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Ecological footprint and real income: Panel data evidence from the 27 highest emitting countries

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ABSTRACT

This study examines the effects of real income, financial development and trade openness on the ecological footprint (EF) of consumption using a panel data of leading world EF contributors during the period 1991–2012. A number of panel unit root tests confirm that the data are first-difference stationary. Results from Pedroni co-integration tests show that the variables are co-integrated. The panel dynamic ordinary least squares (DOLS) method is then employed to estimate the long run association between the variables. The results indicate a positive and significant association between ecological footprint (EF) and real income, and a negative and insignificant impact of trade openness on EF. Financial development is also observed to reduce EF. Afterwards, the group-mean fully modified ordinary least squares method is applied to check the robustness of the DOLS estimates. The findings are partially robust as only real income confirms the positive significant impact on EF. In addition, the vector error correction model supports a unidirectional causal impact running from real income to EF. Finally, findings from variance decomposition analysis and impulse response functions reveal that real income will have an increasing effect on EF for the selected countries into the future.

1. Introduction

Humanity is currently confronted with two major challenges: economic development and preserving the earth's environment. The environment has come to the forefront of contemporary issues for both developed and developing countries primarily as a result of accumulation of greenhouse gases (GHGs) in the atmosphere resulting in an increase in mean global temperatures. With the rapid growth in industrialization over the past 200 years, the world has witnessed a significant rise in energy demand that has made the trade-off between economic development and environmental impact increasingly difficult to manage as this demand has been satisfied by energy production mostly from non-renewable fossil fuels that cause GHG emissions.

In the light of the importance of addressing environmental issues, an enormous volume of research in recent times has investigated the association between economic growth, energy consumption and emissions (Ozturk and Acaravci, 2010; Wang et al., 2011; Saboori et al., 2012; Shahiduzzaman and Alam, 2014; Salahuddin and Gow, 2014; Shahiduzzaman et al., 2015; Salahuddin et al., 2016). However, based on their mixed and inconclusive findings, these studies have offered a diverse set of policy recommendations for different countries and regions to combat these problems.

A major weakness of most of the studies examining the relationship between economic growth, energy consumption, and the environment is that carbon dioxide (CO_2) emissions is used as an indicator of environmental impacts (Wackernagel and Rees, 1996). CO_2 emissions, however, constitutes only a part of the total environmental damage caused by large scale energy consumption (Al-Mulali et al., 2015a).

In contrast, the ecological footprint of consumption (EFC) represents a comprehensive indicator of anthropogenic pressure on the environment (Vackar, 2012; Dietz et al., 2007; Jorgenson, 2003; Jorgenson and Burns, 2007; Jorgenson and Rice, 2005; Rosa et al., 2004; Rothman, 1998; York et al., 2003, 2004, 2009). Recognizing its comprehensiveness as a measure, many recent studies have used EF as an indicator of environmental impact (see, for instance, Al-Mulali et al., 2015c; Wang et al., 2011; Galli et al., 2012a,b; Mostafa, 2010; Caviglia-Harris et al., 2009; Bagliani et al., 2008). Cornelia (2014) treats it as a reliable indicator of the dynamics of renewable resurce use. This method has also been extensively used as an indicator for sustainability for a given population (Lenzen and Murray,

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2001, 2003; Niccolucci et al., 2012; Wackernagel et al., 2004). It is also used to measure and manage the use of resources throughout the economy. A major advantage of EF is that it combines environmental data into a single measure, which can be easily compared to the corresponding productive capacity (Costanza, 2000).

Therefore, in order to provide a better and fine-grained understanding of the relationship between environmental pressure and economic growth, this study considers EFC as the composite indicator of the cumulative human pressure on the natural environment. Based on the literature, the impacts of three independent variables: real GDP per capita (real income), financial development and trade openness are analyzed using panel data of leading world EF contributors, both developed and developing countries.

The rest of the paper is structured as follows: Section 2 provides a review of the available literature. In Section 3, conceptualization, model, data and procedures are presented. Section 4 presents and discusses the results. The paper concludes in section 5 with a discussion on the policy implications of the findings.

2. Literature review

It is widely believed that environmental quality deteriorates in the early stages of economic development and improves gradually as economic growth slows and citizens' standard of living improves. The income-inequality inverted U-shaped relationship theorized by Kuznets (1955) has been reinterpreted in the environmental economics literature through the Environmental Kuznets Curve (EKC) hypothesis. The EKC states that in the initial stages of economic growth, CO_2 emissions increase but after a certain threshold level, these emissions begin to decline. The EKC hypothesis was initially tested by Grossman and Krueger (1991). Numerous studies such as: Dinda and Coondoo (2006), Ozturk and Acaravci (2010), Al-Mulali et al. (2015a), Apergis and Ozturk (2015), Shahbaz et al. (2015) and Al-Mulali et al. (2015b), have examined it using various datasets and econometric approaches. However, the empirical outcomes of these studies are mixed and inconclusive.

