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CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis

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ABSTRACT

This paper investigates the causal relationship between energy consumption, carbon dioxide emissions, economic growth, trade openness and urbanization for a panel of new EU member and candidate countries over the period 1992–2010. Panel unit root tests, panel cointegration methods and panel causality tests are used to investigate this relationship. The main results provide evidence supporting the Environmental Kuznets Curve hypothesis. Hence, there is an inverted U-shaped relationship between environment and income for the sampled countries. The results also indicate that there is a short-run unidirectional panel causality running from energy consumption, trade openness and urbanization to carbon emissions, from GDP to energy consumption, from GDP, energy consumption and urbanization to trade openness, from urbanization to GDP, and from urbanization to trade openness. As for the long-run causal relationship, the results indicate that estimated coefficients of lagged error correction term in the carbon dioxide emissions, energy consumption, GDP, and trade openness equations are statistically significant, implying that these four variables could play an important role in adjustment process as the system departs from the long-run equilibrium.

1. Introduction

Industrial revolution not only started a new era of rapid economic growth among countries but also brought about today's renowned phenomena, global warming and climate change. One of the major aspects of the industrial revolution is transforming the global economy from organic economies based on human and animal power, to inorganic economies based on fossil fuels. The use of fossil fuels unequivocally and continuously disrupted the carbon levels in the atmosphere and therefore causing the heat to be preserved in the atmosphere. This process leads to global warming and climate change. The Intergovernmental Panel on Climate Change (IPCC) report of 2007 reveals that there is a close link between the global average temperature and Green House Gases (GHG) emissions. For instance, the GHG emissions have increased about 1.6% per year with carbon dioxide (CO_2) emissions from the use of fossil fuels about 1.9% per year over the last three decades. The IPCC also reported that the average global temperature was estimated to rise between 1.1 and 6.4 °C in the next 100 years.

The CO_2 emissions from energy consumption have significantly increased in newly industrialized countries since the 1990s compared to industrialized countries. The deterioration of environmental quality has reached to alarming levels and raised concerns about global warming and climate change. Hence, understanding the reasons behind environmental degradation and its relation with economic growth has become increasingly important in recent years. The effects of economic growth on environment have become a common ground of research among economists. Two parallel literatures on the relationship between economic growth and environmental pollution have emerged. The first group of studies has investigated the economic growth and environment nexus in the framework of the Environmental Kuznets Curve (EKC). The EKC was derived from the original Kuznets curve, which investigates the relationship between per capita income and inequality. Kuznets (1955) hypothesized that income inequality first rises and then falls as income per capita increases. Hence, the EKC hypothesis states that as income increases, carbon emissions increase as well until a threshold level of income is reached, after which carbon emissions start to decrease. In this framework, emission is specified as a function of per capita income, which presumes a unidirectional causality running from income to emissions. The validity of the EKC hypothesis and the causal links between emissions and income have been investigated in numerous studies (see for example, Agras and Chapman, 1999; Coondoo and Dinda, 2002; Dinda and Coondoo, 2006; Akbostanci

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et al., 2009; Galeotti et al., 2009; Lee and Lee, 2009). The main problem of these studies is that they suffer from the problem of omitted variable bias.

The second group of studies on the relationship between income and environment has concentrated on the income and energy consumption nexus, because CO_2 emissions are mostly generated by the use of fossil fuels. In this framework, economic growth and energy consumption might be jointly determined and causal direction between these two variables cannot be determined in advance. Many studies have analyzed the relationship between income and energy consumption using data from different countries and regions since the seminal study by Kraft and Kraft (1978) (see for example, Erol and Yu, 1987; Bentzen and Engsted, 1993; Altinay and Karagol, 2004; Soytas and Sari, 2006; Al-Iriani, 2006; Narayan and Smyth, 2008; Apergis and Payne, 2009; Gurgul and Lach, 2011). The main limitation of this group is that they considered the link between income and environment in a bivariate framework as in the EKC framework and hence suffers from omitted variable bias.

The synthesis of above two literatures has created a relatively new research area. This third group of studies has focused on the relationship between emissions, energy consumption and income. Most studies in this group are for single countries (see for example, Ang, 2007; Ang, 2008; Soytas, et al., 2007; Zhang and Cheng, 2009; Halicioglu, 2009; Soytas and Sari, 2009; Wang, et al., 2011). A few studies used cross-country data to investigate this relationship (see for example, Sari and Soytas, 2009; Ozcan, 2013; Farhani et al., 2014). These studies, however, produce mixed results.

