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Testing the EKC Hypothesis: an Empirical Analysis for Selected OIC Members

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Abstract

Environmental issues are one of the crucial problems in the global debate. According to most expert on ecology, economic development decreases the environmental quality. From this point of view, many empirical studies presented in support of the Environmental Kuznets Curve (EKC) hypothesis, which means that there exists an inverse U-shaped relationship between environmental pollution and economic growth.

In this context, this study aims to test the validity of the EKC hypothesis for a panel of 10 Organization of Islamic Cooperation (OIC) Members from 1970 to 2014. The findings of the study from Dynamic SUR estimations show that there is an N-shaped EKC for Algeria, Tunisia and Turkey and present that there is an opposite of the N-shaped EKC for Sudan. Thus, the results showed actions against the environmental problems cannot wait until economic growth.

Keywords: *the EKC; economic development/growth; environmental degradation; second generation panel tests*

JEL Classification: *C33; O0; Q56*

Introduction

Given the current studies on environmental problems such as global warming, the linkage between economic growth and the environment has been the focus point for policymakers. Most studies show that the environment at first worsens at early stages of economic development up to a certain level, but then increases at higher levels. This is the so-called as the Environmental Kuznets Curve (EKC) hypothesis.

There have been three different effects in the environmental pollution and economic growth. These are scale, composition and technique effects. According to scale effect, in the beginning stage of economic growth the greater emission of pollutants decreases environmental quality. Thus, economic growth has negative impact on environment at scale effect stage. According to composition effect, the countries with higher per capita GDP head towards cleaner activities. Thus, per capita income has positive impact on environment. According to technique effect, a wealthy country can make more research and development spending. So, the dirty technology is replaced by cleaner technology. Environmental pollution along with rising in the capacity of higher per capita GDP countries diminishes through technique effect (Dinda, 2004).

The purpose of the study is to investigate the empirical linkage between per capita GDP and the environmental pollution for a panel of 10 Organization of Islamic Cooperation (OIC) Members during the period 1970-2014. The rest is organized as follows: Section 2 presents the previous literature, section 3 gives the data, model and findings and section 4 finals the study.

Previous Studies

Results from empirical studies have also been mixed, both for different environmental indicators and also for different studies looking at the same environmental indicator. Bengochea-Morancho et al. (2001) investigated the validity of the EKC for the EU countries. The findings of the study proved the presence of the EKC hypothesis.

Cole and Neumayer (2005) examine the implications of the EKC for pollution trends in LDCs. Cole and Neumayer (2005) contribute to the literature by explicitly considering whether LDCs can expect to follow an EKC or when LDCs can expect to experience an improvement in environmental quality.

Rashid (2009) analyzed the linkage between CO_2emissions and income for the BRIC countries and the United States from 1981 to 2006. The findings of the study supported the existence of the EKC hypothesis.

Arı and Zeren (2011) tested the existence of EKC hypothesis for the Mediterranean countries from 2000 to 2005. Using the panel data method, the study exerted that CO_2emissions can increase at the high level of economic growth.

Saboori et al. (2012) examined the dynamic linkages among CO_2emissions, income, energy consumption and foreign trade in Indonesia from 1971 to 2007. Using the ARDL methodology, the study found no evidence providing the validity of the traditional EKC curve.

Lacheheb et al. (2015) examines CO_2 emission-economic growth relationship in Algeria from 1971 to 2009. The Long-run findings show that there has been significant connection between CO_2 emission from solid fuel consumption and from electricity and heat production and economic development.

Balin and Akan (2015) investigated whether the traditional EKC curve is valid, or not for 27 developed countries during the period 1997-2009. Using panel data methods, the study suggest that there have been a N-shaped EKC curve between per capita GDP and environmental pollution.