It is also argued that environmental improvement occurs consistently with economic growth. Arrow et al. (1995) showed that people spend proportionately more of their incomes on environmental quality as it rises. Earlier studies by Bergstrom and Goodman (1973) found that a higher level of income contributes towards environmental improvements. Using time series data from 21 countries for the period 1980–2006, Boulatoff and Jenkins (2010) showed the existence of a negative long-run relationship between income and CO_2 emissions.

Yet others, like Panayotou (1993), and Seldeon and Song (1994) have argued that the relationship between economic growth and the environment, whether positive or negative, is not fixed along a country‘s development path; and indeed it may change from positive to negative as a country reaches a level of income at which people demand and can afford a cleaner environment.

Shahiduzzaman and Alam (2012) and Saboori et al. (2012) found an inverted U–shaped relationship between CO_2 emissions and gross domestic product (GDP) in both the short and long run in Australia and Malaysia, respectively. Kearsley and Riddel (2010) found little evidence that environmental quality plays a significant role in shaping the EKCs for seven key pollutants of 27 OECD member countries. Fodha and Zaghdoud (2010) showed that there is a long-run co-integrating relationship between per capita emissions of two pollutants (CO_2 and SO_2) and per capita GDP in Tunisia during the period 1961–2004.

Recent literature considers EF to investigate the EKC hypothesis (Hervieux and Darné, 2014; Cornelia 2014; Caviglia-Harris et al., 2009; Daly and Farley 2004; York et al., 2004). Al-Mulali et al. (2015c) examined the effect of economic growth, renewable energy consumption and financial development on the environment for Latin American and Caribbean countries and the results indicated that the EKC is valid for high and upper middle income countries but not for low income countries. Moran et al. (2008) found a positive association between economic development and EF. Galli et al. (2012a) assessed the overall global footprint and argued that in high income countries the footprint rose while it declined or remained constant in middle and low income countries.

Various methods are used to study the economy-environment relationship using EF. York et al. (2003) interpreted the STIRPAT model using the I = PAT identity of Ehrlich and Holdren (1971), where environmental impact (I) is assessed through changes in any of the Population (P), Affluence (A) and Technology (T) variables.

Toth and Szigeti (2016) estimated the correlation between GDP and EF from 1961 to 2015 and have determined that the main driver of growth and environmental degradation is not population per se, but consumption patterns and levels multiplied by the number of consumers, especially in developed economies, as the I = PAT equation recognized. EF is a widely accepted interactive measure of stress on the environment and treated as the subject of some of the earliest works in structural human ecology (SHE) theory (Jorgenson, 2003; York et al., 2003; Dietz and Jorgenson, 2014; Marquart-Pyatt, 2015).

While the simplicity of interpretation makes the application of EF appealing, its measurement and methodology have led to considerable debate. The major weakness in the measurement of EF is its failure to capture all environmental aspects (Borucke et al., 2013; Galli et al., 2012b; Kitzes et al., 2009; Lin et al., 2015; Loh et al., 2005). It is argued that the measurement of EF considers only those resources or services that can be measured in terms of biologically productive areas. For instance, it excludes freshwater consumption, soil erosion, GHG emissions other than CO_2, toxicity, and eutrophication (Borucke et al., 2013). Despite these criticisms, EF has become a popular metric and serves as a comprehensive tool to assess environmental impacts. While the literature on the emissions-growth nexus is extensive, very few studies have so far used EFC as an indicator of environmenal impacts within a cointegrating framework.

A number of endogenous variables have been incorporated in the modeling of environment-growth nexus. Financial development and trade openness are the two key policy variables that have been extensively used in the literature. Tamazian et al. (2009) found that a high degree of financial development improves environmental conditions. Jalil and Feridun (2011) reported that financial development reduces environmental degradation in China. However, Zhang (2011) found the opposite outcome that financial development contributes significantly towards increasing Chinese environmental degradation. Al-Mulali et al. (2015c) claimed that financial development reduces the EF while trade openness increases it in a panel of 93 countries. Salahuddin et al. (2015) showed that financial development causes a decline in CO_2 emissions in Gulf Cooperation Countries. Financial development was found to cause increased energy consumption and carbon emissions in sub-Saharan African countries (Al-Mulali, 2012). Shahbaz and Lean (2012) obtained similar results for Tunisia. Ozturk and Acaravci (2013) found that financial development has no significant effect on per capita carbon emissions in the long run for Turkey. It is observed in the literature that increased trade openness causes increased pressure on the environment. Ozturk and Al-Mulali (2015) found that trade openness increased environmental degradation in Cambodia.

From the above discussion, it is evident that the empirical literature offers mixed results of the effects of financial development and trade openness on environmental quality. To the best of the authors' knowledge no study has so far investigated the causal