

Long-run analysis of Environmental Kuznets Curve in the Middle East and North Africa

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Abstract:

The main originality of this paper is to empirically investigate the long-run relationship between carbon dioxide (CO₂) emissions, energy use and real GDP per capita in the Middle East and North Africa (MENA) region during the last three decades. We validate the Environmental Kuznets Curve (EKC) hypothesis in the long-run. As income increases, emissions increase as well until some threshold level of income is reached after which emissions begin to decline. The estimated turning point of the EKC confirms our intuitions that only rich net-oil exporting countries achieve CO₂ emissions reduction goal, as they begun to adopt climate change mitigation policies. As for the low-income countries in the MENA region, considerable efforts are still required, and CO₂ emissions should be reduced as their per capita real GDP increases.

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1. Introduction

The main originality of this paper is to empirically assess the impact of economic activity development on the carbon dioxide (CO₂ hereafter) emissions in the Middle East and North Africa (MENA hereafter) region. The empirical literature was dominated by the use of the Environmental Kuznets Curve (EKC) concept in evaluating the impact of economic growth on the CO₂ emissions which causes climate change. Having collected a long panel dataset describing 12 countries for the MENA group, we test the long-run patterns of EKC assumptions using panel cointegration techniques.

In order to empirically evaluate the causal effect between CO₂ emission, as indicator of climate pollution, and economic growth, scholars used the Environmental Kuznets Curve concept. Grossman and Krueger (1991) are the first who used the EKC concept in estimating the relationship between CO₂ emission and economic growth. They demonstrated that income per capita may affect positively CO₂ emission in linear form but its quadratic form has a negative impact on CO₂ emission and they validated EKC assumptions. Following Grossman and Krueger (1991), several papers were undertaken using different dataset and different pollution indicators (SO₂, SPM, nitrogen oxide, etc.) to carry out empirical results that allow testing EKC assumptions.

Climate change is defined as changes in weather patterns and average weather conditions. In most cases, temperature and precipitation are the main variables used in the assessment of weather conditions variation. These variables determine the types of crops grown by farmers, affect directly and indirectly economic activities and daily life habits. Consequently, identifying factors that affect directly climate and weather variations is a crucial and important task. Carbon dioxide emissions are often considered as the principal causes of climate change.

Energy use and economic development could be an important source of variation in Carbon dioxide emissions, especially for emerging countries characterized by a rapid increase of their economic activity like many countries in the Middle East and North Africa. Therefore, studying the causal relationship between environmental degradation, economic development and energy use is an important issue not only for policy makers but also for academic researchers in environmental and development economic.

In the empirical literature, the relationship between environment and development is in most cases expressed as a function of per capita CO₂ emissions by per capita income and the square of per capita income. The EKC hypothesis is accepted if the impact of income on CO₂ emissions is positive and the impact of the square of income is negative and statistically significant. The turning point is given by the first derivation with respect to income.

In a recent literature review on EKC, Bo (2011) concluded that income elasticity of environmental quality demand, technological and composition effects, international trade, FDI and history accidents are the key reasons in explaining EKC. However, empirically, the literature of EKC showed different results with respect to the used indicator and data as well as the econometric method. Several empirical papers have tested the inverted U-shaped relation between income and many indicators of environment degradation including SO₂, SPM, CO₂, nitrogen oxide (see e.g. Grossman and Krueger, 1995; Selden and Song, 1994; List and Gallet, 1999). Intergovernmental Panel on Climate Change (IPCC) report argued that understanding the real relationship between environment and economic growth is the key factor to limit global warming. Most studies used linear, quadratic or cubic form to test the EKC assumptions. Hervieux and Mahieu (2014) argued that two thirds of studies on EKC concept used traditional functional form and only few studies support EKC assumptions. Moreover, in a survey about EKC, Dinda (2004) argued that only air quality indicators show the evidence of an EKC. However, from an empirical point of view, Dinda (2004) conclude that there is no agreement in the literature on the income level at which environmental degradation starts declining.

For the case of China, He and Wang (2012) used a panel dataset of Chinese cities to empirically identify the main determinants of the shape of EKC. They used economic structure, development strategy and environmental regulation to explain the turning point of the EKC. They demonstrated that for the Chinese case, these three variables have a significant impact on the relationship between economic development and the environmental quality but its impact can vary at different development stages. However, in revisiting the validity of EKC hypothesis, Yang *et al.* (2015) used seven emission indicators and a panel dataset of 29 Chinese provinces from 1995 -2010. Their methodology consists in applying sensitivity test following the Extreme Bound Analysis. They demonstrated that the EKC hypothesis cannot be considered valid for any of the seven emission indicators used to test regression sensitivity. They concluded for a positive linear relationship between income and emissions indicators. However, in studying sustainability, Liu (2012) demonstrated that countries follow “grow first

and clean up later” approach, like China, may obtain economic benefits and growth rapidly but this can be accompanied by an environmental sacrifice, social injustice and income inequality. He then calls for sustainable alternatives to enjoy healthier environment, equity income and environmental quality.

In this paper, we confirm the validity of EKC assumptions in the long-run using a panel dataset in 12 MENA countries for the period 1980-2013. We show that economic growth and energy use cause environmental degradation in the long-run but the quadratic form of the per capita income has a negative impact on the CO₂ emissions. These results which are in favor of EKC hypothesis explain the effort of the international community in defining adaptation strategy to climate change mitigation especially in industrialized and emerging countries.

The rest of the paper is organized as follow: in Section 2, we present the dataset and its main proprieties to descriptively understand the heterogeneity in emission behavior between MENA countries. Section 3 describes the empirical methodology which implements panel unit root and cointegration tests. Our empirical specification and the interpretation of results are in Section 4. Section 5 outlines some policy implications in term of climate change mitigation.

2. Data and their properties

In our empirical specification, we analyze the relationship between CO₂ emissions, energy consumption and GDP per capita growth within cointegrating panel data framework. As we expect the presence of long-run relationship between the carbon dioxide emissions, the magnitude of energy consumption changes, the level of country-income approximated by real GDP per capita, and the square of real GDP per capita, the method involves testing for panel unit root for all in level variables.

In Table1, we report the summary statistics associated with our key variables carbon dioxide (CO₂) emissions per capita, energy use per capita, and real GDP per capita. CO₂ emissions correspond to pollutants stemming from burning of fossil fuels and the manufacture of cement. Energy consumption refers to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. The series for real GDP per capita are based on constant 2010 U.S. dollars. Our data are annual and cover the period 1980–2013 for the following 12 MENA countries: Algeria,

Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, and United Arab Emirates (UAE). Data used in the study are from International Energy Agency (IEA) Statistics, the Carbon Dioxide Information Analysis Center (CDIAC), World Bank national accounts data and OECD National Accounts data. More details about data definition and their sources are available in Table A1 in Appendix.

Table 1. Summary Statistics of key variables over 1980–2013

Country	Mean	Max.	Min.	SD
CO₂ emissions (metric tons per capita)				
Algeria	3.08	3.53	1.91	0.36
Bahrain	24.25	29.78	20.01	2.67
Egypt, Arab Rep.	1.77	2.59	1.04	0.49
Jordan	3.21	3.95	2.07	0.38
Kuwait	24.53	33.49	5.08	7.29
Lebanon	3.86	5.35	2.32	0.92
Morocco	1.20	1.90	0.77	0.35
Oman	9.52	17.51	4.45	4.41
Qatar	49.44	70.98	24.71	13.38
Saudi Arabia	14.84	19.19	10.23	2.30
Tunisia	1.96	2.62	1.42	0.35
United Arab Emirates	27.79	36.97	16.05	6.00
TOTAL	13.79	70.98	0.77	15.24
Energy use (kg of oil equivalent per capita)				
Algeria	902.30	1245.99	579.45	153.56
Bahrain	10592.53	12319.35	7794.49	1202.52
Egypt, Arab Rep.	644.10	919.07	348.05	166.89
Jordan	1016.65	1251.90	667.48	123.98
Kuwait	9099.27	11662.27	1341.03	2106.28
Lebanon	1197.27	1710.74	678.58	330.37
Morocco	378.64	571.49	264.08	97.18
Oman	3444.28	7155.12	802.95	2005.90
Qatar	17246.88	22762.08	13697.34	2357.59
Saudi Arabia	4671.00	6792.39	3137.37	943.12
Tunisia	711.25	974.84	493.05	152.23
United Arab Emirates	10070.80	12674.14	7112.67	1774.89
TOTAL	4997.91	22762.08	264.08	5422.62

Source: Data were obtained from International Energy Agency (IEA) Statistics, the Carbon Dioxide Information Analysis Center (CDIAC), World Bank national accounts data and OECD National Accounts data. Notes: Max. Min. and SD are maximum, minimum and standard deviation, respectively. Data period is 1980-2013.

Table 1. Continued

Country	Mean	Max.	Min.	SD
GDP per capita (constant 2010 US dollar)				
Algeria	3813.03	4617.51	3165.90	438.53
Bahrain	20528.45	22877.95	16571.24	2022.57
Egypt, Arab Rep.	1879.33	2668.04	1212.84	454.98
Jordan	3281.74	4120.40	2499.68	481.14
Kuwait	41580.59	49015.89	37153.71	4120.77
Lebanon	6710.56	8763.80	3376.70	1170.34
Morocco	2015.21	3106.95	1290.20	533.11
Oman	16445.19	20257.96	9907.37	2572.59
Qatar	67155.16	74448.87	60736.57	4689.81
Saudi Arabia	17065.82	26419.13	14232.22	3115.30
Tunisia	2889.60	4251.11	2016.00	770.23
United Arab Emirates	63468.56	115003.43	34341.91	19536.62
TOTAL	20569.44	115003.43	1212.84	21716.09

Source: Data were obtained from International Energy Agency (IEA) Statistics, the Carbon Dioxide Information Analysis Center (CDIAC), World Bank national accounts data and OECD National Accounts data. Notes: Max. Min. and SD are maximum, minimum and standard deviation, respectively. Data period is 1980-2013.

As displayed in Table 1, the average of CO₂ emissions per capita ranges from 1.2 in Morocco to 49.44 in Qatar which exhibits the highest variation in terms of carbon emission, with standard deviation equals to 13.38. North African countries, such as Algeria, Morocco and Tunisia, have recorded lowest pollutant emission volatility near to 0.35. With respect to the mean of energy usage per capita, again Qatar has the highest level of consummation (17246.88) and Morocco the least (378.64). The same pattern is obtained when considering energy use variability as measured by the standard deviation. As for real GDP per capita, as is well-known, oil-exporting countries, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and UAE, have the highest income level in the MENA region. As these countries are heavily dependent on oil revenues, and enjoying implicit generous subsidies for energy, thus, it is not surprising that energy intensity to be higher in compassion to low-income countries such as Egypt and Morocco.

3. Empirical methodology: Panel unit roots and cointegration test

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. We employ a class of panel unit root and panel cointegration tests which allow for serial correlation between the cross-sections, *i.e.* the so-called second generation tests. We use the cross-sectionally augmented IPS (Im *et al.*, 2003) panel unit root tests by Pesaran (2007) and the error-correction-based tests for panel cointegration by Westerlund (2007), which both account for possible cross-sectional dependencies.

Table 2. Pesaran (2007) panel unit root test in the presence of cross-section dependence

Variables	Level		First difference	
	Intercept	Intercept & trend	Intercept	Intercept & trend
CO ₂ emissions	-0.704 (0.241)	-0.130 (0.448)	-4.136 (0.000)	-2.251 (0.012)
Energy use	0.113 (0.545)	1.630 (0.948)	-4.579 (0.000)	-4.331 (0.000)
Real GDP per capita	-1.447 (0.074)	0.599 (0.725)	-1.762 (0.039)	-3.065 (0.001)

Note: *p*-values for the null hypothesis of non stationarity are reported between parentheses. Also, the empirical statistics can be compared to the critical value from Pesaran (2007) which are -2.19 for specification with an intercept and -2.86 for specification with intercept and linear time trend, at 5% level. Individual lag lengths are based on Akaike Information Criteria (AIC).

Panel unit root tests results are shown in Table 2 for our key variables - CO₂ emissions per capita, energy use per capita, and real GDP per capita - in for both levels and first differences. In the level case, we are unable to reject the null hypothesis of a unit root for all of our key variables. As for tests on the first differences, we can see that the null of non-stationarity is strongly rejected and our non-stationary variables are integrated of order one, $I(1)$.³

Next, we implement a cointegrating analysis using error-correction-based panel cointegration tests developed by Westerlund (2007) that have good small-sample properties and high power relative to popular residual-based panel cointegration tests (Pedroni, 2004). We test for the existence of a cointegrating relationship among our three main series: CO₂ emissions, energy consumption and GDP per capita growth. Westerlund (2007) tests are

³ A common feature of the panel unit root tests by Pesaran (2007) is that they maintain the null hypothesis of a unit root in all panel members. Therefore, a failure to reject their null can be interpreted unambiguously as evidence for non-stationary holding in the entire panel.

designed to test the null hypothesis of no cointegration by testing whether the error correction term in a conditional error correction model is equal to zero. If the null hypothesis of no error correction is rejected, then the null hypothesis of no cointegration is also rejected. According to the group-mean and panel test statistics reported in Table 3, we can strongly reject the null of no cointegration. Thus, the presence of a long-run steady-state relationship between carbon dioxide emission and its determinants is proved, implying that over the long-run they move together.⁴ In our empirical exercise (Section 4), the long-run cointegrating relationship is estimated with the panel Dynamic OLS (DOLS) procedure as proposed by Mark and Sul (2003).

Table 3. Westerlund (2007) error-correction-based panel cointegration tests

Statistics	Without trend			With trend		
	Value	<i>p</i> -value	Robust <i>p</i> -value	Value	<i>p</i> -value	Robust <i>p</i> -value
<i>Group-mean statistics</i>						
G_τ	-3.612	0.000	0.000	-3.474	0.000	0.000
G_α	-15.453	0.001	0.010	-12.632	0.047	0.000
<i>Panel statistics</i>						
P_τ	-9.398	0.000	0.010	-8.635	0.000	0.010
P_α	-12.356	0.000	0.000	-9.490	0.026	0.030

Note: G_τ and G_α are group mean statistics that test the null of no cointegration for the whole panel against the alternative of cointegration for some countries in the panel. P_τ and P_α are the panel statistics that test the null of no cointegration against the alternative of cointegration for the panel as a whole. Optimal lag and lead lengths are determined by Akaike Information Criterion (AIC). In the last column, we show the bootstrapped *p*-values that are robust in the presence of common factors in the time series. The number of bootstraps is set to 800.

4. Empirical specification and results interpretation

The bulk of empirical literature on the relationship between income, energy consumption and environmental pollutants has considered the following model based on variables in natural logarithms:

$$cd_{it} = \mu_i + \beta_{01}ec_{it} + \beta_{02}y_{it} + \beta_{03}y_{it}^2 + \varepsilon_{it}, \quad (1)$$

where cd_{it} is the carbon dioxide (CO₂) emissions measured metric tons per capita, ec_{it} is energy consumption measured in kg of oil equivalent per capita, and y_{it} is real GDP per capita measured in constant 2010 US dollars. The coefficients β_{01} , β_{02} and β_{03} represent the long-run elasticity estimates of CO₂ emissions with respect to energy consumption, real GDP

⁴ The presence of cointegrating relationship is robust to the use of popular first generation tests (residual-based tests for panel cointegration) such developed by Pedroni (1999, 2004). To save space, we do not list the testing result, however, the result is available upon request.

per capita and squared real GDP per capita, respectively. As is well-known, it is expected that an increase in the energy use leads to an increase in CO₂ emissions ($\beta_{01} > 0$).

As postulated by the EKC hypothesis, there is an inverted U-shaped relationship between the level of environmental degradation and income growth. For the early stages of economic development, carbon emissions increase with real GDP per capita until a turning point of income is reached, after which environmental degradation begins to decline. Thus, the long-run elasticity estimates of CO₂ emissions with respect to real GDP per capita and the square of per capita real GDP per capita are expected to be positive ($\beta_{02} > 0$) and negative ($\beta_{03} < 0$), respectively.

The estimated cointegrating relationship is given by:

$$\widehat{cd}_{it} = \hat{\mu}_i + \underset{(0.115)}{0.587^{***}} ec_{it} + \underset{(0.072)}{0.624^{***}} y_{it} - \underset{(0.023)}{0.133^{***}} y_{it}^2 \quad (2)$$

where the numbers in parentheses denote standard errors and *** indicate 1% of significance level. As displayed in equation (2), panel DOLS estimations appear consistent with the expected signs. The level of energy use and the real GDP per capita have significant positive long-run effects on the CO₂ emissions. A 10% increase in the consumption of energy leads to an increase in pollutants by 5.8% in the MENA region. Regarding the EKC hypothesis: the elasticity of CO₂ emissions with respect to real GDP per capita in the long-run is equal to $\delta cd_{it} / \delta y_{it} = 0.624 - (2 \times 0.133)y_{it}$, implying a threshold income of 3.618 (in logarithms). This is equivalent to a turning point of 10,442 USD in terms of real GDP per capita. Our results are supportive to the presence of an inverted U-shaped relationships between per capita pollution and per capita GDP in our sample of MENA countries.

