DIGITALES ARCHIV

ZBW – Leibniz-Informationszentrum Wirtschaft ZBW – Leibniz Information Centre for Economics

Awad, Atif; Abugamos, Hoda

Article

Income-carbon emissions nexus for Middle East and North Africa countries : a semi-parametric approach

International Journal of Energy Economics and Policy

Provided in Cooperation with: International Journal of Energy Economics and Policy (IJEEP)

Reference: Awad, Atif/Abugamos, Hoda (2017). Income-carbon emissions nexus for Middle East and North Africa countries : a semi-parametric approach. In: International Journal of Energy Economics and Policy 7 (2), S. 152 - 159.

This Version is available at: http://hdl.handle.net/11159/1183

Kontakt/Contact ZBW – Leibniz-Informationszentrum Wirtschaft/Leibniz Information Centre for Economics Düsternbrooker Weg 120 24105 Kiel (Germany) E-Mail: *rights[at]zbw.eu* https://www.zbw.eu/

Standard-Nutzungsbedingungen:

Dieses Dokument darf zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden. Sie dürfen dieses Dokument nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, aufführen, vertreiben oder anderweitig nutzen. Sofern für das Dokument eine Open-Content-Lizenz verwendet wurde, so gelten abweichend von diesen Nutzungsbedingungen die in der Lizenz gewährten Nutzungsrechte. Alle auf diesem Vorblatt angegebenen Informationen einschließlich der Rechteinformationen (z.B. Nennung einer Creative Commons Lizenz) wurden automatisch generiert und müssen durch Nutzer:innen vor einer Nachnutzung sorgfältig überprüft werden. Die Lizenzangaben stammen aus Publikationsmetadaten und können Fehler oder Ungenauigkeiten enthalten.

https://savearchive.zbw.eu/termsofuse

ζRM

Terms of use:

This document may be saved and copied for your personal and scholarly purposes. You are not to copy it for public or commercial purposes, to exhibit the document in public, to perform, distribute or otherwise use the document in public. If the document is made available under a Creative Commons Licence you may exercise further usage rights as specified in the licence. All information provided on this publication cover sheet, including copyright details (e.g. indication of a Creative Commons license), was automatically generated and must be carefully reviewed by users prior to reuse. The license information is derived from publication metadata and may contain errors or inaccuracies.







INTERNATIONAL JOURNAL O

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http://www.econjournals.com

International Journal of Energy Economics and Policy, 2017, 7(2), 152-159.



Income-carbon Emissions Nexus for Middle East and North Africa Countries: A Semi-parametric Approach

Atif Awad*, Hoda Abugamos

Department of Finance & Economic, College of Business Administration, University of Sharjah, Sharjah, UAE. *Email: aawoad@sharjah.ac.ae

ABSTRACT

It is widely accepted that Middle East and North Africa (MENA) region is significantly impacted by climate change. Evidence suggests that the region is positioned at the second place after North America in carbon emission. This study attempts to further examine the impacts of income on carbon emissions in MENA region through investigation of the existence of an environmental Kuznets curve. Within the Stochastic Impacts by regression on population, affluence and technology framework, this is the first study in MENA region to explore the income-carbon emissions nexus; using panel data together with a semi-parametric panel fixed effects regression. Our data set is referred to a panel of 20 countries in MENA region spanning the period 1980-2014. With this information, we find evidence to support an inverted-U shaped relationship between income and CO_2 emissions in the region. These findings suggest that environmental degradation may be reversible and environmental quality may be recoverable alongside the economic growth process in the region.

Keywords: Per Capita Income, Carbon Emissions, Stochastic Impacts by Regression on Population, Affluence and Technology Environmental Kuznets Curve, MENA Region JEL Classifications: Q01, Q28, Q52, Q51

1. INTRODUCTION

It is widely accepted that Middle East and North Africa (MENA) region is significantly impacted by climate change (Wodon et al., 2014; Al-Rawashdeh et al., 2014). According to the International Energy Agency (2014), the region is positioned at the second place after North America in carbon emission and documented by 9 metric tons of CO, per person; which is higher than the average value in Africa (1.1), Asia (3.7), Europe (7.1), and even higher than that worldwide (4.6). Empirical studies addressing this issue in the region agree that energy use and/or consumption and economic growth are the key sources of CO, emissions (Arouri et al., 2012; Al-Rawashdeh et al., 2014; Herrala and Goel, 2012; Méon and Sekkat, 2004). At one hand, the pattern of economic growth and structure change in the economy of the region may be responsible, at least partly, for the deterioration of the environmental quality. At the other hand, the extensive use of energy in the region which has been attributed to high subsidies on petroleum products may encourage an exaggerated and inefficient use of fossil energy. Studies show that eleven out of twenty countries in the world which subsidize gasoline consumption are from MENA region (Brown, 2011).

