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ABSTRACT

Energy Consumption, Economic Growth and CO_2 Emissions in Middle East and North African Countries*

This article extends the recent findings of Liu (2005), Ang (2007), Apergis et al. (2009) and Payne (2010) by implementing recent bootstrap panel unit root tests and cointegration techniques to investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for 12 Middle East and North African Countries (MENA) over the period 1981–2005. Our results show that in the long-run energy consumption has a positive significant impact on CO_2 emissions. More interestingly, we show that real GDP exhibits a quadratic relationship with CO_2 emissions for the region as a whole. However, although the estimated long-run coefficients of income and its square satisfy the EKC hypothesis in most studied countries, the turning points are very low in some cases and very high in other cases, hence providing poor evidence in support of the EKC hypothesis. Thus, our findings suggest that not all MENA countries need to sacrifice economic growth to decrease their emission levels as they may achieve CO_2 emissions reduction via energy conservation without negative long-run effects on economic growth.

JEL Classification: Q43, Q53, Q56

Keywords: Environmental Kuznets Curve, carbon dioxide emissions, energy consumption, growth

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1. INTRODUCTION

The relationship between environmental quality and economic growth is puzzling. According to the Environmental Kuznets Curve (EKC) hypothesis, as income increases, emissions increase as well until some threshold level of income is reached after which emissions begin to decline. There is in existence a plethoric empirical literature of EKC, most of it surveyed by Dinda (2004) and Stern (2004). Most empirical studies have focused especially on emissions of various pollutants such as sulphur and carbon dioxide (SO_2 and CO_2) in industrial countries. With regard to emerging economies, our literature survey typically indicates that very few studies have been carried out and they mainly consider major Asian and Latin American countries and less attention has been given to smaller emerging countries, especially in the Middle East and North Africa region (MENA) (Kraft and Kraft, 1978; Soytas et al. 2007; Ang, 2007; Soytas and Sari, 2009)[1].

M'henni (2005) tests for the EKC hypothesis in Tunisia over the period from1980 to 1997. He makes use of the Generalized Method of Moments (GMM) and examines the following pollutants: CO_2 emissions, fertilizers concentration and the numbers of cars in traffic which served to calculate an index for environmental quality. He concludes that there is no evidence to support the EKC for any of these pollutants. In the same vein but with a different result, based on a cointegration analysis Chebbi *et al.* (2009) establish a positive linkage between trade openness and per capita emissions and a negative linkage between economic growth and per capita pollution emissions in the long-run. Again for Tunisia, Fodha *et al.* (2010) provide support for a long-run relationship between the per capita emissions of two pollutants and per capita GDP, indicating that there is a monotonically increasing linear relationship between per capita CO_2 emissions and per capita GDP, while the relationship between the other environmental indicator, i.e., SO_2 and per capita GDP follows an N-shape, representing the EKC hypothesis. Akbostanci *et al.* (2009) examine the relationship between CO_2, SO_2 and PM_{10} emissions, energy consumption and economic growth in Turkey at two levels. They have looked for the EKC at national level and also for the 58 provinces in Turkey. They found a monotonic and increasing relationship at the national level. However, they found an N shaped curve at the level of provinces. Their findings do not support the EKC. Mehrara (2007) investigated the causal relationship between per capita energy consumption and per capita GDP in oil exporting countries. In his sample, seven MENA countries were examined

[1] Please see Payne (2009) for an excellent recent survey on these works.

(Algeria, Bahrain, Iran, Saudi Arabia, Oman, Kuwait, and United Arab Emirates (UAE)). He found strong unidirectional causality from economic growth to energy consumption. He suggests reforming energy prices in these countries without loss of economic growth and with an improvement of environmental quality.

