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Bounds testing approach to analysis of the environment Kuznets curve hypothesis

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ABSTRACT

This paper examines the long-run and the dynamic temporal relationships between economic growth, energy consumption, population density, trade openness, and carbon dioxide (CO_2) emissions in Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa based on the environment Kuznets curve (EKC) hypothesis. We employ the ARDL Bounds test to cointegration and CUSUM and CUSUMSQ tests to ensure cointegration and parameter stability. The estimated results show that the inverted U-shaped EKC hypothesis holds in Japan and South Korea. In the other six countries, the long-run relationship between economic growth and CO_2 emissions follows an N-shaped trajectory and the estimated turning points are much higher than the sample mean. In addition, the results indicate that energy consumption Granger-causes both CO_2 emissions and economic growth in all the countries. Our results are consistent with previous studies that show that there is no unique relationship between energy consumption, population density, economic growth, trade openness, and the environment across countries.

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1. Introduction

Achieving higher economic growth at lower intensity of resource use without compromising the quality of life of future generations is a continuing and common concern of governments around the world, one that is exacerbated by the increasing threat of global warming and climate change. An urgent issue for environmental policy makers is to understand and predict how environmental quality will evolve over time with continued increase in economic activity.

Environmental economics uses the environmental Kuznets curve (EKC) to model empirically the economic growth–environmental quality trajectory. The EKC postulates an inverted U-shaped relationship between environmental quality and income per capita. Proponents of the EKC claim that in the early stages of industrialization, environmental degradation increases because greater priority is given to increasing material output, and people are more interested in jobs and income than in public properties like environment and its resources. Higher economic activity, however, demands higher inputs of energy and other natural resources and thus higher emissions of pollutants, which in turn worsen the environmental conditions. At the later stage of industrialization, and as income increases beyond a threshold (known as the "turning point"), the willingness to pay for a clean environment increases by a greater proportion than income; regulatory institutions become more effective in reducing pollution levels leading to gradual improvement of environmental conditions[1] (Panayotou, 1993; Stern, 2004; Dinda, 2004).

Following Grossman and Krueger (1991), who first described the EKC and its potentially promising implications for making economic growth sustainable in the future, a plethora of empirical studies have searched for systematic relationships by regressing different measures of air and water quality on various polynomial specifications of income per capita. In general, the EKC hypothesis holds for certain pollutants, including sulfur dioxide (SO_2), suspended particulate matters (SPM), nitrogen dioxide (NO_2), but less likely for carbon dioxide (CO_2).

While some studies on CO_2 emissions find evidence of an inverted U-shaped path relative to income growth,[2] others find a close positive

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[1] For a thorough survey of theoretical and empirical studies dealing with the EKC please, see Dinda (2004) and Stern (2004).
[2] See, for example Grossman and Krueger (1995), Shafik and Bandyopadhyay (1992), Coondoo and Dinda (2002), Apergis and Payne (2010) and Narayan and Narayan (2010).

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relationship between the two variables.[3] Others find that the turning point income value needed to start decreasing emissions is very high or is nonexistent; and others even find an N-shaped path, which may be interpreted to imply that rising income initially deteriorates environmental quality and then improves it—the standard EKC result—but then with additional income, emissions increase again.[4] The mixed and sometimes inconclusive results from extant empirical studies of the EKC, both for different environmental indicators and also, for different studies looking at the same environmental indicator, is worrisome to environmental decision makers desperately seeking possibilities for simultaneous higher income and improved environmental quality.

Most studies of the EKC use cross-section or panel data (under fixed or random effects) analysis, and the implicit assumption is that the coefficients of the inverted U-shaped relationship are country invariant; which implies that the expected shape of the EKC is the same for every country and the predicted turning point income is also the same for every country.[5] One of the shortcomings of the cross-section or panel data analysis is the fact that countries exhibit significant differences in development paths, macroeconomic conditions, natural resource endowment, trade orientation, climate, culture, socio-political structures, and institutions. Given the heterogeneous structural and technical characters between countries, different countries exhibit different patterns for their relationships between environmental quality and economic growth. Therefore, pooling all countries together and testing one EKC for all of them are a biased procedure because it implicitly assumes that all countries in the sample share the same experience (Unruh and Moomaw, 1998).

Cross-section analysis allows for the likelihood that some important variables which are correlated with income but not common to all countries in the panel could be omitted. Stern and Common (2001) pointed out that omitted important explanatory variables may result in a biased estimate of the EKC in a non-random sample of countries. According to de Bruyn et al. (1998) and Fodha, and Zaghdoud (2010), the conventional panel data estimation techniques have generated spurious EKC estimates because they do not adequately capture the dynamic process involved. Fodha and Zaghdoud (2010) cautioned that EKC results from panel data analysis are unrealistic and dangerous. Vincent (1997, p. 417) argued that an EKC obtained from cross-country regressions "may simply reflect the juxtaposition of a positive relationship between pollution and income in developing countries with a fundamentally different negative one in developed countries, rather than a single relationship that applies to both categories of countries." Stern et al. (1996) suggested that it would be more appropriate to study the relationship between environment and economic growth, analyzing the experience of individual countries using both econometric and historical analysis.

Following the suggestion of Stern et al. (1996), this paper examines the determinants of CO_2 emissions in Brazil, China, Egypt, Japan, South Korea, Mexico, Nigeria, and South Africa by using an estimation equation that incorporates energy consumption, population density, and trade openness into the equation of the environmental Kuznets curve. These linkages have not been thoroughly explored to provide useful policy information for environmental decision makers, particularly in developing countries. This paper presents findings to integrate the environment into economic development decisions.

This study contributes to the literature confirming the relationship between economic growth and environmental quality, which has been empirically modeled for several developed countries. There is little evidence in the context of developing countries using time series data. This underrepresentation is explained by the difficulty of obtaining data of sufficient length for developing countries. Stern et al. (1998) cautioned that this underrepresentation could create bias for the estimated EKC, given the on-going structural changes and specialization in favor of less polluting activities in industrialized countries. To avoid possible bias, it is imperative to include the developing countries, in particular the developing countries of Africa, Asia and South America, in the field of study for better understanding of the evolution of the EKC hypothesis within both developed and developing countries. To this end, this paper tests the EKC hypothesis for a sample of eight countries drawn from industrialized, developing, and emerging market economies. These are countries from different geographical regions and income groups, and who are at different stages of economic development in terms of energy consumption, population growth, income growth, and institutional capacity. The study focuses on the trend of CO_2 emissions of each country and analyzes its relationship with respect to GDP per capita growth conditional on specific energy consumption, trade openness, and population density characteristics. Such an approach maps each country's economic growth–environmental quality trajectory on the EKC before and after the turning point. The results indicating their position on the EKC may be useful to formulate policy recommendations directed at conservation, emission reduction, and economic growth and may prove relevant to other countries that have to go through a similar development path.

Second, most previous studies of the EKC have been conducted over a relatively short time horizon and have not taken into account structural breaks in the data series. The use of small sample size creates problem with hypothesis tests with low statistical power and higher confidence interval.[6] Central limit theory suggests that as the size of the sample becomes large, the sampling distribution of the sample mean approaches a more normal distribution, which calls into question the robustness of the results relative to an analysis over a longer time horizon. Moreover, as noted by Perron (1989) and Enders (2004), the ignorance of structural breaks may bias test for unit root to suggest the presence of unit root even though the data generating process is trend stationary. This study overcomes the small sample deficiencies by employing a reasonably longer sample size of about four decades and controlling for possibility of structural breaks in unit root tests along with performing bounds test for cointegration, variance decompositions analysis, Granger causality tests, and CUSUM and CUSUMSQ tests for stability of the economic growth–environmental quality nexus. These allow for a more in-depth analysis of the interrelationships among the variables and enable the determination of the variables with stronger effects. Third, this study emphasizes identifying turning points of the EKC that have not been adequately looked at, using more up-to-date data.

The rest of the paper is organized as follows: Section 2 provides a review of the EKC literature. In Section 3 we discuss the econometric methodology and data used in estimation. Section 4 presents the empirical results and a discussion of the results. Policy implications of the results are presented in Section 5. Our conclusions are reported in Section 6.

2. Literature review

The relationship between economic growth and environmental pollution as well as, energy consumption and economic growth, has been one of the most widely investigated topics in the economics literature during the last few decades. Grossmann and Krueger (1991) who investigated the environmental impacts of the North American Free Trade Agreement and discovered that the relationship between the total discharge of various environmental pollutants and economic growth

[3] See, for example Shafik (1994), Cole et al. (2000), Akbostanci et al. (2009), Ozturk and Acaravci (2010) and Pao and Tsai (2010).

[4] See, for example Shafik and Bandyopadhyay (1992), Grossman and Krueger (1995), Moomaw and Unruh (1997), Dinda et al. (2000), Friedl and Getzner (2003), Cole (2004), Martínez-Zarzoso and Bengochea-Morancho (2004) and Lipford and Yandle (2010).

[5] According to Dijkgraaf and Vollebergh (1998, p. 3–4): "The question, not answered by the empirical studies is what the intuition behind this implicit assumption is. It seems strange that countries, which are very different in geographical conditions, culture and history, would react identical".

[6] See, Zachariadis (2007) for detailed discussion of the limitations associated with a small sample size in terms of inferences drawn from causality tests.

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