Recently, and for two reasons, environmental degradation and income nexus has received increased attention and emerged as one of the most attractive empirical topics of immense interest among economists and policy makers. First, due to the aggravation of pollution problems, policy makers in the region seek to identify the exact relationship between income and environmental quality in order to prepare the required appropriate policy. If the relationship between income and environmental degradation is found to be a monotonously (linear) positive relationship, then environmental quality will continue to deteriorate with income development. Only when income enters a stage of stagnation, the tendency towards environmental degradation would slow down. Therefore, policy makers should re-think about the pattern of economic growth to avoid environmental deterioration. However, if results show a monotonously negative relationship between income and environmental degradation, then environmental quality will continue to improve even with the continuation of the growth

process. Hence, policy makers should continue promoting the process of development to maintain the quality of the environment. In contrast, if a non-monotonous (nonlinear) relationship is found between development and environmental quality, environmental degradation may be reversible and environmental quality may be recoverable. Theoretically, the existence of such a nonmonotonous and nonlinear curve (analogous to an inverted U-shaped curve) may link income per capita to environmental quality indicators such as carbon dioxide and/or sulphur dioxide emissions as termed by the environmental Kuznets curve (EKC) hypothesis. The EKC hypothesis states that in the early stages of socioeconomic growth, environmental quality deteriorates with the increase of gas emissions. However, as the economy continues growing beyond a certain threshold (the turning point), emissions begin to decline and environmental quality starts to improve; forming an approximately inverted U-shaped curve. Validity of the EKC hypothesis indicates that income versus environmental protection dilemma can be resolved. In the context of developing countries, finding evidence in support of this hypothesis might have promising implications for sustainable development in the future (Wang et al., 2016).

The second reason, which is a main concern for economists and econometricians, is related to the appropriate theoretical model that can be used to describe income and environmental quality nexus as well as the relevant estimated method. With regard to the theoretical framework, previous studies frequently employ either ad hoc model or IPAT (i.e., population, affluence and technology) theoretical model as proposed by Ehrlich and Holdren (1971). However, the IPAT model is considered purely a simple function form; parsimoniously indicating that anthropogenic environmental impact is associated with multiple driving forces. Thus, it cannot -individually- determine the extent to which each factor affects the environment (Zhua et al., 2012; Liddle and Lung, 2010). Concerning the estimation method, most of the preceding studies employ a parametric panel fixed effects technique to estimate the impact of income on CO, emissions. However, using this technique usually yields biased estimators as a result of failure to consider relevant explanatory variables and therefore; leads to potential functional form misspecification (Wang et al., 2015).

The present study seeks to fill the gap in the literature concerning the income - CO₂ emissions nexus in MENA region in two principal fashions. First, and to avoid the limitations of IPAT mentioned previously, the present study employs the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model. According to York et al. (2010) the STIRPAT model could precisely specify the functional form of the relationship between anthropogenic gas emissions and economic growth. Second, and instead of using the parametric fixed panel; a method that is extensively used in the previous studies, we employ the semi-parametric regression developed by Baltagi and Li (2002). According to Wang et al. (2016) the semi-parametric regression is a consistent estimation method for a dynamic partially linear panel data model with fixed effects. In contrast to the parametric panel fixed effects regression, the semi-parametric panel fixed effects regression is more flexible; which enables addressing of the potential functional form misspecification (Desbordes and

Verardi, 2012; Wang et al., 2015). Furthermore, it partially avoids dimensionality problems by combining features of parametric and non-parametric techniques. A further advantage of the semiparametric panel fixed effects regression is the possible inclusion of a concise economic interpretation of the results. To the best of the authors' knowledge, this is the first empirical study in MENA region, to investigate the EKC hypothesis by employing the semiparametric regression within the STIRPAT model.

The remaining of the paper is organized as follows. Section 2 briefly describes the empirical evidence from the literature. Sections 3 and 4 examine the models, estimation methods and data sources used to test the EKC hypothesis. Empirical results and related discussion are presented in Section 5. The final section; Section 6 contains concluding comments and policy implications.

2. LITERATURE REVIEW

According to Oscan (2013) there are three empirical research strands examining the above-mentioned topics in the environmental economics literature. The first strand focuses on the environmental pollutants and income nexus, and seeks to examine the validity of the EKC hypothesis. The first empirical study regarding the EKC is attributed to Grossman and Krueger (1991). Thereafter, numerous researchers have tested the EKC hypothesis and arriving to mixed findings (Agras and Chapman, 1999; Dinda and Coondoo, 2006; Fiedl and Getzner, 2003; Galeotti et al., 2009; Selden and Song, 1994; Saboori et al., 2012; Shahbaz et al., 2013; Holtz-Eakin and Selden, 1995; Stern, 2004; He and Richard, 2010; Al-Mulali et al., 2015; Ozturk and Al-Mulali, 2015; Al-Mulali et al., 2016). The second strand comprises studies exploring the growth -energy nexus. These studies date back to the seminal work of Kraft and Kraft (1978). Again, after that, numerous researchers have tested the growth - energy nexus and arriving to mixed findings (Belloumi, 2009; Akarca and Long, 1980; Bentzen and Engsted, 1993; Pao, 2009; Erol and Yu, 1987; Ghosh, 2010; Yu and Hwang, 1984). However, all the studies that tend to employ a bivariate model are criticized due to the omitted variables bias and also because they fail to get consensus results. Nevertheless, to avoid this problem, recent studies have started to examine the nexus of energy consumption and economic growth in a multivariate framework (Gurgul and Lach, 2011; 2012; Altinay and Karagol, 2004; Al-Iriani, 2006; Apergis and Payne, 2009; Narayan and Smith, 2008; Oh and Lee, 2004; Stern, 2000; Yang, 2000; Ozturk, 2010). However, analyzing the growth - environment nexus and growth - energy nexus in a bivariate framework suffers from omitted-variables bias as stated by Saboori and Soleyman (2011). The third stream of research has emerged as reflected by the fact that today numerous studies have gathered both nexuses in a single framework (Ang, 2007; Soytas et al., 2007; Hamit-Haggar, 2012; Ozturk and Acaravci, 2012; Esteve and Tamarit, 2012; Tiwari et al., 2013; Toda and Philips, 1995; Soytas et al., 2007; Akbostanci et al., 2009; Halicioglu, 2009; Jalil and Mahmud, 2009; Soytas and Sari, 2009; Tamazian and Rao, 2009; Zhang and Cheng, 2009; He and Richard, 2010; Lean and Smyth, 2010; Narayan and Narayan, 2010). Recently, the above mentioned multivariate framework has been extended further by including, for example, the impacts of foreign trade and urban population, and human development (HD) into the nexus, in order to avoid omitted variable bias in the econometric estimation (Halicioglu, 2009; and Zhang and Cheng, 2009).

