	**0.044**	**-0.015**	**19,865**
Qatar	**0.004**	**-0.079**	**0.037**	**-0.016**	**26,151**
Saudi Arabia	0.061	0.008	-0.001	0.025	6,602
United Arab Emirates	**0.022**	**-0.032**	**-0.001**	**-0.003**	**13,338**
Total Africa	0.020	0.003	0.010	0.011	
Latin America (15)	0.020	0.011	0.013	0.015	
East Asia (16)	0.038	0.032	0.041	0.037	
West Asia (15)	0.040	0.009	0.019	0.023	
United States	0.023	0.022	0.018	0.021	

Notes: Oil export dependency is defined as per capita oil export revenues in real terms, measured in 2005 U.S. $ and published by U.S. Energy Information Administration. In bold, the most oil export dependent countries, which are, at the same time, those with the lowest average growth rates.

[2] Oil export dependency is defined as per capita oil export revenues in real terms (see U.S. Energy Information Administration, http://www.eia.doe.gov/).

The differential behaviour of the growth rates of these countries, their difficulties to converge to the real per capita GDP levels of developed countries and the little research found in the literature regarding this group of countries motivate the analysis on real convergence made in this paper. We study real convergence towards two different reference economies. First, and as a global reference, we examine the hypothesis of real convergence towards the U.S. economy. Secondly, we also define alternative regional references using the per capita GDP average of the region (Africa, Latin America, East Asia and West Asia).

The 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 and Sala-i-Martin (1992), etc.

In a time series approach, stochastic convergence considers 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 also how persistent are the differences among countries. 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), Carlino and Mills (1993), Bernard and Durlauf (1995), 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 U.K., and Sweden and Denmark. St. Aubyn (1999) finds evidence of convergence between U.S. and each of the U.K., Australia and Japan, using the Kalman filter methodology. Cellini and Scorcu (2000) detect stochastic convergence only for the U.S. and Canada, and the U.S. and the U.K. when they allow for structural breaks. Strazicich et al. (2003) examine the differences in per capita incomes of fifteen OECD countries with the U.S. 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 for the period after the second break.

In this paper, we apply time series convergence tests allowing for structural breaks to the differences in per capita output for 14 OPEC countries, using data for the period 1950-2006. The outline of the paper is as follows. Section II describes the methodology employed in the article to test for convergence. Section III covers the empirical analysis and Section IV offers some conclusions.

II. Time series convergence tests

In a time series testing framework, countries *i* and *j* converge if their outputs are cointegrated with cointegrating vector [1,-1]. That is, the difference $y_{i,y+k} - y_{j,t+k}$ 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 and convergence as catching-up. Long-run convergence can be either unconditional or conditional, depending on the significance of the intercept, α_0, in equation (1) below.[3] Convergence as catching-up takes place if the log of relative output is trend stationary, $\alpha_1 < 0$, in equation (1) below. Although this last definition 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 (see Bernard and Durlauf 1995 and Oxley and Greasly 1995), as the one observed for less developed countries, such as some of the OPEC countries analyzed in this paper.[4] In this context, we will test for convergence analyzing the integration order of the relative incomes using the following equation:

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

[3] 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.

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

where $RI_t = \ln(y_t^{US}) - \ln(y_t^i)$, and the additional p 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) and Cellini and Scorcu (2000) show that the introduction of structural breaks makes the existence of convergence across countries clearer.

For the OPEC economies, we could consider the existence of one or more breaks in per capita log-income differences during the period 1950-2006. As Perron (1989) pointed out, these tests perform poorly when there is a break in the constant or in the deterministic trend function. However, Perron's method has been criticized because 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 search for a break point endogenously and test for the presence of a unit root when the process has a broken constant or trend, and have demonstrated that their tests are robust and more powerful than the Augmented Dickey-Fuller (ADF, Dickey-Fuller 1979) and Phillips-Perron (1988) tests. However, these procedures have also been critized in the literature (see, for example, Nunes et al., 1997 and Lee and Strazicich, 2001, 2003 among others), since these types 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 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:

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

where Z_t reflects the deterministic components, $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}$, $t=2,3,\ldots,T$. $\tilde{d}$ is a vector of coefficients in the regression of Dy_t on DZ_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 it is assumed to be independent and identically distributed with zero mean and finite variance. The DS_{t-i} terms are added to eliminate the possibility of serial correlation. When $Z_t = \{1,t\}$, we have the statistic proposed in Schmidt and Phillips (1992). If we want to account for some structural breaks, we can extend models A (which allows for a one-time change in level) and C (which allows for a change in both the level and trend) considered by Perron (1989) and define Z_t as

follows: $Z_t = \{1, t, D_1, D_2\}'$ 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 dates of the breaks.[5]

