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ENVIRONMENTAL KUZNETS CURVE IN THE MINT COUNTRIES: EVIDENCE OF LONG-RUN PANEL CAUSALITY TEST[1]

MINT ÜLKELERİNDE ÇEVRESEL KUZNETS EĞRİSİ: UZUN DÖNEM PANEL NEDENSELLİK TESTİNDEN KANITLAR

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ABSTRACT

The environmental Kuznets curve hypothesis (EKC) urges that there is an inverse-U-shaped relationship between carbon dioxide emission per capita and income per capita. Although there is lots of paper attempting to test the EKC hypothesis, the reported empirical results and conclusions are ambiguous. Departing from previous literature, this study focusses on two issues. Firstly, it examines the MINT countries which is neglected in the extend EKC literature. The MINT countries consist of Mexico, Indonesia, Nigeria and Turkey. The annual GDP per capita and carbon dioxide emissions per capita were obtained from the World Development Indicators 2013. The data set includes the period of 1967-2010, due to the availability of data. Secondly, the long run panel causality test suggested by Canning and Pedroni (2008) is used the test EKC hypothesis. Results of this study supported the EKC hypothesis only in the case of Nigeria.

***Keywords*:** Carbon dioxide emission, Economic growth, Long-run panel causality test

ÖZ

Çevresel Kuznets Eğrisi (ÇKE) kişi başına gelir ile karbondioksit emisyonu arasında ters U şeklinde bir ilişkinin olduğunu öne sürmektedir. ÇKE hipotezini test etmek isteyen bir çok çalışma olmasına rağmen, ampirik bulgu ve sonuçlar belirsizdir. Bu çalışma iki nedenle önceki literatürden farklılaşmaktadır. İlk olarak bu çalışma daha önceki ÇKE çalışmalarında bulunmayan MINT ülkeleri üzerine yapılmıştır. MINT ülkeleri Meksika, Endonezya, Nijerya ve Türkiye'den oluşmaktadır. Çalışmada Dünya Bankası veri tabanı WDI'ın 2013 verilerinden elde edilen yıllık kişi başına GSYİH ve kişi başına karbondioksit emisyonu rakamları kullanılmıştır. Veriler 1967-2010 dönemine aittir. İkinci olarak ÇKE hipotezini test etmek için Canning ve Pedroni (2008) tarafından önerilen uzun dönem panel nedensellik testi kullanılmıştır. Bu çalışmanın sonuçları ÇKE hipotezini sadece Nijerya örneğinde desteklemiştir.

Anahtar Sözcükler*:* *Karbondioksit emisyonu, Ekonomik büyüme, Uzun dönem panel nedensellik testi.*

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1. Introduction

Industrialization activities of humans over the last 150 years have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere. Emissions of carbon dioxide are, at present, about 35,000 million metric tons per year and, under the absence of further policies, are projected to rise to 41,000 million metric tons of CO_2 per year in 2020 (The World Bank, 2012). The increase in consumption of energy, especially in fossil fuels, leads to increase in emissions of greenhouse gases into the atmosphere, causing it to warm. So global mean temperature has continued to increase and is now about 0.8°C above preindustrial levels (The World Bank, 2012). The potential hazard of climate change has forced nations to take measures to restrain the increase in greenhouse gas emissions. The implementation of international agreements such as the Kyoto Protocol is an indicator that demonstrates the extremeness of impending danger.

Among economists, variables affecting greenhouse gas emissions have been discussed at both theoretical and empirical levels. From the theoretical perspective, the environmental Kuznets curve (hereafter EKC) suggests that there is a uni-directional causal relation from per capita GDP to per capita greenhouse gas emissions. But the EKC urges that the effect of increase in per capita GDP on per capita greenhouse gas emissions may be different between early stages and later stages of economic growth. In the lower level of per capita GDP, increase in economic growth may lead to rise in pollution. However, the trend later reverses, since higher-income levels lead to increase in demand for health and sustainable environment (Grossman and Krueger, 1991). So the EKC hypothesis suggests that there is an inverse U shaped relation between per capita GDP and per capita carbon dioxide emissions. So the EKC argument seeks an answer for the question of "does economic growth need to be slowed in order to avoid increasing harm to the environment" (Carson 2010, 3).