Sari and Soytas (2009) investigate the relationship between carbon emissions, income, energy and total employment in five selected OPEC countries (including two MENA countries: Algeria and Saudi Arabia) for the period 1971–2002. They mainly focus on the link between energy use and income. Employing the autoregressive distributed lag (ARDL) approach, they find that there is a cointegrating relationship between the variables in Saudi Arabia and conclude that none of the countries needs to sacrifice economic growth to decrease their emission levels. Recently, Narayan *et al.* (2010) tested the Environment Kuznet's Curve (EKC) hypothesis for 43 developing countries for the period from 1980 to 2004. They examined the EKC hypothesis based on the short- and long-run income elasticities vis-à-vis CO_2 emissions; that is, if the long-run income elasticity is smaller than the short-run income elasticity then it is evident for them that a country has reduced carbon dioxide emissions as its income has increased. They found that for the Middle Eastern panel, the income elasticity in the long run is smaller than the short run, implying that carbon dioxide emission has fallen with a rise in income. By using the same methodology Jaunky (2010) tested the EKC hypothesis for 36 high-income countries (including three MENA countries: Bahrain, Oman and UAE) over the period 1980-2005. Carbon dioxide emissions and GDP series are integrated of order one and cointegrated especially after controlling for cross-sectional dependence. Unidirectional causality running from real per capita GDP to per capita CO_2 emissions was uncovered in both the short run and long run. The empirical analysis based on individual countries suggests that for Oman (and for other 6 non MENA countries), as well as for the whole panel, CO_2 emissions have fallen as income rises in the long run. A 1% increase in GDP generates an increase of 0.68% in CO_2 emissions in the short run and 0.22% in the long run for the panel. These results do not provide evidence in favor of the EKC hypothesis but indicate that over time CO_2 emissions are stabilizing in rich countries.

As we can see, the results of the available studies for the MENA countries are very heterogeneous. Compared to previous works, our article investigates the MENA countries as a region as well as at a country level by taking advantage of recent advances in the econometrics of non-stationary panel data econometric techniques and seemingly unrelated

regression (SUR) methods. Its aims are threefold. First, we test for the EKC hypothesis in 12 MENA countries for a major pollutant in the region (CO_2). Second, we characterize the turning points until which the economic development improves the environmental quality in MENA Countries. Finally, we explore the nature of the causality relationship between economic growth, energy consumption and emissions of CO_2. Thus, our article contributes to previous empirical verifications of the EKC hypothesis (Stern, 2004; Ang, 2007; Caviglia-Harris *et al.* 2009; Apergis and Payne, 2009) and in particular those focusing on MENA Countries (Mehrara, 2007; Akbostanci *et al.* 2009; M'henni, 2005; Fodha and Zaghdoudi, 2009) by using new robust econometric methods.

The remainder of this paper is organized as follows. Section 2 presents the data, the econometric models and discusses the results. Section 3 discusses the policy implications of our main findings and concludes.

2. METHODOLOGY AND EMPIRICAL RESULTS

2.1. The model and data

To conduct our empirical analysis and investigate the relationship between CO_2 emissions, energy consumption and economic growth which is a synthesis of the EKC and energy consumption growth literatures, we need the following variables for all studied MENA countries:

- CO_2 emission (C);
- Energy consumption (E);
- Per capita real GDP (Y).

We collect data from World Bank Development Indicators (WDI). Our data are annual and cover the period 1981-2005 for the following MENA countries: Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, and UAE. The variables C, E and Y are measured in metric tons per capita, kt of oil equivalent per capita and constant 2005 international dollars respectively.

We empirically investigate the following model based on variables in natural logarithms:

$$C_{it} = a_i + b_i E_{it} + c_i Y_{it} + d_i Y_{it}^2 + \varepsilon_{it} \quad (1)$$

The coefficients *b*, *c* and *d* represent the long-run elasticity estimates of CO_2 emissions with respect to energy consumption, real GDP and squared real GDP, respectively. According to the discussion above, we expect that an increase in energy consumption leads to an increase in CO_2 emissions ($b>0$). Moreover, under the EKC hypothesis an increase in income is associated with an increase in CO_2 emissions ($c>0$) and there is an inverted U-shape pattern at which point an increase in income leads to lower CO_2 emissions ($d<0$).

In what follows, we start by testing for unit roots in our variables. If these variables are non-stationary in our country panel, we investigate the existence of long run cointegration relationships and investigate their magnitude. Finally, we estimate panel error correction models (ECM) in order to examine the interactions between short and long run dynamics of our environmental variables.