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

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

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 equation (3). The process is repeated for each λ, to determine the LM test statistic with the minimum t-value.[6]

III. 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 2006 for 14 OPEC countries (Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela). As reference economies, we use per capita GDP in the United States, and an average of per capita GDP in Africa, Latin America, East Asia and West Asia. All the variables have been obtained from Maddison (2001) and The Groningen Growth and Development Center. The dynamic behavior of the real GDP per capita series over the period 1950-2006 is shown in Figure 1.

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

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

Figure 1. Real per capita GDP, 1950-2006

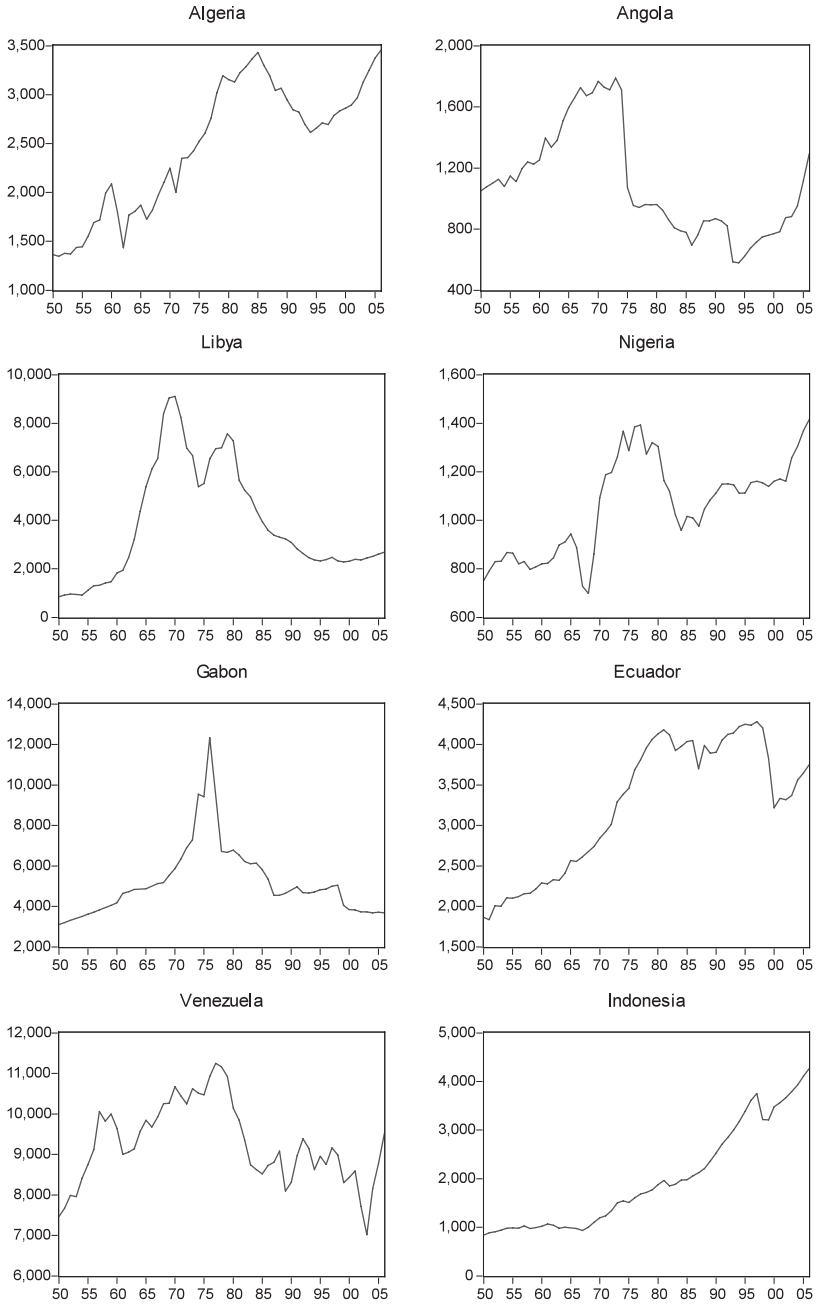
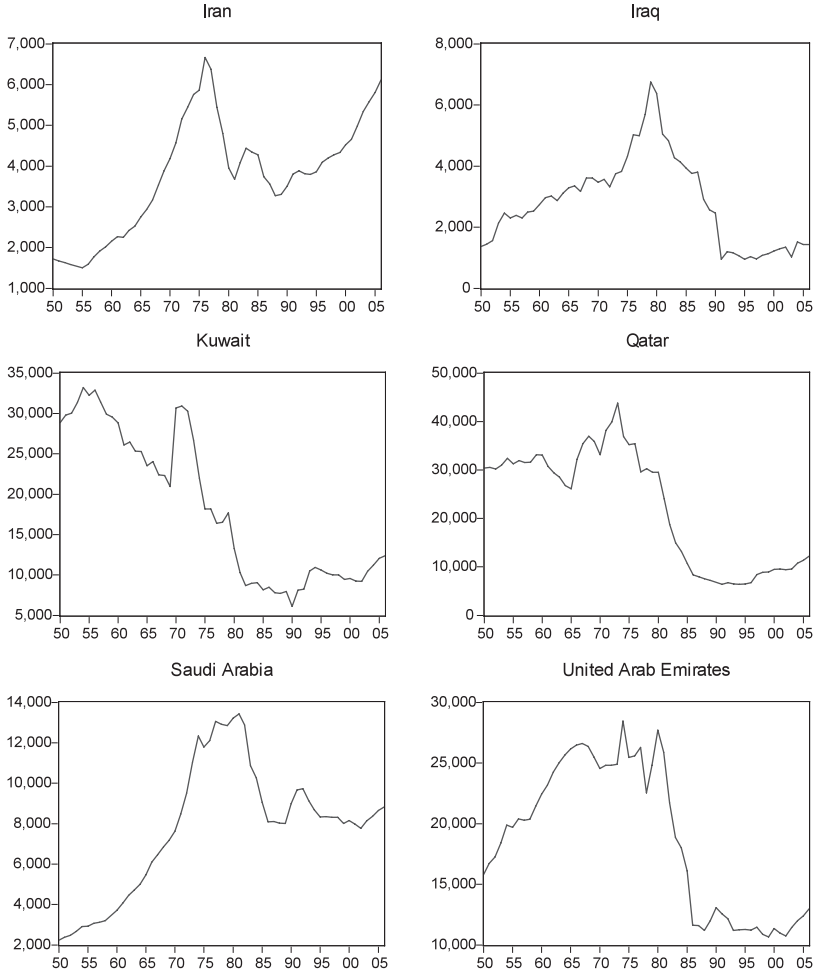