The effect of increase in GDP per capita on carbon dioxide per capita may be abstracted into four mechanisms (Stern 2004,1421; Kijima et al. 2010, 1189; Dinda 2005, 404; Brock and Taylor 2010, 150):

i) Under the hypothesis that there is no change in the technology of the economy, with the given factor input-ratios, growth in the scale of the economy would result in growth in pollution and other environmental impacts. This is called the scale effect.

ii) Some industries are more pollutant than others. Passing from the earlier stage of economic development to the next one, the output mix in the economy changes. That is, there is a tendency to shift away from agriculture toward heavy industry which increases emissions over the course of economic development. However, in the further levels of economic development there is a shift from the heavy industrial sectors toward services and lighter manufacturing. The last change in the economic structure may decrease emissions per unit of output.

iii) In the course of economic development, while energy demand is increasing alternative energy source may be substituted by conventional energy sources and the input mix in consumption may change. If conventional energy sources such as oil or coal are substituted with less environmentally damaging inputs such as natural gas or renewable energy sources.

iv) Improvements in the state of technology may decrease pollution by increasing energy efficiency which leads to use of less energy input and decreasing emissions per unit of input such as electric car.

Some studies in the empirical literature have analyzed the relation between economic growth and carbon dioxide emissions. Some papers selected from literature are reported in Table 1.

Table 1. Selected Studies About Economic Growth-Emissions Relation

Study	Country/Period	Method	Results/Supported hypothesis
Coondoo and Dinda (2002)	88 countries, 1960–1990	Granger causality test	Changes to country
Dinda and Coondoo (2006)	88 countries, 1960–1990	Cointegration and error correction model	$GDP \leftrightarrow CO_2$
Soytaş et al. (2007)	United States, 1960–2004	Granger causality	$GDP \neq CO_2$ No support for EKC
Soytaş and Sarı (2007)	Turkey, 1960–2000	Toda–Yamamoto approach	GDP≠CO2 No support for EKC
Ang (2007)	France, 1960–2000	Cointegration and vector error-correction model	$GDP \rightarrow CO_2$ EKC supported
Akbostancı et al. (2009)	Turkey, 1968–2003	Cointegration, Panel unit root test, Augmented Dickey-Fuller unit root test	$GDP \rightarrow CO_2$ No support for EKC
Apergis and Payne (2009)	6 Central American countries, 1971–2004	Cointegration and vector error-correction model	$GDP \rightarrow CO_2$ EKC supported
Halıcıoğlu (2009)	Turkey, 1960–2005	Cointegration, Granger causality	$GDP \leftrightarrow CO_2$
Apergis and Payne (2010)	11 countries of the Commonwealth of Independent States (CIS countries), 1992–2004	Cointegration and vector error-correction model	$GDP \rightarrow CO_2$ EKC supported
Chang (2010)	China, 1981-2006	Cointegration and vector error-correction model	$GDP \leftrightarrow CO_2$

Note: *→ indicates a causal relation from first variable to second one, ↔ disclose a bidirectional causal relation between the relevant variables, ≠ point to no causal relation between the two variables.*

In the empirical literature cointegration and error correction model were frequently used to analyze the relation between economic growth and carbon dioxide emissions. But the method used in these studies cannot give sign of causal relation. However, since the EKC hypothesis suggests the inverted U-shaped relationship between pollution and economic growth, the sign of the causal nexus between pollution and income must be investigated in order to reach a robust evidence about existence of the EKC hypothesis. Unlike previous research, this study finds sign of causal relation using the long run panel causality test suggested by Canning and Pedroni (2008). In addition, this study focuses on the MINT countries which are termed by Jim O'Neill, retired chairman of Goldman Sachs. According to O'Neill, MINT countries have a number of advantages that could potentially propel them to the world's ten largest economies in three decades. The MINT nations share similar characteristics such as young populations, proximity to major markets and for the most part, are energy and commodity rich. Cheap labor is another advantage of MINT. The analyses on MINT countries are highly neglected in the literature.

In this direction, our study contributes the empirical literature; both by employing on the MINT countries and estimating sign of the coefficient depict the causal relation between income per capita and carbon dioxide emissions.

