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Energy Consumption, Economic Growth and Carbon Emission: Dynamic Panel Cointegration Analysis for Selected OECD Countries

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Abstract

One of the important inputs to the production process is energy. Energy consumption is proportional to a country's economic growth. Energy consumption and energy supplied from fossil fuels in production process, cause carbondioxide (CO_2) emissions and environmental deterioration. In this study, casual relationships among economic growth, energy consumption and CO_2 emissions were investigated for selected eleven OECD countries(Brasil, France, Greece, Italy, Korea Republic, Mexico, Netherland, Poland, Spain, Turkey, UK, USA) and Brasil over the period 1970-2011. In this study, firstly, Cross Sectionally Dependency (CD) in a country was examined by using CDLM test (Cross Sectionally Dependency Lagrange Multiplier) developed by Pesaran (2004). Stationary of series was investigated with CADF test (Cross-Sectionally Augmented Dickey-Fuller) developed by Pesaran (2006) by considering CD. Cointegration relationship among series was examined by using panel cointegration test with multiple structural breaks developed by Basher and Westerlund (2009). As a result of the empirical analysis, cointegration relationship between the series was determined.

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1. Introduction

The relationship between economic growth, energy consumption and carbon emission is a subject which have long been discussed in energy and environmental economics literature. According to several empirical findings, this relationship can be categorized into four groups; while the first group of findings suggests that energy consumption

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stimulates the growth and there is a one-way relationship, the second group argues that energy consumption increases as a result of economic growth, the third group argues that the causality relationship is bidirectional. According to the last groups' findings there is no causality relationship between energy consumption and economic growth.

However, the relationship between economic development and carbon dioxide emissions is formed with the framework of Environmental Kuznets curve (EKC) hypothesis in literature. According to this hypothesis, the emission rates are high in the first stage of the development of the countries, but after a particular development level the emissions get lower and lower as a result of further economic growth.

When the empirical literature is analysed, studies concentrate on the relationship between energy consumption–economic growth and carbon emissions-economic growth (Payne, 2010; Öztürk, 2010). As the seriousness of global warming and its negative impacts on environment received greater attention on international community, many studies particularly focused on the relationship between energy consumption especially the use of fossil fuels and CO_2 emissions (Soytaş and Sarı, 2009a).

When we look at the energy-growth-environment (EGE) studies, Soytaş et al. find Granger non-causality between economic growth and emissions for the US economy. Ang (2007) finds that, in France, economic growth leads both energy use and pollution growth. In China, while Zhang (2000), Zhang and Cheng (2009) and Wang et al. (2011) find that economic growth drives carbon emissions, Jalil and Mahmud (2009) support evidence on the validity of the EKC hypothesis. Even though Halicioglu (2009) supports bi-directional link, neither Soytas and Sari (2009b) nor Ozturk and Acaravcı (2010) find causal link among the variables for Turkey. For the panel consists of six Central American countries, Apergis and Payne (2009) supports the EKC hypothesis.

Stern (2000) for the USA , Masih and Masih (1996) for India, Soytaş and Sarı (2003) for France, Germany and Japan found the results supporting that there is a strong connection between economic growth and energy consumption. When the studies are generally considered in literature, it is difficult to say that there is a consensus about the direction of the relationship between energy- economic growth and environment. However, it can be said that energy consumption generally increases economic growth and carbon emissions.

2. Analysis

The annual data for 1970-2010 period for 11 selected OECD countries and for Brasil were used in the analysis. The country selections were based on a few criteria; to represent developed and emerging economies, to consider economic closeness and level of integration and finally to represent Annex-B countries and non-Annex-B countries in Kyoto Protocol. Variables of the study are Gross Domestic Product (GDP, 2000 fixed prices), energy consumption (EC, kg of oil equivalent per capita) and CO_2 emissions (CE, metrics ton per capita). Variables are included in logarithmic terms in this analysis. The Data is obtained from the web site of the World Bank (www.worldbank.org.tr) and International Financial Statistics (IFS) which is the database of UNCTAD and IMF. For the analysis Gauss-9 program, codes for this program and Stata-11 package program are used.

2.1. Testing the cross-sectional dependency

Before proceeding with further steps, cross-section dependence must be tested. Otherwise, results may be biased and inconsistent (Breusch and Pagan, 1980; Pesaran, 2004). Therefore, prior to further analyses, the existence of cross-section dependency in the series and the cointegration equation should be tested.

The existence of a cross-section dependency among countries is tested via the Breusch-Pagan (1980) *LM* test when time dimension is greater than the cross-section dimension. Pesaran (2004) improved this test in the case of when time dimension is smaller than the cross-section dimension and when the time dimension is greater than the cross-section dimension. This test is biased when the average group is zero, but the average individual is different from zero. Pesaran et al. (2008) adjusted this deviation by adding the variance and the average to the test statistics. Therefore, it is called the bias-adjusted *LM* test (LM_{adj}). The adjusted form of LM_{adj} test statistics is as the following:

$$LM_{adj} = \left(\frac{2}{N(N-1)}\right)^{1/2} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(\hat{\rho}_{ij}^2 \frac{(T-K-1)\hat{\rho}_{ij} - \hat{\mu}_{Tij}}{\upsilon_{Tij}}\right) \sim N(0,1) \quad (1)$$