The main objective of this paper is to investigate the relationship between carbon emissions, energy consumption, and income for a panel of new member and candidate countries of the EU over the period 1992–2010 and to produce new evidence on the economic growth and environment nexus. The contribution of this paper to the related literature is three-fold: first, the EKC hypothesis has not been tested for our sampled countries. Most sampled countries are oil importing countries. Hence, examining the relationship between income and environment for these countries might reveal important information on this issue. Second, a very few studies include trade into the relationship as an additional variable. This study also provides information on the impact of trade openness on the emissions for a sample of countries. This might also solve omitted variable bias problem that previous studies faced. Finally, to our best knowledge, this is the first study that includes urbanization in the relationship between income and environment within the framework of the EKC. Overall, this paper examines the dynamic relationship between carbon emissions, energy consumption, income, trade openness and urbanization and tests the EKC hypothesis for the panel of new EU member and candidate countries.

The rest of the paper is organized as follows. Section 2 discusses the main models and econometric methodology. Section 3 discusses the empirical results of the estimations. Section 4 concludes with a summary of the findings and policy implications.

2. The model and econometric methodology

2.1. The model

To examine the relationship between carbon dioxide emissions, national income and energy consumption, which is a combination of the Environmental Kuznets Curve (*EKC*) and energy consumption growth literature, we employ the similar methodology proposed by Apergis and Payne (2009, 2010), Lean and Smyth (2010) and Arouri et al. (2012). The long-run relationship between above variables is specified as follows:

Model 1:

$$CO_{2it} = \alpha + \beta_1 PGDP_{it} + \beta_2 PGDP_{it}^2 + \beta_3 EC_{it} + \varepsilon_{it} \quad (1)$$

All variables are in natural logarithm. The subscripts *i* and *t* represent country and time, respectively. CO_2 is the per capita carbon dioxide emissions in metric tons. *PGDP* and $PGDP^2$ stand for the per capita real *GDP* and square of per capita real *GDP*, respectively. *EC* represents per capita energy consumption. The coefficients β_1, β_2 and β_3 are the long-run elasticities of CO_2 emissions with respect to per capita real *GDP*, squared per capita real *GDP* and per capita energy consumption, respectively. Under the *EKC* hypothesis, it is expected that $\beta_1 > 0$ and $\beta_2 < 0$. Hence, there is an inverted U-shaped pattern at which point an increase in income leads to lower emissions. It is also expected that an increase in energy consumption leads to an increase in emissions (i.e., $\beta_3 > 0$).

The impact of international trade on environment has been investigated by Antweiler et al. (2001) and Cole and Elliott (2003). International trade causes the movement of final and intermediary goods from one country to another for either consumption or for further production process. Increase in consumption and production due to international trade is one of the sources of pollution. Hence, trade openness might be controlled in the above regression. However, the impact of trade on emissions is an empirical issue. Halicioglu (2009), Jalil and Mahmud (2009), Jayanthakumaran et al. (2012), and Farhani et al. (2014) suggest that the impact of trade on the emissions–income–energy nexus should be investigated. Moreover, the share of urban population can also be controlled in the regression due to the fact that some cities in most countries are growing at a faster rate than the national average, which put some pressure on urban resources and environment. Particularly, in developing and transition countries, workers are migrating from rural to urban areas for better jobs, life, education and treatment. Growing urban population can be considered as another source of pollution. Overall, including the trade openness and the share of urban population in the model can be a solution for the problem of omitted variable bias in the econometric estimation. Hence, the extended quadratic *EKC* model is specified as follows:

Model 2:

$$CO_{2it} = \alpha + \beta_1 PGDP_{it} + \beta_2 PGDP_{it}^2 + \beta_3 EC_{it} + \beta_4 TO_{it} + \beta_5 UR_{it} + \varepsilon_{it} \quad (2)$$

where *TO* and *UR* denote trade openness and the share of urban population, respectively. The signs of β_4 and β_5 are expected to be positive.

2.2. Econometric methodology

The main objective of this paper is to test whether there is a long-run and dynamic causal relationship between carbon dioxide emissions, energy consumption, national income, trade openness and urbanization. The testing procedure consists of the following steps. In the first step, the stationarity properties of the time series variables are examined using alternative panel unit root tests. If these variables are non-stationary, the second step is to test whether there is a cointegrating relationship between the series, using appropriate panel cointegration techniques. Then, if the variables are cointegrated, the long-run elasticities are estimated using the fully modified OLS method. Finally, the third step estimates panel error correction models to examine the interactions between short and long-run dynamics of the series.

2.2.1. Panel unit root tests

In this study, four types of unit root tests are used to determine the order of integration of the series since none of the panel unit root test is free from statistical shortcomings with respect to size and power properties.

Breitung (2001) considers the following equation:

$$y_{it} = \alpha_{it} + \sum_{k=1}^{p+1} \beta_{ik} x_{it-k} + \varepsilon_{it}. \quad (3)$$

In the above equation, the Breitung (2001) test statistic tests the following null hypothesis that the process is difference stationary: