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

Abstract

The main originality of this paper is to empirically investigate the long-run relationship between carbone dioxide (CO2) emissions, energy use and real GDP per capita in the Middle East and North Africa (MENA) during the last three decades. Using panel cointegration tests Westerlund, (2007) and DOLS estimation method, we validate the Environmental Kuznets Curve (EKC) hypothesis in the long run for the MENA region countries. Therefore, we conclude that oil producer countries have adopted several policy decisions in favor of CO2 emissions reduction. The estimated turning point of the EKC confirms our intuitions that only oil producer countries achieve CO2 emissions reduction goal.

Keywords: panel cointegration, Kuznets Curve, MENA countries.
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Introduction

The main originality of this paper is to empirically assess the impact of economic activities development on the CO2 emissions (carbone dioxide) in the Middle East and North Africa (MENA) 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 in the Middle East and North Africa, 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 (EKC) 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…) 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. Carbone dioxide (hereafter CO2) emissions are often considered as the principal causes of climate change.

Energy use and economic development could be an important source of variation in carbone dioxide (hereafter CO2) emissions, especially for emerging countries characterized by a rapid increase of their economic activity like many countries in the Middle East and North Africa (MENA hereafter). 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

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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 indictors of environment degradation including SO2, SPM, CO2, nitrogen oxide, (Grossman & Krueger, 1995; Selden & Song, 1994; List & 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 (2011) 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 paper is organized as follow: in section 1, we present the dataset and its main proprieties to descriptively understand the heterogeneity in emission behavior between MENA countries. Section 2 describes the empirical methodology and results interpretation, section 3 discusses the empirical results and outlines some policy implications in term of climate change mitigation.

1. 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, the method involves testing for panel unit root for all in level variables.

In Table A.1 (see Appendix), we report the summary statistics associated with our key variables carbon dioxide (CO2) emissions per capita, energy use per capita, real GDP per capita, and real GDP growth. 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 and real GDP growth 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 A.2 (see Appendix).

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. However, the pattern is in some extent different in terms of output growth. There are homogeneous features as the mean of real GDP growth is close to 3-5% for most of countries, except for Qatar which exhibits a double-digit growth rate.

2. Empirical methodology

2.1. 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. Panel unit root tests results are shown in Table 1 for our key variables – CO2 emissions per capita, energy use per capita, real GDP per capita, and real GDP growth – in for both levels and first differences. In the level case, we are unable to reject the null hypothesis of a unit root, except for the real GDP growth – annual percentage growth rate of GDP based on constant 2010 U.S. dollars – which by construction a stationary variable. 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)[1].

Table 1. Pesaran (2007) panel unit root test in the presence of cross-section dependence

Variables	Level		First difference	
	Intercept	Intercept & trend	Intercept	Intercept & trend
CO2 emissions	-0.704	-0.130	-4.136	-2.251
	(0.241)	(0.448)	(0.000)	(0.012)
Energy use	0.113	1.630	-4.579	-4.331
	(0.545)	(0.948)	(0.000)	(0.000)
Real GDP per capita	-1.447	0.599	-1.762	-3.065
	(0.074)	(0.725)	(0.039)	(0.001)
Real GDP growth	-4.842	-4.116	-	-
	(0.000)	(0.000)	-	-

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).

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 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 2, 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[2]. In our empirical

[1] 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.

[2] 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.

exercise (sub-section 2.2), the long-run cointegrating relationship is estimated with the panel Dynamic OLS (DOLS) procedure as proposed by Mark and Sul (2003).

Table 2. Westerlund (2007) error-correction-based panel cointegration tests

Statistics	Without trend			With trend		
	Value	p-value	Robust p-value	Value	p-value	Robust p-value
Group-mean statistics						
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
Panel statistics						
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.

The presence of long-run relationship between the integrated variables is the alternative to a linear regression. It confirms the presence of a long-run equilibrium system between CO2 emissions, energy use and economic development. Consequently, the risk of a superiors regression is eliminated and the estimated cointegration vector will measure the long-run impacts and the stability of the distance that characterizes the relationship between the variables in the long term. The next sub section discusses the meaning of the estimated long-run coefficients before concluding with the policy recommendations.