The rest of the paper is organized as follows: The next section describes the data. The empirical procedure and the findings from empirical analysis are represented in section 3. Last section presents conclusion and policy implications of the paper.

2. Data

The data used in this study are annual and cover the period of 1967–2010 due to the availability of data. GDP per capita and CO_2 emissions per capita were attained from World Development Indicator 2013. The series were indexed as 2005=100. All variables were transformed into natural logarithm. The panel consists of four MINT countries. These are Mexico, Indonesia, Nigeria and Turkey. Descriptive statistics of the used variables in this study are reported in Table 2.

Table 2. Descriptive Statistics

Countries	Indonesia		Mexico		Indonesia		Turkey	
Variable	GDP	CO_2	GDP	CO_2	GDP	CO_2	GDP	CO_2
Mean	3.7021	3.9683	3.39429	4.2022	3.84943	4.34134	3.3942	4.2022
Median	3.8514	3.9054	3.35918	4.2997	3.76276	4.48681	3.3591	4.2997
Maximum	5.4441	4.8301	4.98074	4.7698	5.18572	4.89978	4.9807	4.7698
Minimum	1.4922	2.7256	1.85684	3.3838	2.48966	2.80262	1.8568	3.3838
Std. Dev.	0.9773	0.5769	0.87226	0.3850	0.66726	0.43909	0.8722	0.3850
Skewness	-0.6772	-0.4550	0.01109	-0.4079	0.08650	-1.3665	0.0110	-0.4079
Kurtosis	2.9049	2.2161	2.28454	2.1774	2.56941	4.98003	2.2845	2.1774
Jarque-Bera	3.3798	2.6449	0.93935	2.4607	0.39477	20.8817	0.9393	2.4607
Probability	0.1845	0.2664	0.62520	0.2921	0.82087	0.00002	0.6252	0.2921
Observations	44	44	44	44	44	44	44	44

3. Empirical Procedure and Findings

In this study a three-step empirical procedure was followed. In the first step the unit root test suggested by Im et al. (2003) was employed. The null hypothesis of non-stationarity against the alternative that the variable is trend stationary is tested in the unit root test. Im et al. (2003) assume that each panel member has a different autoregressive parameter and short-run dynamics under the alternative hypothesis of trend stationarity. So where we allow different intercepts and time trends for each country can be allowed in the estimated model. The results of unit root tests are shown in Table 3.

The null hypothesis that every country has a unit root for the series in levels cannot be rejected according to results in Table 3.

In the case of first differences, the test statistic is negative and significant in each case at significance level of 1%. So one can conclude that the series are stationary in first differences and the variables are I (1).

Table 3: IPS Panel Unit Root Test Results

Variable / Model	Individual effects and individual linear trends		Individual effects	
	Test Statistic	Probability	Test Statistic	Probability
GDP per capita	4.05471	1.0000	5.91422	1.0000
ΔGDP per capita	-4.95282	0.0000	-5.24626	0.0000
Emissions per capita	-1.20180	0.1147	0.22708	0.5898
ΔEmissions per capita	-6.36836	0.0000	-6.93033	0.0000

In the second step, possible cointegration relation between GDP per capita and CO_2 emissions per capita was investigated. Since it is robust to causality running in both directions and allows for both heterogeneous cointegrating vectors and short-run dynamics across countries, Pedroni (1999, 2004) panel cointegration technique was used. Estimated cointegration regression model which was derived from studies listed in Table 1 is as follows:

$$CO2_{it} = \alpha_i + b_t + \beta_i GDP_{it} + e_{it} \tag{1}$$

where *i* and *t* represent country and time, respectively. GDP is gross domestic product per capita and CO_2 is carbon dioxide emissions per capita. e_{it} symbolizes a stationary error term. In this regression model, the slope of the cointegrating relationship (β_i) can vary across countries. b_t is common time trend. Pedroni (2004) builds the group mean ADF test for the null of no cointegration using the residuals of this regression model. The test has a normal distribution under the null hypothesis of no cointegration. The result is as in Table 4.