Figure 1 (continued). Real per capita GDP, 1950-2006



First, we carry out ADF unit root tests 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 U.S. and to the alternative reference regions (per capita GDP averages in Africa, Latin America, East Asia and West Asia). The results reported in Table 2 indicate that the null hypothesis of a unit root cannot be rejected for any of the countries.

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
Gabon	-0.46	-1.76	-1.70
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
Africa	2.04	-0.78	-1.52
Latin America	2.45	-0.18	-1.67
East Asia	4.36	3.98	2.30
West Asia	1.24	-0.95	-2.01
United States	8.31	1.83	-2.35

Notes: 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. When ADF unit root tests are applied to the first differences of the logs of these variables (growth rates of per capita GDPs), the unit root null hypothesis is rejected in all the cases. Therefore, per capita GDP are considered I(1) series.

The results from the ADF tests to the differences of each of per capita GDP series with respect to the U.S. and the regional references 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 towards the U.S. economy. This finding implies that shocks to relative regional incomes are permanent. When we include an intercept and a time trend in the model, we are also unable to reject the unit root hypothesis in favor of conditional convergence or catching-up towards this economy. However, when we analyze convergence towards alternative reference economies, we can reject the unit root null hypothesis for Kuwait relative to West Asia, and for Nigeria relative to the African average, when a constant is included in the test. Following Carlino and Mills