In the present study and to conserve space, we would only review some selected studies related to MENA region. However, to our knowledge, there are only few studies that analyze economic growth - CO₂ emissions nexus in MENA region. Most importantly, even among these few studies, no consensus exists in regards to the impact of income on carbon emission in the region. So, we classify these studies into country-based studies and panel or cross countries-based studies. Based on the country level analysis, Fodha and Zaghdoud (2010) investigate the validity of the EKC hypothesis for Tunisia using two indicators for pollutant emissions (SO₂ and CO₂), during the period 1961-2004. Employing the Johansen approach for cointegration, as well as Granger causality test, the study arrives to an evidence in support for EKC hypothesis when CO₂ has been used as a proxy for pollutant emissions. In contrast, a monotonically increasing relationship with gross domestic product (GDP) is found to be more appropriate for CO₂ emissions. The causality results support the argument that the relationship between income and pollution in the country is one of the unidirectional causality with income causing environmental changes and not vice versa; both in the short-run and long-run. Alkhathlan and Javid (2013) examine the relationship among economic growth, carbon emissions and energy consumption at the aggregate and disaggregate levels for Saudi Arabia during the period 1980-2011. For the aggregate energy consumption model, the authors use the total energy consumption per capita and CO₂ emissions per capita based on the total energy consumption. For the disaggregate analysis, they use oil, gas and electricity consumption models along with their respective CO₂ emissions. The results of the autoregressive distributed lag technique show that the estimated long-term income elasticities of carbon emissions is higher than the estimated short-term income elasticities of carbon emissions; which imply that over time, per capita carbon emissions increase with the rise in per capita incomes in Saudi Arabia. This result indicates that there is a monotonically increasing relationship between carbon emissions and per capita income in Saudi Arabia. Therefore, the EKC hypothesis does not hold for these three models. Likewise, Al-Rawashdeh et al. (2014) examine whether or not the EKC relationship exists between economic growth and two environmental pollution indicators (SO₂ and CO₂) based on a country level analysis using time series data for all of the 22 MENA countries in the region. Under a country level, the results suggest an evidence of SO₂ - EKC for Algeria, Tunisia, Yemen, Morocco, Turkey and Libya. Regarding CO₂, the findings also support an inverted U-shaped pattern associated with the EKC hypothesis for Tunisia, Morocco, Turkey and Jordan. In analyzing MENA region as a panel, the results show that there is no EKC evidence for SO₂ and CO₂ emissions, but there is only a monotonically increasing linear relationship between income and CO₂ emissions.

M'henni (2005) tests for the EKC hypothesis in Tunisia over the period from 1980 to 1997. The author employs the generalized method of moments and examines the following pollutants: CO₂

emissions, fertilizers' concentration and the number of cars in traffic which serve to calculate an index for environmental quality. The results show that there is no evidence to confirm the EKC for any of these pollutants. Based on the cointegration analysis, again, Chebbi et al. (2009) examine the same issue for Tunisia and arrive to different results. More specifically, they detect 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. Akbostanc et al. (2009) examine the relationship between CO₂, SO₂ and (particulate matter 10 micrometers or less in diameter) emissions. They examine the EKC in Turkey at both national level, as well as at provinces level (58 provinces). They find a monotonic and increasing relationship at the national level. However, at the level of provinces, they discover an N-shaped curve; implying the absence of evidence in support for the EKC.

With regard to the panel or cross countries-based studies, Al-Mulali (2011) examines the impact of oil consumption on the economic growth of MENA countries during the period 1980-2009. The author regress gross domestic product on both oil consumption (in term of thousands of barrels per day) and total carbon dioxide emissions from the consumption of energy. After employing both Pedroni and Kao cointegration tests, the author employs Engle-Granger panel causality technique to examine the direction of the relationship. The results detect the existence of a long-run relationship between the variables. In addition, the causality test reveals the presence of a bi-directional relationship between the variables in both short and long run.

Likewise, Arouri et al. (2012) employ cointegration techniques on data related to economic growth, energy consumption and emissions of CO₂ for 12 countries in MENA region during the period 1981-2005. The main objective of these techniques is to, first, test for the EKC hypothesis in MENA region for CO₂. Second, to investigate the existence of EKC for each country. Finally, to explore the nature of the causality relationship between economic growth, energy consumption and emissions of CO₂. The results show that in the long-run, energy consumption has a positive significant impact on CO₂ emissions in MENA region. More interestingly, the results show that real GDP exhibits a quadratic relationship with CO₂ emissions. Taken together, the findings support an inverted U-shaped pattern associated with the EKC hypothesis for MENA region. In addition, CO₂ emissions increase with real GDP, stabilize, and then decrease. At the country-level, however, the 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. For the causality relationship, the results show that in the short-run, the evidence suggests existence of positive causality from energy consumption to CO₂ emissions. However, in the long run, the evidence suggests existence of bidirectional relationship between the variables. Based on these findings, the authors suggest that future reductions in CO. emissions per capita might be achieved at the same time as GDP per capita continues to grow in MENA region.

Likewise, Omri (2013) examines the nexus between CO, emissions, energy consumption and economic growth using simultaneous-equations models with panel data of 14 MENA countries over the period 1990-2011. The study reveals existence of a bidirectional causal relationship between economic growth and CO₂ emissions for the region as a whole. The author suggests that degradation of the environment has a causal impact on economic growth, and that a persistent decline in environmental quality may exert a negative externality on the economy through affecting human health; and thereby may reduce productivity in the long-run. Meanwhile, Farhani et al. (2013) empirically parallels two panel. The first panel; denoted as panel A, pursues the studies of Halicioglu (2009), Jalil and Mahmud (2009), and Jayanthakumaran et al. (2012) which experiment the introduction of energy consumption and trade into the environmental function. The second panel; panel B, develops the work of Hossain (2011) which tries to propose urbanization as a mean to evade omitted variable bias. The study includes 11 MENA countries over the period 1980-2009. The authors employ panel fully modified ordinary least squares (FMOLS) and dynamic OLS (DOLS) as well as causality test. The empirical results show consistency in light of the EKC biography based on the cointegrated and causal relationships. The results imply that an increase in energy use, together with higher GDP and greater trade openness tend to reveal more CO₂ emissions. Furthermore, the addition of urbanization in the environmental function enhances the final results and positively affects the pollution level. Regarding the causality test, for Panel A, it is found that real GDP and energy consumption cause CO, emissions in the short-run panel causality. This implies that in the absence of energy conservation policies due to the economic development, these countries consume more energy; which may result in more pollution for the environment. In the log-run, there are two causal relationships among the variables running from all variables to CO₂ emissions and to energy consumption. For panel B, the results indicate that real GDP, energy consumption and urbanization exert a causal significant effect on CO₂ emissions, and trade openness exerts a causal significant effect on urbanization in the short-run.

Moreover, Farhani et al. (2014) examine the existence of long-run equilibrium relationships for two different EKC specifications for 10 MENA countries over the period 1990-2010. In the first one, CO₂ emissions variable has been regressed on per capita real GDP, energy consumption, trade openness, manufacture value added and modified HD index (HDI). In the second model, genuine saving index is regressed on HDI, energy consumption, trade openness, manufacture value added and the role of law. The two models have been estimated using two recent techniques; namely panel FMOLS and DOLS. The results of the first specification; namely EKC, show that there is an inverted U-shaped relationship between environmental degradation and income; while for the second specification; namely modified EKC, the findings show that there is an inverted U-shaped relationship between sustainability and HD. A study by Arouri et al. (2012) has implemented recent bootstrap panel unit root tests and cointegration techniques to investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for 12 MENA countries over the period 1981-2005. The results detect evidence in support of the EKC hypothesis in MENA region. More specifically, the results demonstrate that the level of CO_2 emissions first increases with income, then stabilizes, and then declines. In contrast, Ozcan (2013) tests the EKC hypothesis for 12 MENA countries during the period 1990-2008; by employing a cointegration approach. The results provide evidence contrary to the EKC hypothesis.

The review of the extant studies that examine MENA region demonstrates the absence of any consensus in regards to the nature of the relationships between income and carbon emission as described by the EKC hypothesis. The conflicting results of these studies may be attributed to country-specific policies, the use of different energy consumption and income measures, the econometric methodology, omitted variable bias, model specifications or the varying time spans of the studies. However, most importantly, all these studies, however, have weaknesses that this study aims to address. They mainly involve the use of *ad-hoc* model specifications which are not based upon solid theoretical models. As a result, the findings of the present study may prove beneficial and relevant value-added for policy-makers seeking to implement appropriate policies that can maintain environmental quality within the region.

3. THEORETICAL FRAMEWORK AND METHODOLOGY

To address the limitation of IPAT, we employ a stochastic version of IPAT designated STIRPAT; which provides a relative quantitative framework to explore the environmental impact of income progress (Dietz and Rosa, 1997). The model specification is

$$I_{i} = ap_{i}^{b}A_{i}^{c}T_{i}^{d}\varepsilon_{i}$$

$$\tag{1}$$

In equation 1, I denotes environmental impact, P, A, and T stand for population, affluence, and technology factors respectively. Explanatory variable coefficients to be estimated are represented by a, b, c, and d; ϵ represents random error; and subscript i denotes the panel unit; which refers to 20 MENA countries in the present study. To test the existence of the EKC, York et al. (2010) incorporate a quadratic term of the per capita GDP factor into the STIRPAT model. Following previous studies, we derive extended versions of the STIRPAT model to test for the presence of an inverse U-shaped curve relationship between per capita GDP and carbon emission. In this model, all variables except urbanization are converted into natural logarithmic form for direct interpretation as elasticities. Accordingly, within the EKC hypothesis framework, the augmented model is estimated as

$$lnCE_{ti} = \alpha_{i} + \beta_{1}lnP_{it} + \beta_{2}lnA_{it} + \beta_{3}lnEl_{it} + \beta_{4}UR_{it} + \beta lA_{it}^{2} + T_{t} + \varepsilon_{it}$$
(2)

Where countries are indexed by i and time periods by t; CE_{it} is the amount of CO_2 emissions of country i in year t; A is GDP per capita; P is the total population; EI is energy intensity; UR is the level of urbanization; α_i represents a country-specific effect that is constant with time, and a time specific effect T₁ may be used to account

for time-varying omitted variables and stochastic shocks that are common to all countries. Energy intensity may be interpreted as a proxy for technology level which may damage the environment (Zarzoso et al., 2007), whereas time-specific effect is sometimes interpreted as the effect of technical progress in carbon emission control overtime (Stern, 2002). Meanwhile, Anderson and Cavendish (2001) point out that prior studies paid little attention to the role of technical progress in air pollution abatement. Ignoring this determinant could drastically underestimate possibilities for countries to decrease pollution levels with economic growth.