Table 4. Panel Cointegration Result

	Period	Countries	Group mean ADF	Probability
GDP and CO2	1967-2010	4	-2.079080	0.0188

According to Table 4, one can reject the null hypothesis of no cointegration. In third step, it is focused on whether innovations to GDP per capita have a long-run effect on CO_2 emissions per capita and the sign of this effect. GDP per capita and CO_2 emissions per capita series can be analyzed in the form of a dynamic error correction model, since the series are non-stationary but there is a cointegrating relation between them. To estimate the error correction model, a two-step procedure was followed. Firstly, using fully modified ordinary least squares (FMOLS) technique suggested by Pedroni (2000), the cointegrating coefficients between GDP per capita and CO_2 emissions per capita for each country were estimated. The FMOLS estimation can be applied to a panel which has heterogeneity property across individual members (countries). Producing asymptotically unbiased estimators, FMOLS also produces nuisance parameter free standard normal distributions. In this way, inferences can be made regarding common long run relationships which are asymptotically invariant to the considerable degree of short run heterogeneity that is prevalent in the dynamics typically associated with panels that are composed of aggregate national data (Pedroni 2000, 93-94). That is, FMOLS estimator corrects the standard pooled OLS for serial correlation and endogeneity of regressors that are normally present in long-run relationship. FMOLS results are reported in Table 5.

Table 5. FMOLS Results

	Coefficient	**t Statistic**
Mexico	0.29	2.97***
Indonesia	0.61	8.45***
Nigeria	0.23	1.37*
Turkey	0.60	7.39***
Panel group	0.43	10.09***

**** and * denote significance at the 1 and 10 per cent level, respectively*

According to Table 5, per capita GDP has a positive long-run effect on the per capita CO_2 emissions for all countries. Later the estimated cointegrating relationship was used to construct the disequilibrium term, $\hat{e}_{it} = CO2_{it} - \hat{\alpha}_i - \hat{\beta}_i GDP_{it}$. The estimated error correction model as is follow:

$$\Delta GDP_{it} = c_{1i} + \lambda_{1i}\hat{e}_{it-1} + \sum_{j=1}^{K}\varphi_{11ij}\Delta GDP_{i,t-j} + \sum_{j=1}^{K}\varphi_{12ij}\Delta CO2_{i,t-j} + \varepsilon_{1it} \quad (2)$$

$$\Delta CO2_{it} = c_{2i} + \lambda_{2i}\hat{e}_{it-1} + \sum_{j=1}^{K}\varphi_{21ij}\Delta GDP_{i,t-j} + \sum_{j=1}^{K}\varphi_{22ij}\Delta CO2_{i,t-j} + \varepsilon_{2it} \quad (3)$$

The variable e_{it} represents how far our variables are from the equilibrium relationship and the error correction mechanism estimates how this disequilibrium causes the variables to adjust towards equilibrium in order to keep the long-run relationship intact. The Granger representation theorem implies that at least one of the adjustment coefficients λ_{1i}, λ_{2i} must be non-zero if a long-run relationship between the variables is to hold. If one tests the significance of λ_{2i} for a country, the result of test can be interpreted as whether innovations to per capita GDP have a long-run effect on per capita CO_2 emissions. Furthermore a test for the sign of the ratio $\lambda_{2i}/\lambda_{1i}$, can be interpreted as a test of the sign of the long-run effect of innovations to per capita GDP on per capita CO_2 emissions (Canning and Pedroni, 2008:513). If long-run causality test finds that λ_{2i} is non-zero at acceptable significance level, there should be a persistent long-term relation as founded by FMOLS estimation. So long-run causality test confirms the FMOLS results, the EKC hypothesis cannot be hold, since the hypothesis assumes an inverse-U-shaped relationship between carbon dioxide emission per capita and GDP per capita. Table 6 represents the results of long-run causality test.