2.2. Panel unit root testing

The body of literature on panel unit root and panel cointegration testing has grown considerably in recent years and now distinguishes between (i) the first-generation tests [Maddala and Wu (1999), Levin *et al.* (2002) and Im *et al.* (2003)] developed on the assumption of the cross-sectional independence of panel units (except for common time effects), (ii) the second-generation tests [Bai and Ng (2004), Smith *et al.*(2004), Moon and Perron (2004), Choi (2006) and Pesaran (2007)] allowing for a variety of dependence across the different units, and also (iii) panel data unit root tests that make it possible to accommodate structural breaks. In addition, in recent years it has become more widely recognized that the advantages of panel data methods within the macro-panel setting include the use of data for which the spans of individual time series data are insufficient for the study of many hypotheses of interest. To test for the presence of such cross-sectional dependence in our data, we have implemented the simple test of Pesaran (2004) and have computed the Cross section Dependence (CD) statistic. This test is based on the average of pair-wise correlation coefficients of the OLS residuals obtained from standard augmented Dickey-Fuller regressions for each individual. Its null hypothesis is cross-sectional independence and is asymptotically distributed as a two-tailed standard normal distribution. Results, available upon request, indicate that the null hypothesis is always rejected regardless of the number of lags included in the augmented DF auxiliary regression (up to five lags) at the five percent level of significance. This confirms that the MENA countries are, as expected, cross-sectionally correlated, which can indeed reflect here the presence of similar regulations in

various fields (such as environmental policy and regulation, economy, finance, trade, customs, tourism, legislation, and administration), high economic, fiscal and political corporation and increasing financial and economic integration.

To determine the degree of integration of our series of interest (C, E, Y, and Y^2) in our panel of 12 MENA countries, we employ the bootstrap tests of Smith *et al.* (2004), which use a sieve sampling scheme to account for both the time series and cross-sectional dependencies of the data through bootstrap blocks. The specific tests that we consider are denoted $\bar{t}$, $\overline{LM}$, $\overline{\max}$, and $\overline{\min}$. $\bar{t}$ is the bootstrap version of the well-known panel unit root test of Im *et al.* (2003), $\overline{LM} = N^{-1}\sum_{i=1}^{N} LM_i$ is a mean of the individual Lagrange Multiplier (LM_i) test statistics, originally introduced by Solo (1984), $\overline{\max}$ is the test of Leybourne (1995), and $\overline{\min} = N^{-1}\sum_{i=1}^{N} min_i$ is a (more powerful) variant of the individual Lagrange Multiplier (LM_i), with $\min_i = \min(LM_{fi}, LM_{ri})$, where LM_{fi} and LM_{ri} are based on forward and backward regressions (see Smith *et al.*, 2004 for further details). We use bootstrap blocks of m=20.[2] All four tests are constructed with a unit root under the null hypothesis and heterogeneous autoregressive roots under the alternative, which indicates that a rejection should be taken as evidence in favor of stationarity for at least one country.

The results, shown in Table 1 suggest that for all the series (taken in logarithms) the unit root null cannot be rejected at the 5% level of significance in our country panel for the four tests.[3] We therefore conclude that the variables are non-stationary in our country panel.[4]

[2] The results are not very sensitive to the size of the bootstrap blocks.

[3] The order of the sieve is permitted to increase with the number of time series observations at the rate $T^{1/3}$ while the lag length of the individual unit root test regressions are determined using the Campbell and Perron (1991) procedure.

[4] The lag order in the individual ADF type regressions is selected for each series using the AIC model selection criterion. Another crucial issue is the selection of the order of the deterministic component. In particular, since the cross-sectional dimension is rather large here, it may seem restrictive not to allow at least some of the units to be trending, suggesting that the model should be fitted with both a constant and trend. However, since the trending turned out to be not very pronounced, we have considered that a constant is sufficient in our analysis. Actually, the results of the bootstrap tests of Smith *et al.* (2004) are not very sensitive to the inclusion of a trend in addition to a constant in the estimated equation (see Statistic b in Table 1). We have of course also checked using the bootstrap tests of Smith *et al.* (2004) that the first difference of the series are stationary, hence confirming that the series expressed in level are integrated of order one.

