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Persistence of policy shocks to Ecological Footprint of the USA

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ABSTRACT

This is the first study that aims to investigate policy shocks to Ecological Footprint of the USA. More precisely, we analyze the stochastic behaviors of the Ecological Footprint and its components (carbon Footprint, cropland, grazing land, forest products, built-up-land, and fishing grounds) by using Fourier unit root tests that are more powerful under an unknown number of breaks. The stationarity of a time series gives information about its future behavior based on past behavior. More specifically, stationarity properties give information on whether shocks have transitory or permanent effects on a variable; therefore, the stationarity of a time series has important implications to the formation of appropriate policies by decision makers. Stochastic properties of the Ecological Footprint are important considerations to the implementation of global and local policies targeting global warming, climate change and environmental degradation. Empirical results show that the Ecological Footprint is non-stationary which suggests that policies affecting the Ecological Footprint will have long-term and permanent effects. Findings and policy implications are further discussed.

1. Introduction

The majority of studies in the literature which aim to analyze national and international environmental quality and make policy recommendations focus on CO_2 emissions as a key indicator. They eventually confirm an inverted U-shaped relationship between income and environmental degradation, implying that initial stages of economic growth and development decreases environmental quality and that later stages of economic growth and development enhances environmental quality after per capita income reaches a threshold (Grossman and Krueger, 1991, 1995). The inverted U-shaped relationship might be valid for emissions of pollutants, but might not be valid for resource stocks. Therefore, the relevant observation should also focus on resource stocks such as soil stock, forestry stock, mining stock, and oil stock. Otherwise it has been shown to be valid for pollutants like CO_2 sulfur and so on, not for the accumulation of stocks of waste (Arrow et al., 1995). In addition, as stated by Stern (2014, p.11) "It is clear that the levels of many pollutants per unit of output in specific processes have declined in developed countries over time with technological innovations and increasingly stringent environmental regulations. However, the mix of effluent has shifted from sulfur and nitrogen oxides to carbon dioxide and solid waste, so that aggregate waste is still high and per capita waste might not have declined." These comments suggest that specific indicators of degradation and waste need to be complemented by an aggregate indicator.

Ecological Footprint (EF hereafter) developed by Rees (1992), Wackernagel (1994), Wackernagel and Rees (1996) is a mature aggregate indicator for analysis of human demand on natural resources and has been used for many recent analyses: Bagliani et al. (2008), Guan et al. (2008), Caviglia-Harris et al. (2009), Chambers and Guo (2009), Zhang et al. (2010), Yiqing et al. (2012), Wang et al. (2013), Al-Mulali et al. (2015), Hervieux and Darn & (2015), Ozturk et al. (2016). It is defined as the biologically productive surface area (productive land and sea areas) necessary for a given population to produce the resources it consumes and to absorb the corresponding waste it generates, using prevailing technology (Wackernagel and Silverstein, 2000). It answers the question of how much of the regenerative biological capacity of the planet is demanded by a given human activities like resources consumption, goods and services production (Kitzes and Wackernagel, 2009). Conceptually, it can be described as the pressure of human activities on nature (Bartelmus, 2008). A key aspect of the EF methodology is that it capsulizes a wide range of environmental data into a single indicator (Costanza, 2000). Also, it is incorporated as an indicator of environmental performance by many governmental and intergovernmental organizations like European Energy Agency, European Union, European Commission and United Nations (EEA, 2010; Best et al., 2008; UNDP, 2014) since it provides a basis for setting goals, identifying options for action, and tracking progress toward stated goals (Borucke et al., 2013). Therefore, understanding stochastic behaviors of the EF is important, especially in terms of policy implementation.

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This paper aims to investigate stationarity properties of the EF for the USA. Stationarity properties or stochastic behaviors of a variable are crucial for several reasons. If a series follows unit root process, shocks to this series will have permanent effects; conversely if a series is stationary, shocks will have transitory effects (Lee and Chang, 2008). As stated by Nelson and Plosser (1982) stationarity is very important for policy implicationsbecause knowing whether shocks (policy implications) permanently affect a variable is an important consideration in policy discussions (Dogan, 2016; Smyth and Narayan, 2015). The issue of stationarity also gives information about future behavior of a variable as based on past behavior and allows policy makers to be able to formulate appropriate policies for the future (Mishra et al., 2009). In the case of stationarity, forecasting can be possible for a variable due to the stochastic nature of key factors (Hasanov and Telatar, 2011). Therefore, measuring the persistence of a variable provides foresights for the design, implementation, and effectiveness of environmental policies aimed at lowering the economy's dependence on environmentally damaging practices (Belbute and Pereira, 2017). Additionally, time series analyses should consider the stationarity properties of variables in order to analyze the relationship between them. If two variables have stochastic trends and are thought to be in long-run equilibrium then the time series are commonly hypothesized to be cointegrated and this hypothesis can be tested empirically (Phillips and Sul, 2007).

The stationarity of the EF has important implications for country policies towards environmental degradation. It is crucial to understand the effect of policies that will be implemented in the forthcoming years to address climate change in the as part of commitments made in the 21st Conference of the Parties in Paris 2015. The USA committed to an economy-wide target of reducing its greenhouse gas emissions by 26-28 per cent below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%. Also, lots of environmental threats have gradually arisen in the country, just like everywhere in the world. Therefore, required actions should urgently be taken against environmental degradations. Otherwise, "*the laissez-faire equilibrium leads to an "environmental disaster," where the quality of the environment falls below a critical threshold*" (Acemoglu et al., 2012, p.132). To the best of our knowledge, this is the first paper to investigates stochastic behaviors of the EF. So, this study contributes to the field of empirical research dealing with environmental issues and their policy implications. The remainder of the paper is organized as follows: literature review,,data and empirical methodology, estimation results, discussions, conclusions, and policy recommendations.