Table 3. ADF unit root tests on per capita GDP differences

	With no regressors	With an intercept	With an intercept and a linear time trend	Converging?
Differences of log real per capita GDP series with the U.S.				
Algeria	0.32	-1.39	-1.96	U
Angola	0.32	-1.19	-1.07	U
Ecuador	0.70	-0.85	-1.63	U
Gabon	1.39	0.32	-1.49	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
Differences of log real per capita GDP series with Africa				
Algeria	0.84	-1.10	-1.73	U
Angola	-0.97	-1.27	-1.59	U
Gabon	-0.75	-0.41	-1.37	U
Libya	-1.10	-1.84	-1.93	U
Nigeria	-0.88	-2.94**	-2.98	C
Differences of log real per capita GDP series with Latin America				
Ecuador	1.61	0.03	-1.81	U
Venezuela	-0.89	-0.61	-2.92	U
Differences of log real per capita GDP with East Asia				
Indonesia	1.29	0.62	-0.44	U
Differences of log real per capita GDP series with West Asia				
Iran	-1.56	-2.30	-2.37	U
Iraq	1.17	0.33	-1.87	U
Kuwait	-1.79*	-1.07	-1.31	D
Qatar	-1.43	-0.57	-1.38	U
Saudi Arabia	-0.65	-1.77	-1.44	U
United Arab Emirates	-0.77	-0.36	-2.32	U

Notes: The critical values are: model with no regressors: -1.61, -1.95 model with an intercept:-2.60, -2.92 model with an intercept and a linear time trend: -3.18, -3.50. * and ** indicate significant at the 10% and 5% levels, respectively. U, C and D denote unit root, convergence and divergence, respectively.

(1993), two conditions are required for convergence: shocks to relative per capita incomes should be temporary (stochastic convergence), and initially poor countries should catch up to rich countries (β-convergence). The analysis of β-convergence suggests the existence of conditional convergence for Nigeria towards the African average, although the β-convergence hypothesis is rejected for Kuwait.

The little evidence of convergence or catching-up in this group of countries could be due to the existence of different convergence speeds in the convergence process or to the possibility of countries moving between convergence and non-convergence processes, two possibilities which will be studied while allowing for structural breaks when applying the miminum Lagranger Multiplier statistic suggested by Lee and Strazicich (2003). We begin our tests for time series convergence by employing the minimum two break LM unit root tests, and we examine the significance of each break at the 10% level. If the two identified breaks are not significant, we perform the one break minimum LM unit root test of Lee and Strazicich (2001). If no break is significant, we report the conventional ADF unit root test. That is, we endogenously determine the number of breaks for each country.

The main results presented in Table 4 may be summarized as follows: First, a broad examination of the significance of the dummy variables indicates that the convergence processes of the different OPEC countries have experienced structural changes which must be taken into account when analyzing the order of integration of relative incomes. Second, we can reject the unit root null hypothesis (in model C) in five cases (Angola, Gabon, Indonesia, Iraq and Saudi Arabia) when analyzing per capita GDP differences with respect to the U.S.. When the alternative reference economies are considered, we can reject the unit root null hypothesis in seven cases: Gabon and Nigeria relative to the African average, Ecuador relative to Latin America, Indonesia in relation to East Asia, and Iraq, Kuwait and Saudi Arabia relative to West Asia. However, and following again Carlino and Mills (1993), stationarity does not mean convergence, since it is also required that countries with below-average per capita output levels grow more than the average. In order to test for this hypothesis, we follow Tomljanovich and Vogelsang (2002) and Nieswiadomy and Strazicich (2004) and study whether catching-up in per capita output after the structural break happened for all these cases. For this purpose, we run the following two regressions (depending on whether we allow for one or two breaks):

$$RI_t = \mu_1 + \mu_2 + \beta_1 t_1 + \beta_2 t_2 + u_t, \tag{4}$$

$$RI_t = \mu_1 + \mu_2 + \mu_3 + \beta_1 t_1 + \beta_2 t_2 + \beta_3 t + u_t, \tag{5}$$

Table 4. LM unit root tests on per capita GDP differences

	Change in the intercept				Change in both the intercept and the linear time trend			
	LM stat	TB1	TB2	Converging?	LM stat	TB1	TB2	Converging?
Differences of log real per capita GDP series with the United States								
Algeria	-2.85	1961		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
Gabon	0.32			U	-4.51*	1983		D
Indonesia	-2.78	1970		U	-5.58*	1962	1991	C
Iran	-3.17	1976	1980	U	-3.33	1984		U
Iraq	-0.26			U	-7.02**	1970	1989	D
Kuwait	-2.50	1968	1998	U	-4.12	1979		U
Libya	-1.22			U	-2.41	1979		U
Nigeria	-1.86			U	-3.97	1981		U
Qatar	-0.95			U	-4.94	1978	1994	U
Saudi Arabia	-2.59	1989		U	-6.62**	1970	1981	D
United Arab Emirates	-1.92	1972	1976	U	-3.96	1991		U
Venezuela	-0.38			U	-3.54	1981		U
Differences of log real per capita GDP series with Africa								
Algeria	-1.10			U	-3.29	1961		U
Angola	-1.27			U	-3.33	1982		U
Gabon	-3.16	1978	1984	U	-4.50*	1972		D
Libya	-2.51	1974	1981	U	-1.84			U
Nigeria	-2.57	1972	1974	U	-6.60**	1966	1984	C