Table 1 – Panel unit root tests of Smith *et al.* (2004) for the carbon dioxide emissions per capita and potential determinants (1981-2005)*

	Carbon Dioxide Emissions per capita (C)				Energy per capita (E)			
Test	Statistic (a)	Bootstrap P-value*	Statistic (b)	Bootstrap P-value*	Statistic (a)	Bootstrap P-value*	Statistic (b)	Bootstrap P-value*
$\bar{}$	-1.406	0.643	-2.457	0.340	-1.512	0.526	-2.026	0.385
$\overline{LM}$	3.319	0.266	5.819	0.225	5.505	0.229	6.645	0.198
$\overline{\max}$	-0.829	0.777	-2.034	0.196	-1.063	0.435	-1.855	0.404
$\overline{\min}$	2.268	0.189	4.464	0.172	2.513	0.112	4.221	0.255
	Per Capita Real GDP (Y)				Square of Per Capita Real GDP (Y^2)			
Test	Statistic (a)	Bootstrap P-value*	Statistic (b)	Bootstrap P-value*	Statistic (a)	Bootstrap P-value*	Statistic (b)	Bootstrap P-value*
$\bar{}$	-1.521	0.492	-2.446	0.152	-2.393	0.187	-2.157	0.198
$\overline{LM}$	3.891	0.123	5.841	0.133	4.692	0.264	3.504	0.384
$\overline{\max}$	0.216	0.865	-0.685	0.974	0.327	0.846	-0.687	0.784
$\overline{\min}$	2.177	0.224	1.954	0.993	2.161	0.237	1.972	0.814

Notes: (a) Model includes a constant. (b) Model includes both a constant and a time trend.
** Test based on Smith et al. (2004). Rejection of the null hypothesis indicates stationarity at least in one country. All tests are based on 2,000 bootstrap replications to compute the p-values.*
Null hypothesis: unit root (heterogeneous roots under the alternative).

2.3. Panel cointegration

Given that all the series under investigation are integrated of order one, we now proceed with the two following steps. First, we perform 2nd generation panel data cointegration tests (that allow for cross-sectional dependence among countries) to test for the existence of cointegration between C and its potential determinants E, Y, Y^2 contained in X. Second, if a cointegrating relationship exists for all countries, we estimate for each country the cross-section augmented cointegrating regression

$$C_{it} = \alpha_i + \gamma_i X_{it} + \mu_1 \overline{C}_t + \mu_2 \overline{X}_t + u_{it}, \quad i = 1,...,N; \quad t = 1,...,T \tag{2}$$

by the Cross Correlated Effects (CCE) estimation procedure proposed by Pesaran (2006) that allows for cross-section dependencies that potentially arise from multiple unobserved common factors. The cointegrating regression is augmented with the cross-section averages of the dependent variable and the observed regressors as proxies for the unobserved factors. Accordingly, $\bar{G}$ and $\bar{X}_t$ denote respectively the cross-section averages of C and X_i in year t. Note that the coefficients of the cross–sectional means (CSMs) do not need to have any economic meaning as their inclusion simply aims to improve the estimates of the coefficients

of interest. Therefore, this procedure enables us to estimate the individual coefficients γ_i in a panel framework.[5]

In addition, we also compute the CCE-MG estimators of Pesaran (2006). For instance, for the γ parameter and its standard error for N cross-sectional units, they are easily obtained as follows: $\hat{\gamma}_{CCE-MG} = \frac{\sum_{i=1}^{N} \hat{\gamma}_{i-CCE}}{N}$, and $SE(\hat{\gamma}_{CCE-MG}) = \frac{\sum_{i=1}^{N} \sigma(\hat{\gamma}_{i-CCE})}{\sqrt{N}}$, where $\hat{\gamma}_{i-CCE}$ and $\sigma(\hat{\gamma}_{i-CCE})$ denote respectively the estimated individual country time-series coefficients and their standard deviations.

We now use the bootstrap panel cointegration test proposed by Westerlund and Edgerton (2007). This test relies on the popular Lagrange multiplier test of McCoskey and Kao (1998), and makes it possible to accommodate correlation both within and between the individual cross-sectional units. In addition, this bootstrap test is based on the sieve-sampling scheme, and has the advantage of significantly reducing the distortions of the asymptotic test. Another appealing advantage is that the joint null hypothesis is that all countries in the panel are cointegrated. Therefore, in case of non-rejection of the null hypothesis, we can assume that there is cointegration between C and its potential determinants contained in *X*.

The asymptotic test results (Table 2) indicate the absence of cointegration. However, this is computed on the assumption of cross-sectional independence, which is not the case in our panel. Consequently, we also used bootstrap critical values. In this case we conclude that there is a long-run relationship between carbon dioxide emissions and potential determinants, implying that over the long-run they move together.