Ertugrul et al. (2016) examined the relationship between CO2 emissions, real income, trade openness, and energy consumption in the period of 1971–2011 for the top ten carbon-emitting countries among developing economies. The empirical results showed that, for long-term estimates, the main factors of carbon emissions are energy consumption, real income, and trade openness. The empirical findings support the EKC hypothesis for India, China, Korea, and Turkey.

Rahman et al. (2020) examined the environmental Kuznets curve (EKC) hypothesis for the BCIM-EC (Bangladesh–China–India–Myanmar economic corridor) member countries under the Belt and Road Initiative (BRI) of China. Findings for panel data analysis showed that GDP per capita and energy consumption have positive effects on CO2, while the effect of the quadratic term of GDP per capita is negative in the short-run. In addition, the authors showed that the short-run effects do not remain valid in the long-run, except for energy use. Therefore, they suggested that the EKC hypothesis is only a short-run phenomenon in the case of the panel data framework.

Data, Model and Findings

This study institutes an econometric model to illustrate the linkage between per capita GDP and CO_2 emissions as follows.

$$co2_{it} = \alpha + \partial_i.pgdp_{it} + \beta_i.pgdp_{it}^2 + \chi_i.pgdp_{it}^3 + e_{it}$$

where i represents the countries and t is the year, CO_2 is log of per capita CO_2 emissions, pgdp, $pgdp^2$ and $pgdp^3$ is the log of per capita GDP and its squared and cubic terms, respectively. All data were obtained from World Development Indicators of World Bank. CO_2 emissions are measured in metric tons per capita. This sample is determined based on the data availability. In the analysis, it was focused on CO_2 emissions per capita, because CO_2 emissions are the most important global environment pollutant contributing about 72% of the global warming and climate change (Balin and Akan, 2015: 85).

With regard to the above model:

- if $\beta_1 = \beta_2 = \beta_3 = 0$ *no relationship;*
- if $\beta_1 \succ 0, \beta_2 = \beta_3 = 0$ *a monotonic increasing relationship;*
- if $\beta_1 \prec 0, \beta_2 = \beta_3 = 0$ *a monotonic decreasing relationship;*
- if $\beta_1 \succ 0, \beta_2 \prec 0, \beta_3 = 0$ *an inverted U-shaped relationship;*
- if $\beta_1 \prec 0, \beta_2 \succ 0, \beta_3 = 0$ *a U-shaped EKC;*
- if $\beta_1 \succ 0, \beta_2 \prec 0, \beta_3 \succ 0$ *N-shaped EKC;*
- if $\beta_1 \prec 0, \beta_2 \succ 0, \beta_3 \prec 0$ *Opposite to the N-shaped relationship;*
- if $\beta_1 \succ 0, \beta_2 \succ 0, \beta_3 \prec 0$ *inverted U-shaped relationship in a cubic polynomial form;*
- if $\beta_1 \prec 0, \beta_2 \prec 0, \beta_3 \succ 0$ *U-shaped relationship in a cubic polynomial form.*

Testing for cross-sectional dependence and the homogeneity of slope coefficients in a panel study is important for selecting the appropriate estimator. Especially, due to globalization and increasing integration of economies, cross-sectional dependence seems to be likely that shocks to individual countries affect other countries in the panel too.

In the study, it is investigated with Pesaran and Yamagata's (2008) homogeneity tests. Pesaran and Yamagata (2008) proposed a standardized version of Swamy's test of slope homogeneity for panel data models. Pesaran and Yamagata (2008) take into account the equation:

$$y_{it} = \alpha_i + \beta_i'.x_{it} + \mu_{it}$$

The null hypothesis and the alternative hypothesis of interest are:

$H_0 : \beta_i = \beta$ for all i,

$H_1 : \beta_i \neq \beta_j$ for a non-zero fraction of pairwise slopes for $i \neq j$. Under the null hypothesis $\tilde{\Delta} \rightarrow_d N(0,1)$ as $(N,T) \xrightarrow{j} \infty$ so long as $\sqrt{N}/T^2 \rightarrow 0$, where the standardized dispersion statistic, $\tilde{\Delta}$

is defined by $\tilde{\Delta} = \sqrt{N}.\left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right)$ where $\tilde{S}$ is the Swamy's statistic and it is valid for a fixed N and as $T \rightarrow \infty$. Pesaran and Yamagata (2008) also proposed the adjusted version of $\tilde{\Delta}$ for the small samples[1].

$$\tilde{\Delta}_{adj} = \sqrt{N}.\left(\frac{N^{-1}\tilde{S} - E(\tilde{z}_{iT})}{\sqrt{Var(\tilde{z}_{iT})}}\right), \text{ where } E(\tilde{z}_{iT}) = k \text{ , } Var(\tilde{z}_{iT}) = \frac{2k.(T-k-1)}{T+1}.$$

The result of the $\tilde{\Delta}_{adj}$ statistic from Table 1 indicates that the slope coefficients aren't homogeneous.

Table 1. Pesaran and Yamagata (2008)'s Homogeneity Test

	Test statistic	**P-value**
$\tilde{\Delta}$	6.155	0.000
$\tilde{\Delta}_{adj}$	6.441	0.000

Secondly, testing for cross-sectional dependence in panel analysis is crucial issue. To test the presence of cross-sectional dependence, it was performed the Breusch and Pagan's (1980) LM_{BP} test. The test statistic developed by Breusch and Pagan (1980) is as follows:

$$LM_{BP} = T.\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \sim \chi^2_{N.(N-1)/2}$$

where:

- $\hat{\rho}_{ij}$ shows the estimation of the correlation coefficient among the residuals obtained from individual OLS estimations of $y_{it} = \alpha_i + \beta_i '.x_{it} + \mu_{it}$ for i=1,2,…,N;
- t=1,2,…,T.

Under the null hypothesis of no cross-sectional dependency on the LM_{BP} test, is used when N is fixed and T goes to infinity, is asymptotically distributed as chi-squared with N(N-1)/2 degrees of freedom.

Table 2. LM_{BP} Test Results

Variable	**Statistic**	**p-value**
co2	230.213	0.00
pgdp	576.921	0.00
Pgdp^2	100.106	0.00
Pgdp^3	98.494	0.00

[1] For a detailed proof and information, see Swamy (1970) and Pesaran and Yamagata (2008).

It is clear that the null of no cross-sectional dependence across the selected countries can be rejected from Table 2.

Aftermath of the tests of homogeneity and cross sectional dependency, Hadri and Kurozumi (2012)'s panel stationarity test is used. This test is sensitive to cross sectional dependency among the panel series. Hadri and Kurozumi (2012)'s panel stationarity test states that under a null hypothesis, series do not contain unit root, while an alternative hypothesis states that series contain unit root. In addition, this test allowing serial correlation and cross-sectional dependence can be used in which both T<N and T>N.

Hadri-Kurozumi (2012) used the following equation:

$$y_{it} = k'_t\delta_i + f_t.\gamma_i + \varepsilon_{it}\,, \quad \varepsilon_{it} = \phi_{i1}.\varepsilon_{it-1} + ... + \phi_{ip}.\varepsilon_{it-p} + v_{it} \quad \text{for } i=1,...,N,\ t=1,...,T$$

where:

- z'_t is deterministic
- $k'_t\delta_i$ represents the individual effects
- f_t is an unobserved common factor
- γ_i is the loading factor
- ε_{it} denotes the individual-specific error.

H-K (2012) regress y_{it} on $w_t = \left[k'_t, \bar{y}_t, \bar{y}_{t-1}, ..., \bar{y}_{t-p}\right]$ in order to correct the cross-sectional dependence, for each i, construct the following the statistic:

$$Z_A = \frac{\sqrt{N}(\overline{ST} - \xi)}{\zeta}$$

where:

$$\overline{ST} = 1/N.\sum_{i=1}^{N} ST_i$$

with

$$ST_i = \frac{1}{\hat{\sigma}_i^{\,2}.T^2}\sum_{t=1}^{T} S^w{}_{it}$$

where $S_{it}{}^w = \sum_{r=1}^{t}\hat{\varepsilon}_{ir}$, $\hat{\sigma}_i^{\,2}$ is the estimator of the long-run variance.