It is worth noting that the position of the threshold income in our study is in some extent different from that estimated by Arouri *et al.* (2012). The authors found a turning point of income amounts to 3.618 in logarithms, which is equivalent to 37,263 USD. Indeed, we have used the same sample of 12 MENA countries, however, the time span in the study of Arouri *et al.* (2012) is shorter covering 1981-2005. We increase the time span to take care for a plausible change in these countries behavior regarding energy consumption and income change. The extent of the period to 2013 is relevant compared to Arouri *et al.* (2012). As we estimate a greater impact of energy use on CO₂ emissions and lower impact of real GDP, the interpretation of our result can be linked to many events occurred after 2005 including the oil

price shock in 2009 and the world financial crises which certainly has an impact on economic activities. Moreover, with respect to the turning point of real GDP per capita in our study, we see that is smaller, in magnitude, compared to Arouri et al. (2012), namely 10,442 USD versus 37,263 USD. As a matter of fact, only rich net-oil oil exporting countries in our sample, *i.e.* Gulf Cooperation Council (GCC) countries, have a level of income in average exceeding our estimated threshold. As we can see from Table 1, only Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE have reached the turning point level in terms of per capita GDP. Contrary to Arouri et al. (2012) who found that some GCC countries, such as Bahrain, Oman and Saudi Arabia, are not surpassing the estimated turning point.

In terms of adoption of climate change mitigation policies to reduce CO₂ emissions during the last three decade, these countries are incited by several climate agreements following the United Nations Climate Change Conference (UNCCC) in Qatar. The conference reached an agreement to extend the life of the Kyoto Protocol, which had been due to expire at the end of 2012, until 2020, and to reify the 2011 Durban Platform, meaning that a successor to the Protocol is set to be developed by 2015 and implemented by 2020. Wording adopted by the UNCCC in Qatar incorporated for the first time the concept of loss and damage, an agreement in principle that richer nations could be financially responsible to other nations for their failure to reduce carbon emissions CO₂. We can conclude that oil producer countries in the MENA region including Kuwait, Oman, Qatar, Saudi Arabia and UAE have already begun the adoption of climate change mitigation measure to reduce CO₂ emission given their high level of energy use. The other low-income countries in the MENA region including Tunisia, Egypt, Morocco, Algeria, Jordan and Lebanon are characterized by an average real GDP per capita inferior to the estimated turning point of EKC in this paper. These countries may reach the turning point in some years given their development plan defined especially after the so called Arab spring.

5. Conclusions and policy recommendations

The main purpose of this paper is to propose a long-run analysis of the Environmental Kuznets Curve in the Middle East and North African countries (MENA region). Including the first two global oil producer countries, the MENA region has known a rapid development of its economic activities. This situation was followed by an increase in the standard of living which explains the increase of the per capita energy use and then CO₂ emissions in these countries, such as UAE, Qatar, and Saudi Arabia. The environmental economic literature was

dominated by the use of the EKC, as theoretical background, in measuring the impact of economic development and energy use on environmental degradation. Furthermore, many results were found indicating that real GDP may increase CO₂ emissions but its quadratic form has a negative impact on environmental degradation. These results validated which is called the inverted U-shape of the EKC.

Using panel cointegration estimation and tests, we have tested the presence of a long-run relationship between CO₂ emissions, energy use and real GDP in the MENA region for a long period of time (1980-2013). Our results validate the EKC assumptions in the long-run, and confirm the presence of an inverted U-shape pattern at which point an increase in income leads to lower CO₂ emissions. We reveal that, as income increases, emissions increase as well until the threshold income of 10,442 USD is reached, after which emissions begin to decline. It is worth highlighting that only Gulf Cooperation Council (GCC) countries are reaching (in average) the estimated turning point level. Oil producer countries in the MENA region including Kuwait, Oman, Qatar, Saudi Arabia and UAE have already begun the adoption of climate change mitigation measure to reduce CO₂ emission given their high level of energy use. Thus, decisions in term of environment protection have significantly reduced the CO₂ emissions in the GCC region. However, with respect to the low-income countries in the MENA region, considerable efforts are still required, and CO₂ emissions should be reduced as their per capita real GDP increases. Furthermore, it is also important to recommend the switch to a green economy using a green energy as we estimated a higher positive and significant impact of energy use on CO₂ emission. The French energy transition law is one of the best examples that can be adopted in these countries. It is very important to invest in the transition to follow a sustainable economy. The adoptions of several climate agreements, during the last five years like the Paris agreement in 2015, incite the international community to adopt seriously climate change mitigation measures.

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Appendix:

Table A1. Data sources and description

Variable name	Measure	Description	Data sources
CO ₂ emissions	Metric tons per capita	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	The Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory (ORNL).
Energy use	Kg of oil equivalent per capita	Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.	International Energy Agency (IEA) Statistics
Real GDP per capita	GDP based on constant 2010 U.S. dollars divided by midyear population	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars.	World Bank national accounts data and OECD National Accounts data files.