Table 2 – Panel cointegration between carbon dioxide emissions and potential determinants (1981-2005)

	LM-stat	Asymptotic p-value	Bootstrap p-value #
Model with a constant term	2.608	0.005	0.877

Notes: bootstrap based on 2000 replications.
a - null hypothesis: cointegration of carbon dioxide emissions and potential determinant series.
 # Test based on Westerlund and Edgerton (2007).

[5] Note that in order to estimate the long-run coefficients we have also implemented the Pooled Mean Group (PMG) estimators (see Pesaran and Smith (1995), Pesaran, Shin and Smith (1999)), which allowed us to identify significant differences in country behaviour. However, we only report the results of the Common Correlated Effects (CCE) estimators developed by Pesaran (2006), since they allow taking unobservable factors into account, which would not be the case of the PMG estimators.

2.4. The magnitudes of the cointegration relationship

Given the evidence of panel cointegration, the long-run pollution income relations can be further estimated by several methods for panel cointegration estimation. We estimate the above equation to assess the magnitude of the individual γ_i coefficient in the cointegrating relationship with the CCE estimation procedure developed by Pesaran (2006), which addresses cross-sectional dependency.

$$C_{it} = \alpha_i + \gamma_{it} E_{it} + \gamma_{2i} Y_{it} + \gamma_{3i} Y_{it}^2 + u_{it} \tag{3}$$

with $i = 1,...,N$, $t = 1,...,T$, and the respective estimation results are reported in Table 3.

Table 3 – Individual country CCE estimates for 12 MENA countries for the carbon dioxide emissions and potential determinants (1981-2005)

Country	E		Y		Y^2		Constant	
	γ_1	t-Stat	γ_2	t-Stat	γ_3	t-Stat	α	t-Stat
Algeria	1,034	2.248	2.473	4.015	-0.170	-2.417	-25.642	-3.537
Egypt	-0.443	-2.021	0.817	3.624	-0.218	-2.982	-4.357	-2.240
Jordan	0.823	6.691	0.435	2.924	-0.166	-2.806	-2.489	-3.676
Lebanon	0.116	2.991	0.935	2.920	-0.454	-2.045	-7.288	-5.932
Morroco	0.923	7.211	-0.407	-1.938	0.588	4.820	-7.477	-6.605
Tunisia	0.199	2.031	0.051	2.218	0.223	2.798	-0.133	-4.089
Bahrain	-0.017	-2.098	1.507	3.767	-1.100	-31.763	-7.833	-2.224
Kuwait	-0.041	-2.369	3.823	7.227	-1.927	-6.785	-11.488	-2.698
UAE	0.129	3.376	-2.337	-4.734	1.071	3.264	28.736	2.796
Oman	0.052	2.243	0.278	2.419	-0.228	-2.923	-2.835	-3.520
Qatar	0.759	4.288	3.039	2.569	-1.188	-4.702	-6.816	-3.735
Saudi Arabia	1.688	3.776	0.385	2.688	-1.244	-2.295	7.504	6.620

Note: the coefficients of the variables $\overline{E}_t$ and $\overline{X}_t$ of equation (a) have not been reported in the table.

In most cases, the parameters are quite significant at the 1% level of significance. The relationship between energy consumption and CO_2 emissions is positive except for Bahrain, Egypt and Kuwait. The results indicate that a 1% increase in energy usage per capita increases CO_2 emissions per capita by 1.688% in Saudi Arabia and by only 0.052% in Oman.

From the sign of the parameter, the results show that there are inverse U-shaped relationships between per capita pollution and per capita GDP for all studied MENA countries, expect Morocco, Tunisia and UAE. For instance, for Egypt the elasticity of CO_2 emissions per capita with respect to real GDP per capita in the long-run is 0.817–0.438Y with the threshold income of 1.865 (in logarithms). While, for another north African country, Algeria, the elasticity is 2.473–0.340Y with the threshold income of 7.273 (in logarithms).

For Saudi Arabia, the elasticity of CO_2 emissions with respect to real GDP is 0.385–2.488Y, implying a threshold income of only 0.154 (in logarithms).

The Tunisian case deserves special attention, since it is the only country where a positive monotonic relationship between income and emissions of CO_2 is found (the elasticity is 0.051 + 0.446Y). Morocco and the UAE deserve further investigations because we found an inverted curve as compared to what is predicted by the theory.

We have to point out that for all the countries where we found an EKC, we are confronted by the problem of the position of the threshold compared to the level of real GDP reached by each country during the period. Our calculations (see table 4) lead us to conclude that none of the studied cases verified this particular EKC hypothesis, except Jordan.