With regard to urbanization, we follow Wang et al. (2016) and we add urbanization variable as an essential part in the investigation of income - carbon emission nexus. This is because; some possible effects of urbanization on the environmental quality are somewhat and independently debated in three relevant theories. The first is the ecological modernization theory; which claims that environmental problems may rise from low to intermediate stages of development. Nonetheless, extra modernization can reduce such inverse impacts; as societies start to recognize the significance of environmental sustainability. The second is the urban environmental transition theory; where an increase in affluence of cities often leads to an increase in manufacturing activities; leading to massive industrial pollution-related issues as air and water pollution. However, such inverse impacts decrease in affluent cities as a result of advanced environmental regulations, technological progress and structural improvement in the economy. The third is the compact city theory; where high urban density allows cities to accomplish economies of scale of urban public infrastructure, and decrease car usage, travel length, allocation losses of electricity supply, and minimize energy consumption and CO, emissions (Burton, 2000; Capello and Camagni, 2000; Burton et al., 2004; Newman and Kenworthy, 1989).

Within the aforementioned framework, we first examine the existence of income and carbon emission EKC; using parametric panel fixed effects regression. A more flexible method is used to explore this topic is the semi-parametric panel fixed effects model of Baltagi and Li (2002); which does not place an ex-ante restriction on the shape of the relationship curve between income and carbon emission and can therefore address potential functional form misspecification (Wang et al., 2015). In the present study, the semi-parametric model for testing the relationship between income and carbon emission may be described as

$$\ln CE_{ti} = \alpha_{i} + \beta_{1} \ln P_{it} + \beta_{2} \ln El_{it} + \beta_{3} u_{it} + f(lA_{it}) + T_{t} + \varepsilon_{it}$$
(3)

Where the functional form f(.) in the model is unspecified because the income variable is a non-linear input to the model. Unobserved heterogeneous effects can be removed at the first difference:

$$\begin{split} & lnCE_{it-1}\text{-}lnCE_{it-1} = \beta_1(lnP_{it}\text{-}lnP_{it-1}) + \beta_2(lnEl_{it}\text{-}lnEl_{it-1}) + \beta_3(U_{it}\text{-}U_{it-1}) \\ & + [f(lA_{it})\text{-}f(lA_{it-1})] + T_t - T_{t-1} + \epsilon_{it} - \epsilon_{it-1} \end{split}$$

To consistently estimate the first difference model, the following series of differences are derived to respectively estimate $[f(UR_{it})-f(URi_{t-1})]$ in line with Baltagi and Li (2002).

$$p^{k}(lA_{it}, lA_{it-1}) = [p^{k}(lA_{it}) - p^{k}(lA_{it-1})]$$
(5)

Where, p^k (UR) and p^k (ln A) are the first k terms of a sequence of function (p1 (UR), p2 (UR),...) and (p^1 (ln A), p^2 (ln A),...), respectively. In practice, a typical example of p^k series could be a spline; corresponding to piecewise polynomials with pieces depicted by a sequence of smooth knots. Once β coefficients are estimated, the values of unit-specific intercepts α_i can be calculated. Thus, equation 5 can be reduced to

$$\mathbf{u}_{it}^{\hat{}} = \ln C \mathbf{E}_{it} - \beta_1^{\hat{}} \ln \mathbf{P}_{it} - \beta_2^{\hat{}} \ln E \mathbf{L}_{it} - \beta_3^{\hat{}} \mathbf{U}_{it} - \alpha_i^{\hat{}} = \mathbf{f}(\mathbf{I} \mathbf{A}_{it}) + \varepsilon_{it}$$
(6)

The curve f (.) can be easily estimated by performing spline regression u_{it} on the UR_{it} variable in equation 6. We execute a B-spline regression model of order k=4.

4. DATA AND VARIABLES

We investigate whether there is an evidence of a non-monotonic relationship between income and carbon emission; as postulated by the EKC hypothesis, for a balanced panel of 20 MENA countries and data spanning 1980-2014. All data for the analysis was collected from the World Bank Development indicators. For this dataset, we apply, and for the first time, parametric and semiparametric panel fixed effects models. All underlying variables with their descriptive statistics are listed in Table 1. It should be noted that all variables except urbanization are converted into natural logarithmic form.

5. RESULTS AND DISCUSSION

Empirical results for per capita GDP - CO₂ emissions nexus are given in Table 2. Column 1 of the table presents results of the parametric fixed effects regression estimator within the per capita GDP - CO₂ emissions EKC hypothesis framework. The findings reveal that the elasticity of CO₂ emission with respect to energy use is highly significant at the 1% level, and its sign is positive. A 1% increase in energy use leads to 0.6% increase in carbon emission. The estimated coefficients for both; urbanization and population variables are not significant and have unexpected signs. The affluence variable and its quadratic term are both highly significant and they have the expected signs. Findings from the parametric fixed effects model confirm the presence of the income - CO₂ emissions EKC hypothesis. Column 2 presents estimates of control variables in the semi-parametric panel fixed effects model. Unlike the parametric fixed, the semi-parametric results detect insignificant impact for the energy use variable. In contrast to the parametric fixed effects model, the population variable is positive and highly significant at the 1% level. The results of the semi-parametric panel data model suggest that only population variable is the main source for carbon emission in MENA region.