2.2. 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:

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

where cd_{it} is the carbon dioxide 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 CO_2 emissions with respect to energy consumption, real GDP per capita and squared real GDP per capita, respectively. As it is well-know, it is expect that an increase in the energy use leads to an increase in CO_2 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 increases 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 CO_2 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:

$$\widehat{cd}_{it} = \hat{\mu}_i + \underset{(0.115)}{0.587^{***}} ec_{it} + \underset{(0.072)}{0.436^{***}} y_{it} - \underset{(0.113)}{0.250^{***}} y_{it}^2, \qquad (2)$$

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 estimated coefficients by DOLS in equation (2) are significant. Therefore, results are consistent and confirm the expected signs, as the square of income impact on CO2 emissions is negative. The economic development at an advanced stage is in favor of an environmental protection. The Environmental Kuznets Curve assumptions are then validated for the MENA region between 1980 and 2012.

The lev of energy use and the real GDP per capita have significant positive long-run effects on the CO_2 emissions. A 10% increase in the consumption of energy leads to an increase in pollutants by 5.8% in the MENA region. The long-run elasticity of carbon emissions with respect to income level is equal to 0.436, indicating that a 10% raise in real GDP per capita means increases per capita emissions by 4.36%. Our long-run coefficients are in some extent different from those estimated by Arouri et al. (2012) which found a coefficient of respectively 0.47 and 1.23. 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 CO_2 emissions and lower impact of real GDP. The interpretation of our result can be linked to many event occurred after 2005 including the oil price shock in 2009 and the world financial crises which certainly has an impact on economic activities in the MENA region which is the first world energy producer. However, in comparing the turning point, we see that is greater, in magnitude, compared to Arouri et al. (2012) (–0.25 versus –0.17). This can be explained by the adoption of climate change mitigation policies by the MENA countries to reduce CO_2 emissions during the last decade.

If we look to the energy consumption impact on CO2 emissions, we see that it increases CO2 emissions by 5.7% for a 10%. This positive impact is relevant compared to the literature because in most cases energy consumption does increase the CO2 emissions and is recognized as the major cause of climate changes. However, the difference for the MENA region compared to others contexts is that in magnitude, the impact is so much higher. This is can be explained by the open access to energy in the Gulf Cooperation Council countries. Indeed, some countries like Qatar, Saudi Arabia and Kuwait reduced the oil price at their territories to make households benefit from the natural resource.

Conclusion 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, life style and economic growth during the last five decades. This situation was followed by an increase in the standard of life which explains the increase of the per capita energy use and then CO_2 emissions in these countries (UAE, QATAR, KSA). In contrast, the environment protection is ignored to concentrate actions in guaranteeing luxury life.

We want to update conclusions regarding the economic development impact on environment in the MENA region during the last four decades. Data are very useful to do that, and we used the adequate econometric method to estimate and test this impact. As a matter of fact, 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 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 those of Arouri et al. (2012). Since we estimate relatively higher turning point (–0.25), we conclude for an efficient climate change mitigation policies adopted by the MENA countries. Decisions in term of environment protection have significantly reduced the CO2 emissions in the region. 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 A.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
GDP per capita (constant 2010 US dollars)				
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
Real GDP growth (annual %)				
Algeria	2.80	7.20	–2.10	2.34
Bahrain	4.18	12.87	–7.56	4.31
Egypt, Arab Rep.	4.78	10.01	1.08	2.11
Jordan	4.84	19.01	–13.45	5.30
Kuwait	3.70	33.99	–20.62	11.10
Lebanon	4.73	38.20	–42.45	13.01
Morocco	4.26	12.37	–5.41	4.06

Table A.1 (cont.). Summary Statistics of key variables over 1980–2013

Country	Mean	Max.	Min.	SD
Oman	5.61	17.05	-3.44	5.28
Qatar	12.10	26.17	3.72	7.47
Saudi Arabia	2.91	9.96	-10.43	4.97
Tunisia	4.07	7.95	-1.92	2.53
United Arab Emirates	4.04	23.87	-14.96	7.05
TOTAL	4.84	38.20	-42.45	6.43

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 A.2. Data sources and description

Variable name	Measure	Description	Data sources
CO2 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.
Real GDP growth	Annual percentage growth rate of GDP based on constant 2010 U.S. dollars	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.