Jordan was among the original 30 countries in 1980 to declare support for the World Conservation Strategy. Another milestone is the "National Environment Strategy" for Jordan (NES). In October 1995, the new Jordanian Environmental Law was passed to achieve the principal objectives mentioned in the NES, and the National Environmental Action Plan (NEAP) was prepared in September 1996, the national Agenda-21 project was launched to lay the ground for sustainable resource development and environmentally sound management in the country.

Table 4- EKC for CO2 in the MENA region (1981-2005)

Country	Intercept	Inverted U shape curve	Turning point	Ymax	Ymin	EKC
Algeria	2.473 - 0.34Y	Yes	Very high	7176	5530	No
Egypt	0.817 - 0.436Y	Yes	6514	4318	2460	No
Jordan	0.435 - 0.332Y	Yes	3706	4360	3032	Yes
Lebanon	0.935 - 0.908Y	Yes	2.801	20368	6565	No
Morocco	-0.407 + 1.176Y	No	?	3588	2254	No
Tunisia	0.051 + 0.446Y	No	Monotonic	6444	3602	No
Bahrain	1.507 - 2.20Y	Yes	1984	28069	16648	No
Kuwait	3.823 - 3.854Y	Yes	2697	44354	22873	No
UAE	-2.337 + 2.142Y	No	?	90478	41862	No
Oman	0.278 - 0.456Y	Yes	1840	19544	10269	No
Qatar	3.039 - 2.376Y	Yes	3593	77232	43705	No
Saudi Arabia	0.385 - 2.488Y	Yes	1168	34116	18243	No
12 countries	1.23 - 0.34Y	Yes	37263	90478	2254	Yes

Finally, the results from the common correlated effects mean group (CCE-MG) method are reported in Table 5.

Table 5 – Results for common correlated effects mean group (CCE-MG) estimations, 12 MENA countries (1981-2005) for CO_2 emissions

	(1) X= (E, Y, Y^2)
Constant	-3.26
	(-5.22)
E	0.47
	(2.86)
Y	1.23
	(3.28)
Y^2	-0.17
	(-4.22)

Note: t-statistics are in parentheses.

On average, over the studied MENA countries, there is a positive relationship between CO_2 emissions and energy consumption: a 1% increase in energy consumption per capita increases CO_2 emissions per capita by 0.47% in the MENA region. As for the average EKC hypothesis: the elasticity of CO_2 emissions per capita with respect to real GDP per capita in the long-run is 1.23–0.34Y with the threshold income of 3.618 (in logarithms).

Taken together, our results are supportive of the EKC hypothesis in the MENA region: the level of CO_2 emissions first increases with income, then stabilizes, and then declines. Thus, there appears to be an inverted U-shaped relationship between CO_2 emissions per capita and real GDP per capita in the MENA region when taken as a whole. The heterogeneity of the countries' sample with mainly rich oil producing countries and the others leads to a broad gap between Ymin (USD 2 254) and Ymax (USD 90 478). This situation increases the probability that the turning point would be between the two data. At the same time we can also point out that only Kuwait, Qatar and UAE had reached this turning point level in terms of per capita GDP.

2.5. Estimation of a panel ECM representation

In the previous sub-section we have estimated the long-run relationships between carbon dioxide emissions and potential determinants for our panel of 12 MENA countries, using the common correlated effects mean group (CCE-MG) estimates (see Table 3). Having established the long-run structure of the underlying data and given that there exists a long-run relationship for all countries in our four panel sets, we turn to the estimation of the complete panel error-correction model (PECM) described by equation (4):

$$\Delta C_{it} = \sum_{j=1}^{p} \beta_j \, C_{it-j} + \sum_{j=0}^{p} \theta_j \, \Delta X_{it-j} + \lambda_i \left[C_{it-1} - \alpha - \gamma X_{it-1} \right] + \varepsilon_{it}, \tag{4}$$

We use the Pooled Mean Group (PMG) approach of Pesaran, Shin and Smith (1999), with long-run parameters obtained with CCE techniques, in order to obtain the estimates of the loading factors λ_i (weights or error correction parameters, or speed of adjustment to the equilibrium values), as well as of the short-run parameters β_j and θ_j for each country of our panel. Consequently, the loading factors and short-run coefficients are allowed to differ across countries.[6]

The lag length structure *p* is chosen using the Schwarz (SC) and Hannan-Quinn (HQ) selection criteria, and by carrying out a standard likelihood ratio testing-down type procedure to examine the lag significance from a long-lag structure (started with *p=4*) to a more parsimonious one. Afterwards, in order to improve the statistical specification of the model, we implemented systematically Wald tests of exclusion of lagged variables from the short-run dynamic (they are not reported here) to eliminate insignificant short-run estimates at the 5% level. The results of the PECM estimations based on equation (4) are reported in Table 6, only for significant short-run estimates at the 5% level.

[6] Note that before considering equation (3), we first used a Wald statistic to test for common parameters across countries (i.e $\lambda_i = \lambda$, and $\gamma_i = \gamma$, for i=1,...,N) with the CCE techniques of Pesaran (2006) that allow common factors in the cross-equation covariances to be removed. We found that only the null hypothesis $\gamma_i = \gamma$, for i=1,…,N was not rejected by data, whereas the speeds of adjustment λ_i vary considerably across countries (results are available upon request).

Table 6 – Panel Error-Correction estimations for C_{it}, X= (E, Y, Y^2), (1981-2005)

	D C_{it-1}	D C_{it-2}	DE_{it}	DE_{it-1}	DY_t	DY_{it-1}	D Y^2_{it}	Loading factor λ_i
Algeria	0.19 (2.55)		0.61 (2.86)		1.721 (3.65)		-0.017 (-2.43)	-0.24 (-4.23)
Egypt	-0.33 (-1.80)		0.25 (2.13)		0.53 (2.26)	1.54 (2.98)		-0.44 (-2.35)
Jordan			0.41 (3.43)		0.66 (5.09)	-0.25 (-1.99)	0.015 (2.49)	-0.21 (-3.20)
Lebanon	-0.51 (-3.01)							-0.02 (-2.71)
Morroco			0.25 (2.91)		0.54 (4.06)	-0.25 (-2.22)	-0.031 (-3.62)	-0.44 (-4.09)
Tunisia	-0.62 (-3.86)		0.38 (3.02)		0.94 (2.12)			0.05 (1.975)
Bahrain			0.54 (2.03)					-0.15 (-1.98)
Kuwait			0.24 (2.60)		0.51 (3.23)		-0.029 (-2.25)	-0.42 (-3.23)
UAE			0.31 (2.48)		0.67 (2.66)			-0.55 (-2.73)
Oman			0.402 (2.57)					-0.18 (-2.34)
Qatar	0.38 (2.90)		0.19 (2.05)		0.40 (2.18)			-0.33 (-2.23)
Saudi Arabia			0.22 (2.20)		0.46 (2.30)		-0.02 (-2.91)	-0.38 (-2.37)
CCE-MG	intercept -3.26 (-5.22)	*E* 0.47 (2.86)	*Y* 1.23 (3.28)	Y^2 -0.17 (-4.22)				

Notes: The estimations are obtained from the Pooled Mean Group approach with long-run parameters estimated with CCE techniques. The coefficients of the variables $\overline{E}_t$ *and* $\overline{X}_{1t}$ *of equation (2) have not been reported in the table. t-statistics are in brackets. C – Carbon Dioxide Emissions; E – Energy; Y – Per Capita Real GDP; Y2 – Square of Per Capita Real GDP.*

Results from Table 6 allow checking for two sources of causation: (1) the lagged difference terms (short-run causality) and/or (2) the error correction terms (long-run causality). The short-run dynamics confirm the evidence of significant positive causality from energy consumption to CO_2 emissions. The causality from GDP to CO_2 emissions depends on the level of economic growth. As for the long-run dynamics, the loading factor, which measures the speed of adjustment back to the long-run equilibrium value, is significantly negative in all cases (except for Tunisia) confirming that all the variables of our model move together over the long run. Thus, the long-run equilibrium deviation has a significant impact on the growth of CO_2 emissions.

3. CONCLUSION AND POLICY IMPLICATIONS

Our article had three aims. First, we investigate the existence of EKC in the MENA region (taken into account 12 Countries) in the matter of Carbon dioxide. Second, we investigate the

existence of EKC for each country. Finally, we explore the nature of the causality relationship between economic growth, energy consumption and emissions of CO_2. Our study extends the recent works of Liu (2005) and Ang (2007) and Apergis and Payne (2009) by implementing recent bootstrap unit root tests and panel cointegration techniques to investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for 12 MENA countries over the period 1981–2005.