The partial fit for the per capita GDP and CO_2 emissions nexus in the semi-parametric panel fixed effects model is represented in Figure 1. The plot seems to confirm the existence of an EKC between income and CO_2 emissions in the region. The relationship appears more obviously inversely U-shaped; CO_2 emissions increase with real GDP, stabilize, and then start to decrease. The

Table 1: Descriptive statistics of variable	Table	1:	Descri	ptive	statistics	of	variable
---	-------	----	--------	-------	------------	----	----------

Variables	Definition	Mean	Minimum	Maximum
Ln CE	Carbon dioxide emissions, metric tons per capita	1.55	-2.38	4.22
Ln A	GDP per capita (constant 2005 US\$)	8.36	6.08	11.05
Ln El	Energy use (kg of oil equivalent) per \$1,000 GDP (constant 2011 PPP)	4.75	3.71	5.70
Ln P	Population, total	15.98	13.07	18.31
UR	Urban population (% of total)	69.58	20.93	99.16

GDP: Gross domestic product

Table 2. Estimates for meene-co, emissions mout	Table 2	2: Es	stimates	for	income-	CO.	emissions	mode	ł
---	---------	-------	----------	-----	---------	-----	-----------	------	---

Variables	Parametric model	Semi-parametric model
Constant	-14.84* (1.19)	
Ln A	2.55* (0.27)	
Ln EL	0.60* (0.05)	0.09 (0.20)
Ln P	-0.03 (0.03)	0.61* (0.13)
UR	-0.002 (0.003)	-0.01 (0.013)
Ln A ²	-0.09*(0.02)	
Country	Yes	Yes
dummies		
Year dummies	Yes	Yes
Adjusted R ²	0.76	0.66
Observed	415	401

Cluster-robust standard errors in parentheses. Superscripts *denote statistical significance at 1% levels

Figure 1: Partial fit of per capita gross domestic product and CO₂ emissions nexus



Points on graph are estimated partial residuals for carbon emission. Maroon curve represents fitted values for adjusted effects of other explanatory variables in the model, and 95% confidence bands are indicated by shading areas

curve develops gradually to be largely flat; suggesting that it is approaching the turning point. Once income reaches the turning point, carbon emission begins to fall. Thus, from the results of the two panel regression methods, we confirm the presence of the income - CO_2 emissions EKC hypothesis, and it is more pronounced in the semi-parametric fixed effects model.

6. CONCLUSION AND POLICY IMPLICATION

The present study seeks to examine the impacts of income on carbon emission in MENA region through investigation of the existence of an EKC. Within the STIRPAT framework, this is the first study in MENA region to explore the income and carbon emission nexus; using panel data together with semi-parametric panel fixed effects regression. Our data set is referred to a panel of 20 countries in MENA region spanning the period 1980-2014. With this information, we find evidence to support an inverted U-shaped relationship between income and CO_2 emissions in the region. One possible justification for our findings is related to the fact that in the region, there are several initiatives of renewable energy which are taken in consideration in Algeria, the Kingdom of Saudi Arabia and other MENA countries like the pioneering project of Masdar Sustainable City. These initiatives are expected to improve the situation in the next years. Overall, our results suggest that environmental degradation may be reversible and environmental quality may be recoverable alongside the development process in the region.

REFERENCE

- Agras, J., Chapman, D. (1999), A dynamic approach to the environmental Kuznets curve hypothesis. Ecological Economics, 28(2), 267-277.
- Akarca, A.T., Long, I.T.V. (1980), On the relationship between energy and GNP: A re-examination. Journal of Energy and Development, 5, 326-331.
- Akbostanci, E., Turut-Asik, S., Tunc, I.G. (2009), The relationship between income and environment in Turkey: Is there an environmental Kuznets curve? Energy Policy, 37(2), 861-867.
- Al-Iriani, M.A. (2006), Energy-GDP relationship revisited: An example from GCC countries using panel causality. Energy Policy, 34(17), 3342-3350.
- Alkhathlan, K., Javid, M. (2013), Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. Energy Policy, 62, 1525-1532.
- Al-Mulali, U. (2011), Oil consumption, CO₂ emission and economic growth in MENA countries. Energy, 36, 6165-6171.
- Al-Mulali, U., Adebola, S.S., Ozturk, I. (2016), Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: An autoregressive distributed lag (ARDL) approach. Natural Hazards, 80(3), 1729-1747.
- Al-Mulali, U., Tang, C.F., Ozturk, I. (2015), Estimating the environment Kuznets curve hypothesis: Evidence from Latin America and the Caribbean countries. Renewable and Sustainable Energy Review, 50, 918-924.
- Al-Rawashdeh, R., Jaradat, A.Q., Al-Shboul, M. (2014), Air pollution and economic growth in MENA countries: Testing EKC hypothesis. Environmental Research, Engineering and Management, 4, 54-65.
- Altinay, G., Karagol, E. (2005), Electricity consumption and economic growth: Evidence for Turkey. Energy Economics, 27, 849-856.
- Anderson, D., Cavendish, W. (2001), Dynamic simulation and environmental policy analysis: Beyond comparative statics and the environmental Kuznets curve. Oxford Economics Papers, 53, 721-746.

Ang, J.B. (2007), CO₂ emissions, energy consumption, and output in

France. Energy Policy, 35, 4772-4778.

