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Is economic growth good or bad for the environment? Empirical evidence from Korea

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ABSTRACT

The effects of economic growth on the environment in Korea, for a given level of energy consumption, and fossil fuels and nuclear energy in electricity production, are examined in a dynamic cointegration framework. To that end, the autoregressive distributed lag (ARDL) approach is used. We find empirical evidence supporting the existence of the environmental Kuznets curve (EKC) hypothesis for Korea; that is, economic growth indeed plays a favorable role in influencing environmental outcomes. It is also found that, in both the short- and long-run, nuclear energy has a beneficial effect on environmental quality, whereas fossil fuels in electricity production and energy consumption have a detrimental effect on the environment.

1. Introduction

It is conventional wisdom in environmental economics that the *environmental Kuznets curve* (EKC) hypothesis is used to examine the environmental consequences of economic growth. The EKC hypothesis postulates an inverted-U-shaped relationship between income per capita and certain types of pollution (e.g., SO_2 and CO_2 emissions). More specifically, in the early stages of economic development, pollution levels increase rapidly with growing income, because high priority is given to increases in material output and people are more concerned about economic growth than environmental protection. In the later stage, on the other hand, people increase their demand for a clean environment with higher income levels and hence regulatory institutions enforce strict environmental regulations, thereby contributing to a lower pollution levels. Hence, the combination of these two effects posits that the relationship between income and pollution levels resembles an inverted-U curve. The EKC implies that, since economic development is possibly compatible with environmental improvement, economic growth can be a part of the solution for environmental problems (Kijima et al., 2010).

Since the early 1990s, a considerable number of empirical studies have tested the EKC hypothesis for many countries using a variety of environmental indicators (e.g., SO_2, CO_2, CO, SPM, etc.) (See Dinda, 2004; He, 2007; Kijima et al., 2010 for detailed overview of the previous studies). Plenty of empirical studies have found evidence of the existence of the trade-off between economic growth and the environment (e.g., Baek et al., 2009; Grossman and Krueger, 1991; Iwata et al., 2010; Jalil and Mahmud, 2009; Kim and Baek, 2011; Liu, 2005; Nasir and Rehman, 2011; Panayotou, 1993; Shafik and Bandyopadhyay, 1992); for example, Liu (2005) finds empirical evidence of the EKC for CO_2 emissions in OECD countries. Some studies, however, have found little evidence of the EKC (e.g., Dinda, 2001; Harbaugh et al., 2002; Holtz-Eakin and Shelden, 1995; Iwata et al., 2011; Robers and Grimes, 1997; Soytas et al., 2007); for example, Iwata et al. (2011) show that the EKC hypothesis for CO_2 emissions does not hold for non-OECD countries. The mixed empirical evidence emerging from the literature suggests that, given wide cross-country variations observed in social, economic, political and biophysical factors that may affect the environment and various stages of economic development in different countries, the findings obtained from one country using specific environmental indicators cannot be generalized for other countries and/or other types of pollutants. In other words, the EKC is an individual country and/or indicator specific phenomenon as the results vary according to countries and/or measures of environmental quality (Dinda, 2004; Nasir and Rehman, 2011). Hence, it is more desirable to conduct a separate study for an individual country in order to identify the main factors affecting specific environmental indicators accurately.[2] Until recently, however, relatively limited efforts have been made to investigate evidence of a

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[2] Examples that test the EKC hypothesis for an individual country include Baek et al. (2009), Kim and Baek (2011), Chang (2010), and Nasir and Rehman (2011). For example, Baek et al. (2009) find empirical evidence of the EKC for SO_2 emissions in developed countries such as Japan, Canada and U.S. Nasir and Rehman (2011) confirms the existence of the EKC for CO_2 emissions in Pakistan.

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link between economic growth and environmental quality in Korea. This study thus attempts to fill this gap.

The objective of this study is to empirically examine the existence of the EKC for CO_2 emissions in Korea. The debate regarding the link between global warming and emission of greenhouse gases (GHGs) has recently been received a great deal of attention. Since, among other GHGs, carbon dioxide (CO_2) emissions emitted by energy consumption (i.e., combustion of fossil fuels) are considered to be the major culprit behind global warming, CO_2 emissions have been the most commonly used indicator in the recent EKC literature. In addition, electricity is generally produced from conventional thermal (fossil fuel) sources (e.g., coal, oil and natural gas) and nuclear power; when producing electricity, the former generally generates greater amounts of CO_2 emissions, while the latter emits far lower levels of CO_2 emissions. The empirical focus, therefore, is on the assessment of the short- and long-run effects of income growth on CO_2 emissions in Korea, controlling for energy consumption, as well as thermal sources and nuclear energy in electricity production. Korea generates approximately 60% of its electricity from conventional thermal sources; in 2008, for example, approximately 67% of thermal generation was coal-fired, 29% was natural gas-fired and 4% was oil-fired. In addition, since the first commercial operation of the Kori nuclear power plant in 1978, Korea has been the world's fifth largest nuclear energy production country (after U.S., France, Japan, and Russia). Accordingly, nuclear power has accounted for a substantial portion of Korea's electricity generations over the past decades; between 1989 and 2007, for example, Korea generated approximately 40% of its electricity from nuclear plants (Fig. 1).

