



Energy conservation and sustainable economic growth: The case of Latin America and the Caribbean

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ARTICLE INFO

Article history:

Received 14 February 2011

Accepted 6 April 2011

Available online 8 May 2011

Keywords:

Energy consumption

Carbon dioxide emissions

Latin America and the Caribbean

ABSTRACT

This study examines the causal relationships among energy consumption, economic growth and carbon dioxide emissions in twenty countries from Latin America and the Caribbean region. The methodology includes the use of Phillips and Perron (PP) tests, a cointegration model with vector error correction modeling (VECM) and vector autoregression (VAR) with Granger causality. The study concludes that of the twenty countries analyzed, only in four of them will it be possible to implement energy conservation policies without affecting their economic growth, four others are not able to consider an energy conservation policy with economic growth, and the other twelve should focus on their economic growth before adopting any conservation policies. Energy efficiency was found in this region, especially in the countries which have both cointegration and short-term equilibrium.

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1. Introduction

Environmental issues will play an essential role in determining the characteristics of and options for economic development in this century. Nowadays, the most important environmental problem is global warming, since it is affecting not only natural ecosystems but also economic activity. Global warming is generated by greenhouse gases emissions (GHG), which rise into the atmosphere and trap the sun's energy, keeping heat from escaping. The increase in GHG emissions is fundamentally linked to various human activities. One of the principal GHG is carbon dioxide, which enters the atmosphere through the burning of fossil fuels (oil, natural gas and coal), solid waste, trees and wood products and also as a result of other chemical reactions (e.g., in the manufacturing of cement). As Ang (2007) and Kuntsi-Reunanen (2007) have pointed out, energy consumption is a key determinant of carbon dioxide emissions, and so they can be reduced by reducing energy consumption.

In order to reduce the effects of this environmental problem, governments must develop and implement energy conservation policies. However, energy consumption often affects economic growth, as was demonstrated by Hondroyannis et al. (2002), Ghali and El-Sakka (2004), Paul and Bhattacharya (2004), Oh and Lee (2004), Ho and Siu (2007), Erdal et al. (2008), Bowden and Payne (2009), Zhang and Cheng (2009) and Chang (2010), and thus the

creation of any energy conservation policy could lead to a reduction in economic growth and finally to a fall in income and employment.

Currently, Latin America and the Caribbean are suffering the effects of climate change more than any other region. The Economic Commission for Latin America and the Caribbean (ECLAC) reported at the Copenhagen Summit (Barcena et al., 2009) that if no international agreement is reached to mitigate the effects of this environmental problem, the cost for the region could be equivalent to 137% of its current GDP by 2100.

According to World Bank Development Indicators in 2009, the GDP and per capita GDP of the Latin American and the Caribbean countries saw a marked improvement from 2000 to 2008, when per capita GDP rose at a rate of 2.2% per year, compared with only 1.5% in the previous ten years. In addition, the per capita energy consumption in Latin America and the Caribbean has also followed an overall upward trend. The average energy consumption growth rate over the period 1970–2007 was 3.15% per year, compared with only 2.11% worldwide. Furthermore, the average growth rate of carbon dioxide emissions related to the energy consumption within this region over the period 1980–2005 was 1.76% annually, compared with 0.94% for the rest of the world EIA in 2008.

There have been a great number of studies concerning the causal relationship between energy consumption and economic growth for individual countries since 1978 (Akarca and Long (1980) in the U.S.; Glasure and Lee, 1998; Aqeel and Butt, 2001; Erdal et al., 2008; Bowden and Payne, 2009). However, although researchers have studied some of the countries from Latin America and the Caribbean, few of them have analyzed them all in the same work.

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The direction of the causal relationship between energy consumption and economic growth could assume four forms: (1) no causality (neutrality hypothesis) between energy consumption and economic growth, which implies neither conservative nor expansive policies in relation to energy consumption have any effect on economic growth; (2) uni-directional causality (conservation hypothesis) running from GDP to energy consumption, which implies that energy conservation policies may be implemented with little or no adverse effects on economic growth; (3) uni-directional causality (growth hypothesis) running from energy consumption to economic growth, which implies that restrictions on the use of energy may adversely affect GDP, while increases in energy consumption may contribute to economic growth; (4) bi-directional causality (feedback hypothesis) between energy consumption and GDP, and thus any energy conservation policy will adversely affect the economic output, while an increase in the economic output will increase the level of energy consumption.

The neutrality hypothesis between GDP and energy consumption was proved by Akarca and Long (1980), Yu and Hwang (1984), Yu and Jin (1992), Cheng (1995), Apergis and Payne (2009c) in the US, Fatai et al. (2004) in New Zealand, Altinay and Karagol (2004), Jobert and Karanfil (2007), Halicioglu (2009) and Soytas and Sari (2009) in Turkey, Yu and Choi (1985), Erol and Yu (1987) and Lee (2006) in the UK, Glasure and Lee (1998) and Chiou-Wei et al. (2008) in South Korea and Lee (2006) in Germany.