- Apergis, N., Payne, J.E. (2009), CO₂ emissions, energy usage, and output in central America. Energy Policy, 37, 3282-3286.
- Arouri, M.E., Youssef, A., M'henni, H., Rault, C. (2012), Energy consumption, economic growth and CO₂ emissions in middle East and North African countries. Energy Policy, 45, 342-349.
- Baltagi, B.H., Li, D. (2002), Series estimation of partially linear panel data models with fixed effects. Annals of Economics and Finance, 3, 103-116.
- Belloumi, M. (2009), Energy consumption and GDP in Tunisia: Cointegration and causality analysis. Energy Policy, 37, 2745-2753.
- Bentzen, J., Engsted, T. (1993), Short- and long- run elasticities in energy demand: A cointegration approach. Energy Economics, 15, 9-16.
- Brown, L.R. (2011), World on the Edge: How to Prevent Environmental and Economic Collapse. New York: Norton and Company.
- Burton, E. (2000), The compact city: Just or just compact? A preliminary analysis. Urban Studies, 37, 1969-2001.
- Burton, E., Jenks, M., Williams, K. (2004), The Compact City: A Sustainable Urban Form? Washington, DC: Taylor & Francis.
- Capello, R., Camagni, R. (2000), Beyond optimal city size: An evaluation of alternative urban growth patterns. Urbanization Studies, 37, 1479-1496.
- Chebbi, H., Olarreaga, M., Zitouna, H. (2009), Trade openness and CO₂ emissions in Tunisia. In: Proceedings of the ERF16th Annual Conference. November. p7-9.
- Desbordes, R., Verardi, V. (2012), Refitting the Kuznets curve. Economic Letter, 116, 258-261.
- Dietz, T., Rosa, E.A. (1997), Effects of population and affluence on CO₂ emissions. Proceeding of the National Academy of Science of the USA, 94, 175-179.
- Dinda, S., Coondoo, D. (2006), Income and emissions: A panel based cointegration analysis. Ecological Economics, 57, 167-181.
- Ehrlich, P.R., Holdren, J.P. (1971), Impact of population growth. Science, 171, 1212-1233.
- Erol, U., Yu, E.S.H. (1987), On the causal relationship between energy and income for industrialized countries. Journal of Energy and Development, 13(1), 113-122.
- Esteve, V., Tamarit, C. (2012), Threshold cointegration and nonlinear adjustment between CO2 and income: The environmental Kuznets curve in Spain, 1857-2007. Energy Economics, 34(6), 2148-2156. DOI: 10.1016/j.eneco.2012.03.00.
- Farhani, S., Shahbaz, M., Arouri, M. (2013), Panel Analysis of CO2 Emissions, GDP, Energy Consumption, Trade Openness and Urbanization for MENA Countries. MPRA Paper 49258.
- Farhani, S., Mrizak, S., Chaibi, A., Rault, C. (2014), The environmental Kuznets curve and sustainability: A panel data analysis. Energy Policy, 71, 189-198.
- Fiedl, B., Getzner, M. (2003), Determinants of CO₂ emissions in a small open economy. Ecological Economics, 45, 133-148.
- Fodha, M., Zaghdoud, O. (2010), Income and environmental degradation in Tunisia: An empirical analysis of the environmental Kuznets curve. Energy Policy, 38, 1150-1156.
- Galeotti, M., Manera, M., Lanza, A. (2009), On the robustness of robustness checks of the environmental Kuznets curve hypothesis. Environment and Research Economic, 42(4), 551-574.
- Ghosh, S. (2010), Examining carbon emissions economic growth nexus for India: A multivariate cointegration approach. Energy Policy, 38, 3008-3014.
- Grossman, G., Krueger, A. (1991), Environmental impacts of a North American free trade agreement. National Bureau of Economics Research Working Paper, No. 3194. Cambridge: NBER.
- Gurgul, H., Lach, Ł. (2011), The role of coal consumption in the economic growth of the Polish economy in transition. Energy Policy, 39,

2088-2099.

- Gurgul, H., Lach, Ł. (2012), The electricity consumption versus economic growth of the Polish economy. Energy Economics, 34(2), 500-510.
- Halicioglu, F. (2009), An econometric study of CO₂ emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37, 1156-1164.
- Hamit-Haggar, M. (2012), Greenhouse gas emissions, energy consumption and economic growth: A panel cointegration analysis from Canadian industrial sector perspective. Energy Economics, 34, 358-364.
- He, J., Richard, P. (2010), Environmental Kuznets curve for CO₂ in Canada. Ecological Economics, 69(5), 1083-1093.
- Herrala, R., Goel, R.K. (2012), Global CO₂ efficiency: Country-wise estimates using a stochastic cost frontier. Energy Policy, 45, 762-770.
- Holtz-Eakin, D., Selden, T.M. (1995), Strokingthe fires: CO₂ emissions and economic growth. Journal of Public Economy, 57(1), 85-101.
- Hossain, M.S. (2011), Panel estimation for CO₂ emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy, 39, 6991-6999.
- International Energy Agency. (2014), World Energy Investment Outlook Report. France: International Energy Agency.
- Jalil, A., Mahmud, S.F. (2009), Environment Kuznets curve for CO2 emissions: A cointegration analysis. Energy Policy, 37, 5167-5172.
- Jayanthakumaran, K., Verma, R., Liu, Y. (2012), CO₂ emissions, energy consumption, trade and income: A comparative analysis of China and India. Energy Policy, 42, 450-460.
- Kraft, J., Kraft, A. (1978), On the relationship between energy and GNP. Journal of Energy and Development, 3, 401-403.
- Lean, H.H., Smyth, R. (2010), CO₂ emissions, electricity consumption and output in ASEAN. Applied Energy, 87, 1858-1864.
- Liddle, B., Sidney, L.S. (2010), Age-structure, urbanization, and climate change in developed countries: Revisiting STIRPAT for disaggregated population and consumption-related environmental impacts. Population and Environment, 31, 317-343.
- M'henni, H. (2005), Economic development, adjustment and environmental quality: The case of Tunisia for a contingent valuation study. Mediterranean Journal of Economics, Agriculture and Environment, IVN(2), 342-349.
- Méon, P.G., Sekkat, K. (2004), Does the quality of institutions limit the MENA's integration in the world economy? The World Economy, 27, 1475-1498.
- Narayan, P.K., Narayan, S. (2010), Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. Energy Policy, 38, 661-666.
- Narayan, P.K., Smyth, R. (2008), Energy consumption and real GDP in G7 countries: New evidence from panel cointegration with structural breaks. Energy Economics, 30, 2331-2341.
- Newman, P., Kenworthy, J. (1989), Cities and Automobile Dependence: A Sourcebook. Monograph. UK: Gower.
- Oh, W., Lee, K. (2004), Causal relationship between energy consumption and GDP: The case of Korea 1970-1999. Energy Economics, 26, 51-59.
- Omri, A. (2013), CO₂ emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. Energy Economics, 40, 657-664.
- Oscan, B. (2013), The nexus between carbon emissions, energy consumption and economic growth in middle East countries: A panel data analysis. Energy Policy, 62, 1138-1147.
- Ozcan, B. (2013), The nexus between carbon emissions, energy consumption and income in middle East countries: A panel data analysis. Energy Policy, 62, 1138-1147.
- Ozturk, I. (2010), A literature survey on energy-growth nexus. Energy Policy, 38(1), 340-349.
- Ozturk, I., Acaravci, A. (2012), The long-run and causal analysis of energy,