2. Literature review

Various econometric studies have applied the EF as an indicator of environmental pressure for a country or a group of countries for different purposes as in Bagliani et al. (2008), Guan et al. (2008), Chambers and Guo (2009), Zhang et al. (2010), Yiqing et al. (2012), Wang et al. (2013), Al-Mulali et al. (2015), Hervieux & Darn & (2015), Ozturk et al. (2016). However, no studies were found that directly analyze the stationarity of the EF, since available literature in this field mostly uses CO_2 emissions as environmental indicator. So, results of studies which base on stationarity or unit root applications and which use CO_2 emissions for environmental analyses might provide an informative perspective for this field. List (1999) for the USA, Strazicich and List (2003) for 21 industrialized countries, Nguyen-Van (2005) for 100 countries, Aldy (2006) for 23 OECD countries, Ezcurra (2007) for 87 countries, Panopoulou and Pantelidis (2007) for 128 countries, Avila (2008) for 23 countries, Lee and Chang (2008) for 7 countries, Camarero et al. (2008) for 22 OECD countries, Westerlund and Basher (2008) for 28 countries, Jobert et al. (2010) for 22 European countries, Li and Lin (2013) for 12 the USA states, Christidou et al. (2013) for 36 countries, Ahmed et al. (2016) for 38 countries, Belbute and Pereira (2017) for the world's overall, Tiwari et al. (2016) for 35 sub-saharan countries found evidence about stationarity. While Lanne and Liski (2003) for 16 developed countries, Aldy (2006) for 88 countries, Aldy (2007) for the USA, Lee and Chang (2008) for 14 countries, Barassi et al. (2008) for 21 OECD countries, Lee and Lee (2009) for most of 109 countries, Li and Lin (2013) for 38 the USA states, Presno et al. (2015) for 28 OECD countries for 124 countries, provided evidence about non-stationarity. Since the stationarity also means convergence for the panel series, some papers mentioned here focused on convergence by using unit root tests, while some focused on stationarity. Empirical results, however, determine that shocks to relevant variable permanent or transitory for each focus.

3. Methodology and data

In time series analysis covering the changing in a variable from past to present stationarity means that variance and mean of variables are unchanging over time. So, in a stationary series shocks effect it at a decreasing rate in the course of time. This is known as mean reverting process. Such a series fluctuates its own expected value that is equal to mean and shocks (policies) don't leave permanent effect on the series. Thus, policies are not efficient. However, if a series is not stationary (it has unit root) policies which tend to effect that variable will be efficient (Nelson and Plosser, 1982; Perron, 1989). Here, policy stance should also be considered in terms of transitory or permanent effect. Because, in case of stationarity, there is no such thing that all policies have transitory effect or all policies will not be efficient. Transitory policies (i.e. those that aim to change the volume of relevant variable) will tend to have only transitory effects. Permanent changes, therefore, require a more permanent policy stance in such a situation. On the other hand, in case of non-stationarity, then even transitory policies will have permanent effects (Belbute and Pereira, 2017).

Unit root analyses are used for testing stationarity of the series. There are some unit root tests following different test procedure in the literature. Dickey and Fuller (1981) ADF test, Phillips and Perron (1988) PP test, Kwiatkowski et al. (1992) KPSS test, Elliott et al. (1996) DF GLS test, Ng and Perron (2001) NP test are widely used ones. However, these unit root tests tend to accept the null hypothesis that generally based on unit root if the series have structural breaks (Perron, 1989). So, structural breaks in a series should be considered. Lee and Strazicich (2003) propose a two-break minimum Lagrange multiplier (LM) unit root test in which the alternative hypothesis unambiguously implies trend stationarity. There are two other unit root tests considering two structural breaks. These are Zivot and Andrews (1992) ZA test and Lumsdaine and Papell (1997) LP test. But important issue for ZA and LP is that they assume no break under the unit root null and derive their critical values accordingly. Thus, the alternative hypothesis means that structural breaks are present while the series might have unit root. In this respect LM test proposed by Lee and Strazicich (2003) allows breaks under the null and alternative and takes into account existence of unit root. Additionally, optimal number of break points is endogenously determined. So, LM test proposed by Lee and Strazicich (2003) is more successful under two structural breaks. However, Prodan (2008) shows that it can be quite difficult to properly estimate the number and the magnitudes of multiple breaks, particularly when the breaks are of opposite sign. Considering this problem. Enders and Lee (2012a), Rodrigues and Taylor (2012) & Enders and Lee (2012b) propose Fourier unit root test based on a variant of Gallant's (1981) Flexible Fourier Form. Many breaks known or unknown in a series can be captured by using a small number of low-frequency components from a Fourier approximation. Hence, instead of selecting specific break dates, the number of breaks, and the form of the breaks, the specification problem is transformed into incorporating the appropriate frequency components into the estimating equation (Enders and Lee, 2012b).

Fourier unit root tests that rely on approximation consider deviations from the mean in deterministic terms through trigonometric expanding. In this direction, Enders and Lee (2012a) use LM type