Table 6. Long-Run Causality Test Results

	λ_1 = CO2→GDP			λ_2 = GDP→CO2			$-\lambda_2/\lambda_1$
	Estimate	**Test**	**p value**	**Estimate**	**Test**	**p value**	**Estimate**
Mexico	0.01	0.08	0.94	-0.14	-2.20	0.03	0.07
Indonesia	0.08	0.41	0.68	0.04	0.40	0.69	-2.30
Nigeria	-0.08	-0.66	0.51	-0.33	-2.49	0.01	-0.25
Turkey	0.22	1.36	0.17	-0.01	-0.13	0.89	24.28
Group Mean	0.06	0.30	0.62	-0.11	-1.11	0.13	-0.09
Lambda-Pearson		5.76	0.67		16.83	0.03	2.28

According to Table 6 the null hypothesis of non-Granger causality from per capita CO_2 to per capita GDP cannot be rejected for all countries. While there is a uni-directional causal nexus from GDP per capita to CO_2 per capita in the case of Mexico and Nigeria at 5% significance level, no causal relation is found in the pattern of Indonesia and Turkey. Sign ratio ($-\lambda_2/\lambda_1$) is positive for Mexico (0.07). The negative adjustment coefficient (-0.14) implies that the disequilibrium causes the variables to adjust towards cointegrating equilibrium relation. Therefore one concludes that the positive long term relation between GDP per capita and CO_2 emissions per capita is persistent. That is, the EKC hypothesis does not hold in Mexico. However, in the case of Nigeria the sign ratio is negative (-0.25). That is, although the adjustment coefficient is found to be negative, the disequilibrium cannot cause the variables to adjust towards positive cointegrating equilibrium relation. That is while per capita GDP is increasing, the effect of increase in per capita GDP on per capita CO_2 emissions may change. This may be evidence supporting the EKC hypothesis.

The group mean and lambda-Pearson based test give information about the pervasiveness of a long-run causal effect in the whole panel. The group mean test is based on the sample average of the individual country λ_{2i} or λ_{1i} tests and tests the null hypothesis of long-run causal effect is zero on average for the panel. Group mean test indicate that even if the negative sign is found for average λ_{2i}, there is no average causal relation between GDP per capita and CO_2 emissions per capita at 10% significance level. That is average causal relation is zero in the panel.

The lambda-Pearson panel test uses the p values associated with each of the individual country t tests to compute the accumulated marginal significance associated with these. According to lambda-Pearson test there is a uni-directional positive causal relation from GDP per capita to CO_2 emissions per capita. Since the group mean and lambda-Pearson test reach opposite results, one can say that a long-run causal effect is present; however, for some members of the panel it is positive while for others it is negative. Lastly the analyses find no evidence in the favor of presence of causal relation between GDP per capita and CO_2 emissions in Turkey and Indonesia.

4. Concluding Remarks

This study analyzed the causal relation between in the case of MINT countries. The economic growth patterns of MINT countries are so different that it may lead to reach changing findings to the countries. GDP per capita in Mexico and Turkey are about $500 in 1967 and $10,000 in 2010. However, Indonesia GDP per capita increased from nearly $60 in 1967 to $3,000 in 2010. Similarly Nigeria per capita GDP is about $99 in 1967 and $1,500 in 2010. So Mexico and Turkey

GDP growth rates are higher than those of Indonesia and Nigeria. Since the EKC hypothesis urges that there is an inverse U shaped relation between per capita GDP and per capita carbon dioxide emissions, one can expect that the EKC hypothesis may be supported in the case of Mexico and Turkey. But, this study finds no support in favor of the causal relation between GDP per capita and carbon dioxide emissions per capita in Turkey. Furthermore, opposite to the expectation, there is a positive and persistent long term relation between GDP per capita and CO_2 emissions per capita in the case of Mexico.

According to Brock and Taylor (2010) diminishing returns and technological progress are main elements which are reducing emission level as countries mature and approach their balanced growth path. In this scenario, a tightening of pollution policy raises costs and lowers the level of pollution, but not its long run rate of growth. So, the technological progress leads to decrease in pollution level while economic growth slows down. If a country such as Mexico or Turkey does not reach its maturity level, since the rate of technological progress is not enough to suppress the pollutant effect of rapid economic growth, the EKC hypothesis may be invalid.

In the pattern of Indonesia, again, no supportive findings was found about causal nexus between GDP per capita and CO_2 per capita. However, in the case of Nigeria, a negative sign ratio was found. That is the positive effect of increase in per capita GDP on per capita CO_2 emissions may change. So this may be weak evidence supporting the EKC hypothesis.

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