growth, openness and financial development on carbon emissions in Turkey. Energy Economics, 36, 262-267.

- Ozturk, I., Al-Mulali, U. (2015), Investigating the validity of the environmental Kuznets curve hypothesis in Cambodia. Ecological Indicators, 57, 324-330.
- Pao, H.T. (2009), Forecast of electricity consumption and economic growth in Taiwan by state space modelling. Energy, 34, 1779-1791.
- Saboori, B., Soleymani, A. (2011), CO₂ emissions, economic growth and energy consumption in Iran: A cointegration approach. International Journal of Environment and Society, 2(1), 44-53.
- Saboori, B., Sulaiman, J., Mohd, S. (2012), Economic growth and CO₂ emissions in Malaysia: A cointegration analysis of the environmental Kuznets curve. Energy Policy, 51, 184-191.
- Selden, T.M., Song, D. (1994), Environmental quality and development: Is there a Kuznets curve for air pollution emissions? Journal of Environmental Economics and Management, 27(2), 147-162.
- Shahbaz, M., Ozturk, I., Afza, A., Ali, A. (2013), Revisiting the environmental Kuznets curve in a global economy. Renewable and Sustainable Energy Reviews, 25, 494-502.
- Soytas, U., Sari, R. (2009), Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. Ecological Economics, 68, 2706-2712.
- Soytas, U., Sari, R., Ewing, B.T. (2007), Energy consumption, income, and carbon emissions in the United States. Ecological Economics, 62, 482-489.
- Stern, D.I. (2000), Multivariate cointegration analysis of the role of energy in the U.S. macro economy. Energy Economics, 22, 267-283.
- Stern, D.I. (2002), Explaining changes in global sulfur emissions: An econometric decomposition approach. Ecological Economics, 42, 201-220.
- Stern, D.I. (2004), The rise and fall of the environmental Kuznets curve. World Development, 32, 1419-1439.
- Tamazian, A., Rao, B.B. (2009), Do Economic, Financial and Institutional Developments Matter for Environmental Degradation? Evidence from Transitional Economies. EERI Research Paper Series No. 02/2009.

- Tiwari, A.K., Shahbaz, M., Hye, M.Q.A. (2013), The environmental Kuznets curve and the role of coal consumption in India: Cointegration and causality analysis in an open economy. Renewable and Sustainable Energy Reviews, 18(3), 519-527.
- Toda, H.Y., Philips, P.C.B. (1993), Vector auto regressions and causality. Econometrica, 61, 1367-1393.
- Wang, Y., Han, R., Kubota, J. (2016), Is there an environmental Kuznets curve for SO₂ emissions? A semi-parametric panel data analysis for China. Renewable and Sustainable Energy Reviews, 54, 1182-1188.
- Wang, Y., Zhang, X., Kubota, J., Zhu, X., Lu, G. (2015), An empirical study of the environmental Kuznets curve for environmental quality in Gansu province. Ecological Indicators, 56, 96-105.
- Wodon, Q.A., Liverani, G.J., Bougnoux, N. (2014), Climate Change and Migration: Evidence from the Middle East and North Africa. Washington, DC: The World Bank.
- Yang, H.Y. (2000), A note on the causal relationship between energy and GDP in Taiwan. Energy Economics, 22(3), 309-317.
- York, R., Rosa, E.A., Dietz, T. (2010), Ecological modernization theory: Theoretical and empirical challenges. In: Redclift, M.R., Woodgate, G., editors. The International Handbook of Environmental Sociology. 2nd ed. Cheltenham, UK: Edward Elgar.
- Yu, E.S.H., Hwang, B.K. (1984), The relationship between energy and GNP: Further results. Energy Economics, 6(3), 186-190.
- Zarzoso, I.M., Morancho, A.B., Lage, R.M. (2007), The impact of population on CO₂ emissions: Evidence from European countries. Environmental Resources Economics, 38, 497-512.
- Zhang, X.P., Cheng, X.M. (2009), Energy consumption, carbon emissions, and economic growth in China. Ecological Economics, 68, 2706-2712.
- Zhua, H., You, W., Zeng, Z. (2012), Urbanization and CO₂ emissions: A semi-parametric panel data analysis. Economic Letter, 117, 848-850.