The conservation hypothesis running from GDP to energy consumption was demonstrated by Kraft and Kraft (1978) and Abosedra and Baghestani (1991) in the US, Cheng and Lai (1997) in Taiwan, Cheng (1998) in Japan, Aqeel and Butt (2001) in Pakistan, Lise and Van Montfort (2007) and Ang (2008) in Malaysia, Masih and Masih (1996) in Indonesia, Al-Iriani (2006) in six West Asian countries and Mehrara (2007) in 11 oil exporting countries.

The growth hypothesis running from energy consumption to economic growth was proved by Stern (1993) and Soytas et al. (2001) in Turkey, Oh and Lee (2004) in Korea, Wolde-Rufael (2004) in Shanghai, Lee and Chang (2005) in Taiwan, Ang (2007) in France, Ho and Siu (2007) in Iran, Chang (2010) in China, Erol and Yu (1987) in Canada, Masih and Masih (1996) in India, Glasure and Lee (1998) in Singapore, Narayan and Smyth (2008) in the G7 countries, Bowden and Payne (2009) in the US and Apergis and Payne (2009b) in Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

The feedback hypothesis between energy consumption to economic growth was demonstrated by Hwang and Gum (1992) and Masih and Masih (1997) in Taiwan, Glasure (2002) in Korea, Hondroyannis et al. (2002) in Greece, Ghali and El-Sakka (2004) in Canada, Paul and Bhattacharya (2004) in India, Erdal et al. (2008) in Turkey, Belloumi (2009) in Tunisia, Nachane et al. (1988) in 16 countries, Masih and Masih (1996) in Pakistan, Asafu-Adjaye (2000) in the Philippines and Thailand, Soytas and Sari (2003) in Argentina, Soytas and Sari (2006) in Canada, Italy, Japan and the UK, Lee and Chang (2007) in 22 developed countries, Lee et al. (2008) in 22 OECD countries and Apergis and Payne (2009a) in Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

Based on the previous studies, the principal reasons for testing the causal relationship between economic growth and energy consumption, in both the short and long term, for each of the twenty Latin American and the Caribbean countries analyzed in this study are as follows:

1. The fact that energy consumption in this region is growing faster than the energy consumption in the rest of the world (with the exception of China), and these countries are thus becoming increasingly important in the efforts to combat climate change.

2. The fact that the Latin American and the Caribbean countries are suffering the effects of climate change more than other regions, and that the real GDP of this region is following an upward trend.
3. The fact that previous studies have not tested the energy consumption—economic growth causal relationship for most of the countries in this region, and in order to create effective conserving energy policies it is important to know more about this relationship.

The purpose of this study is to know in which of the twenty Latin American and Caribbean countries analyzed it will be possible to create energy conservation policies to mitigate global warming without affecting economic growth. This is accomplished by using a similar model to the one presented by Ang (2007), with which he examined the causal relationship between carbon dioxide emissions, energy consumption and economic growth in France. In this study, the model has been modified to test the relationship among the variables in a linear form for Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and Venezuela, over the period 1971–2005.

The principal contribution of this study will be to provide energy conservation policy advice to reduce climate change without affecting economic growth in the Latin American and Caribbean region, helping them to achieve more sustainable development.

This research paper is divided into four sections: Section 1 includes the research background, literature review and purpose, while Section 2 features the methodology behind the data collection, cointegration, vector error correction and Granger causality test. Section 3 contains the empirical components of the study. Lastly, this paper ends with conclusions and policy suggestions drawn from the research findings.

2. Methodology

This section presents the research design of the study, research variables, data collection and data analysis procedures, which include Phillips and Perron unit roots tests, cointegration, vector error correction modeling, vector autoregression and Granger causality tests.

2.1. Data

Annual data for the energy consumption, gross domestic product, and carbon dioxide emissions for the twenty Latin American and Caribbean countries comes from the same source, the 2009 World Development Indicators database from the World Bank. Due to data availability, the analysis is confined to the period 1971–2005, and all the data has been compiled for individual countries. The energy consumption (E) is measured in kilotons of oil equivalent; the gross domestic product (GDP) in millions of U.S. dollars at constant 2000 prices; and the carbon dioxide emissions (C) data in kilotons of carbon.

2.2. Data analysis procedure

In order to test the stationarity of the time series, Phillips and Perron (PP) unit roots tests were used (Phillips and Perron, 1988), first in levels and then in first differences. If a variable was found to be $I(1)$ (non-stationary in levels and stationary when first differenced), then it was included in the next step of the analysis, otherwise it was excluded from further analysis. When deciding

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