To conduct a formal test of the EKC for Korea, we use an autoregressive distributed lag (ARDL) approach to cointegration or an ARDL bound testing approach (referred to here as ARDL model) developed by Pesaran et al. (2001). This approach is used for several reasons. First, the ARDL can be applied irrespective of whether the underlying regressors are $I(0)$ or $I(1)$, and hence avoids uncertain unit roots and the pre-testing problem. Second, because an error-correction model can be derived from the ARDL model via a simple linear transformation, the ARDL is commonly employed to estimate the short- and long-run parameters of the model simultaneously. Third, the ARDL is proven to be more robust and performs better for finite and small sample sizes (Panopoulou and Pittis, 2004; Pesaran et al., 1998).

It is worth mentioning that our paper is part of a recently emerged body of literature; a number of studies have sought to investigate the effect of income growth on CO_2 emissions, after controlling for nuclear power and/or energy consumption (e.g., Apergis and Payne, 2009; Chang, 2010; Iwata et al., 2011; Narayan and Narayan, 2010; Richmond and Kaufman, 2006). Studies, however, have mostly concentrated on examination of the CO_2 emissions-income-energy consumption nexus using panel data of a group of countries. Few studies have been conducted to investigate CO_2 emissions-income-energy consumption-nuclear energy nexus with individual country-specific data and time-series models as we intend to do in this paper. To our knowledge, Iwata et al. (2010) are perhaps the first and only study that has addressed this issue. They use the ARDL model to examine the effect of economic growth on CO_2 emissions in France, after controlling for nuclear energy (and energy consumption); they find that the EKC hypothesis holds for France and that nuclear energy plays a key role in improving environmental quality.[3]

The remainder of this paper is organized as follows. The next section introduces the empirical model associated with the ARDL modeling and the data used for the analysis. The following section discusses the empirical results. The last section makes some concluding remarks.

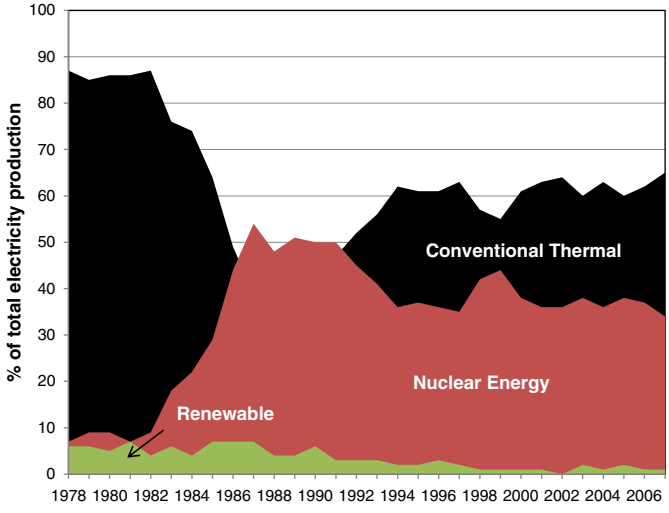

Fig. 1. Percentage of electricity production by type in Korea, 1978–2007.

2. Methodology

2.1. Equations to be estimated

In examining the EKC hypothesis, empirical studies have typically employed a reduced-form model in which the environmental indicator is a (nonlinear) quadratic function of income as follows:

$$e_t = \alpha_1 + \beta_1 y_t + \beta_2 y_t^2 + \beta_3 z_t + \varepsilon_t \quad (1)$$

where e_t is an environmental indicator — e.g., CO_2 emissions in this study; y_t is income; z_t is other factors influencing environmental degradation — e.g., energy consumption and electricity production in this study; and ε_t is an error-term. It is important to note that, since Korea's first nuclear plant was completed in 1978, electricity generated by nuclear power can only be traced back to 1978. For this reason, we compile two datasets for the empirical analysis: the first dataset contains every variable but the nuclear power for the 1971–2007 period (case I), and the second dataset covers all variables for the 1978–2007 period (case II). Hence, our two models are stated as follows:

Case I.

$$\ln(CO_2)_t = a_0 + a_1 \ln Y_t + a_2(\ln Y_t)^2 + a_3 \ln EN_t + a_4 THR_t + \varepsilon_t \quad (2)$$

Case II. [4]

$$\ln(CO_2)_t = b_0 + b_1 \ln Y_t + b_2(\ln Y_t)^2 + b_3 \ln EN_t + b_4 NUR_t + \mu_t \quad (3)$$

where *ln* is the natural logarithmic form; CO_2 is the per capita CO_2 emissions; Y is the per capita real GDP; EN is the energy consumption; THR is the electricity production from conventional thermal sources or fossil fuel sources (e.g., coal fired, natural gas-fired and oil-fired); and NUR is the electricity production from nuclear source. The EKC hypothesis predicts that the coefficient on the income is positive ($a_1 > 0$ and $b_1 > 0$) and the coefficient on the squared income is negative ($a_2 < 0$ and $b_2 < 0$), so that we observe an inverted-U-shaped relationship. Since an increase in energy consumption leads to an

[3] Iwata et al. (2012) recently published an article that analyzed the CO_2 emissions-income-nuclear energy nexus for 11 OECD individual countries (including Korea) using an ARDL model; they find that the EKC holds for Finland, Japan, Korea and Spain. It should be pointed out, however, that we did not recognize this paper because it was not available at the time this paper was submitted to the journal.

[4] Inclusion of conventional thermal and nuclear sources in the model would yield unacceptable coefficient estimates, due mainly to multicollinearity between them; for example, the correlation coefficient between thermal sources (THR) and nuclear power (NUR) over the sample period is −0.99. For this reason, we drop the thermal sources from case II.