H-K (2012) obtain the estimator of the long-run variance by:

$$\hat{\sigma}_{iSPC}^2 = \frac{\hat{\sigma}_{vi}^2}{(1-\hat{\varphi}_i\,)^2} \quad \text{where} \quad \hat{\sigma}_{vi}^2 = 1/T.\sum_{t=1}^{T}\hat{v}_{it}^2 \quad \text{and} \quad \hat{\varphi}_i = \min\left\{1 - \frac{1}{\sqrt{T}}, \sum_{j=1}^{p}\hat{\varphi}_{ij}\right\}.$$

and Hadri-Kurozumi (2012) institutes Z_A^{SPC} as below:

$$Z_A{}^{SPC} = \frac{1}{\hat{\sigma}_{iSPC}^2.T^2}\sum_{t=1}^{T}(S_{it}{}^w)^2$$

The Z_A^{SPC} is preferred over the Z_A in case of cross-sectional dependence.

Table 3 shows the panel stationarity test results. According to Table 3, the null hypothesis of a stationarity cannot be rejected at the 5% significance level for all variables.

Table 3. Results for the Hadri-Kurozumi (2012) stationary test

Constant		
Variable	**ZA-Spac Test Statistic**	**p-value**
co2	-2.47	0.991
pgdp	-0.78	0.781
Pgdp^2	1.59	0.055
Pgdp^3	-2.46	0.991

We then proceed to investigate the presence of the EKC hypothesis for selected OIC countries using Mark et al. (2005)'s Panel Dynamic SUR method. Table 4 illustrates the empirical findings of the test.

Table 4. Results for Panel Dynamic SUR Method

Country	pgdp	s.e	t	pgdp^2	s.e	t	pgdp^3	s.e	t
Algeria	21.743	6.381	3,4	-2.679	778.729	-3	110.025	31.674	3
Egypt	-41.130	104.075	-0,4	4.893	14.540	0	0	1	0
Iran	-464.529	4.235	-0,1	57.775	491.544	0	-2.384	19.002	0
Iraq	458.674	574.058	0,8	-57.126	73.325	-1	2.368	3.119	1
Morocco	6.644	68.426	0,1	-1.627	9.189	0	0	0	0
Oman	4.368	4.552	1,0	-464.262	482.302	-1	16.462	17.026	1
Saudi Arabia	-212.295	8.813	0,0	20.594	876.833	0	-1	29.064	0
Sudan	-232.382	40.835	-5,7	33.422	5.867	6	-1.601	0	-5
Tunusia	357.029	75.990	4,7	-44.342	9.734	-5	1.842	0	4
Turkey	553.994	92.948	6,0	-61.738	10.472	-6	2.307	0	5

Dynamic SUR estimations indicate that there exists an N-shaped EKC for Algeria, Tunisia and Turkey. For Sudan, there exists an opposite to the N-shaped EKC. The results for the other countries found no statistically effects on environmental degradation.

Conclusion

Environmental problems are getting more focus point along with the increasing global warming and climate change. From this point of view, in this study it was investigated that the traditional EKC hypothesis is valid, or not in 10 OIC members.

Traditional EKC hypothesis suggests that as income increases the level of environmental degradation will decrease finally. One of the most important conclusions of this study is that actions against the environmental issues cannot wait until economic growth rise. The findings shows that environmental degradation will not disappear with economic growth, conversely environmental degradation can be sharper after a threshold level of economic growth for Algeria, Tunisia and Turkey. It will be reverse of this situation for Sudan.

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