Regional-level

Departing from the hypothesis that the 12 countries are homogenous and looking at the regional-level, our results show that in the long-run energy consumption has a positive significant impact on CO_2 emissions in MENA region. More interestingly, we show that real GDP exhibits a quadratic relationship with CO_2 emissions. Taken together, our findings support an inverted U-shape pattern associated with the Environmental Kuznets Curve hypothesis for the MENA region: CO_2 emissions increase with real GDP, stabilize, and then decrease.

Our result can be explained by at least three complementary arguments. Firstly, most of MENA countries have made strong effort in matter of building a capacity to manage environmental problems and especially air pollution. Over the past two decades, most MENA Countries have built specific environmental institutions in order to meet the challenges they face. Most MENA countries have dedicated Ministry for environment and specific laws for different environmental areas like Water pollution, Soil pollution, Air pollution. In some countries specific agencies have been dedicated for these specific areas. The decline of the CO2 emissions as GDP increases may be explained by more effectiveness of these institutions and laws. Secondly, the raise of citizens' awareness as GDP increases may explain the change of CO2 emissions about climate change in those countries and the move towards more sustainable consumption of energy. Producers (Multinationals) are aware about the Greenhouse effects and are using technologies saving energy and diminishing the CO2 emissions. By consequence the consumers in MENA countries are benefiting from this technological change. As an example, the car Park in MENA Countries is rapidly changing and consumers are adopting more energy saving cars. Thirdly, most of MENA Countries, after a long period of subsidizing the Oil in their domestic countries are moving toward a policy of "the true prices" and are cutting these subsidies. As a consequence there's a shift in the consumption of energy and the use of technologies saving energy and less polluting. Our

findings support that at the macro-level the region is moving toward a new stage where economic development is not causing environmental degradation measured by CO2 emissions. Small changes in every country is causing big shift in the whole region.

Country-Level

At the country-level, our results show that EKC is not verified for the studied countries except for Jordan. Although the estimated long-run coefficients of income and its square satisfy the EKC hypothesis in most studied countries, the EKC turning points are very low in some cases and very high in other cases, hence providing rather poor evidence in support of the EKC hypothesis.

This result is puzzling but can be explained by two complementary arguments. Firstly, most of these countries are exploring new pattern of economic growth and CO2 emissions but their current efforts and policies are not sufficient in order to reverse the general trend. They have not yet reached the regime of a positive effect of growth on CO2 emissions. The economic composition of these economies is changing slowly. Most of these countries are based on primary sector (Rentier States[7]) and the shift toward a service economy is low. Some countries like Qatar, United Arab Emirates, Tunisia, and Morocco are exploring a shift in their structural economic composition. When this change becomes more visible EKC becomes verified at the country level. Secondly, most of these countries are moving toward pro-active approach of ecological modernization. In the case of Gulf Cooperation Council countries (GCC), the shift towards more energy efficiency could improve their performance (Doukas et al, 2006). These countries are exploring new policies but this reorientation has not yet resulted in the development of consistent strategies and policies (Reiche, 2010). A gradual price hikes and government retrofitting of buildings are largely recommended as policies for improving the current situation (Krane, 2010). At the same time one must mention the several initiatives in matter of renewable energy taken in Algeria, the Kingdom of Saudi Arabia and other MENA countries like the pioneering project of Masdar Sustainable City[8]. These initiatives are changing the situation and are expected to improve the situation in the next years. The efforts and policies changes are not captured by actual statistics and the EKC is not verified at the country level, however all these initiatives are improving the situation.

[7] The term Rentier States connotes a country that derives most of its national income from the external sale of natural resources.

[8] MENA countries are estimated to have a potential to generate 630,000,000 megawatts of solar power and also 75000 megawatts of wind power potential (Ghaddar, 2009).

Finally, our results confirm the EKC is a sensitive construct, which depends on the level of observation. Since then we must be careful with this tool in order to formulate economic policies. For MENA countries, we demonstrate that the curve is valid at the regional-level and we can give solid explanation for this fact by considering recent efforts made at the political, institutional and economic levels. However the explanation is not valid at the country-level. Several previous papers have addressed this point by exploring the differences between regional provinces and a country level and find conclusions close to ours.

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