Table 4 (continued). LM unit root tests on per capita GDP differences

	Change in the intercept				Change in both the intercept and the linear time trend			
	LM stat	TB1	TB2	Converging?	LM stat	TB1	TB2	Converging?
Differences of log real per capita GDP series with Latin America								
Ecuador	-3.11	1986	1992	U	-6.93**	1980	1998	D
Venezuela	-1.72	1979	1988	U	-5.07	1964	1978	U
Differences of log real per capita GDP series with East Asia								
Indonesia	-1.52	1983	1999	U	-6.18**	1965	1984	C
Differences of log real per capita GDP series with West Asia								
Iran	-3.11	1981	1997	U	-4.64	1962	1983	U
Iraq	0.33			U	-7.95**	1989		D
Kuwait	-1.07			U	-4.53*	1980		D
Qatar	-0.57			U	-1.38			U
Saudi Arabia	-2.21	1976	1983	U	-5.50*	1981	1992	D
United Arab Emirates	-0.36			U	-3.12	1983		U

Notes: The 10% and 5% asymptotic critical values have been obtained from Lee and Strazicich (2001). * and ** indicate significant at the 10% and 5% levels, respectively. U, C and D denote unit root, convergence and divergence, respectively. After testing for stochastic convergence, following Carlino and Mills (1993), we test for time series beta convergence.

where, for example, in equation (5), 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 in the last period is equivalent to testing whether the parameters μ_3 and β_3 are different from zero and negatively related. The last column in Table 4 summarizes the results found in this analysis. In this case, and following Tomljanovich and Vogelsang (2002) and Nieswiadomy and Strazicich (2004), C denotes catching-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 equations (4) and (5)), D denotes divergence (stationarity around different time trends that do not satisfy the aforementioned β-convergence condition), and U denotes unit root (we did not find evidence to reject the unit root null hypothesis). After estimating these equations for the five cases identified, we only find evidence of catching-up (towards the US) after the breaks for Indonesia and Angola. When we define per capita differences relative to the regional references, we only find evidence of catching-up for Nigeria relative to Africa, and for Indonesia relative to East Asia.

IV. Concluding remarks

In this article we have examined the real convergence process for 14 OPEC countries by means of using time-series tests over the period 1950-2006. Convergence is defined both towards the U.S. economy and towards alternative regional references, defined as the per capita GDP average of each country's region (Africa, Latin America, East Asia and West Asia). Following Carlino and Mills (1993), we have carried out stochastic convergence and β-convergence tests. That is, we first test for stationarity in relative incomes, and then we test whether initially poorer countries have grown at a higher growth rate than rich countries. Stochastic convergence tests have been carried first based on ADF unit root tests, and then allowing for structural breaks using the one (and two) break(s) minimum LM unit root tests of Lee and Strazicich (2001, 2003).

Using ADF unit root tests, we find no evidence of unconditional convergence for any of the OPEC countries towards the U.S., although we find evidence of convergence for Nigeria towards the African average.

However, when we analyze the possibility of structural breaks, we find significant evidence of structural breaks in relative per capita incomes. Furthermore, we only find evidence of catching-up (towards the U.S.) after the break for Indonesia and Angola. When we define per capita differences relative to the regional references,

we only find evidence of catching-up for Nigeria relative to Africa, and for Indonesia relative to East Asia.

The lack of support for income convergence in OPEC countries is in line with the literature suggesting that natural resource dependence crowds out other types of capital and thereby inhibits economic growth (Gylfason 2000, 2004). According to this literature, natural resource abundance may affect growth through different channels: crowding out physical and human capital, discouraging foreign capital inflows, impeding diversification, etc. However, the case of Indonesia exemplifies how natural wealth per se is not the problem. Indonesia, although a natural resource-rich economy, has grown at higher rates than the rest of OPEC countries by diversifying its economy. Furthermore, an analysis of the results, together with the growth rates of the countries reported in Table 1, suggests that the relative performance of each of the OPEC countries is negatively related with their oil export dependency (Bhattacharyya and Blake 2010).

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