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Energy consumption, economic growth and CO_2 emissions in Middle East and North African countries ☆

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ABSTRACT

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. CO_2 emission reductions per capita have been achieved in the MENA region, even while the region exhibited economic growth over the period 1981–2005. The econometric relationships derived in this paper suggest that future reductions in CO_2 emissions per capita might be achieved at the same time as GDP per capita in the MENA region continues to grow.

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 from 1980 to 1997. He makes use of the Generalized Method of Moments (GMM) and examines the following pollutants: CO_2 emissions, fertilizers' concentration and the number 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 and Zaghdoud (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. Akbostancı et al. (2009) examine the relationship between CO_2, SO_2 and PM_{10} emissions,

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[1] Please see Payne (2010) for an excellent recent survey on these works.

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 (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 and Popp (2012) 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. 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- 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 the seemingly unrelated regression (SUR) methods. It's 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; Akbostancı et al., 2009; M'henni, 2005; Fodha and Zaghdoud, 2010) using the 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