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Will initiatives to promote hydroelectricity consumption be effective? Evidence from univariate and panel LM unit root tests with structural breaks

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HIGHLIGHTS

- Applies unit root tests to hydroelectricity consumption.
- Hydroelectricity consumption is stationary.
- Shocks to hydroelectricity consumption result in temporary deviations from the long-run growth path.

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ABSTRACT

This paper examines whether initiatives to promote hydroelectricity consumption are likely to be effective by applying univariate and panel Lagrange Multiplier (LM) unit root tests to hydroelectricity consumption in 55 countries over the period 1965–2011. We find that for the panel, as well as about four-fifths of individual countries, that hydroelectricity consumption is stationary. This result implies that shocks to hydroelectricity consumption in most countries will only result in temporary deviations from the long-run growth path. An important consequence of this finding is that initiatives designed to have permanent positive effects on hydroelectricity consumption, such as large-scale dam construction, are unlikely to be effective in increasing the share of hydroelectricity, relative to consumption of fossil fuels.

1. Introduction

Hydroelectricity is a form of hydropower used to produce electricity via the kinetic energy of moving water, which is converted to electrical energy by a water turbine driving a generator (Bakis, 2007). Hydropower has been described “as the most technically mature and reliable source of renewable energy” (Jia et al., 2012, p. 1357). It is the most important renewable energy source for the generation of electricity worldwide, providing 97 per cent of all electricity generated from renewable sources (Bakis, 2007). In 2008, hydropower generation was responsible for approximately 20 per cent of the world′s electricity, and 40 per cent of the electricity in developing countries, which was second only to fossil fuels (Jia et al., 2012). In that same year, there were 16 countries that relied on hydropower for more than 90 per cent of their energy supply; 49 countries that relied on hydropower for more than 50 per cent of their energy supply and 57 countries that relied on hydropower for more than 40 per cent of their energy supply (Jia et al., 2012).

The world′s demand for electricity is expected to increase. The United States Energy Information Administration forecasts that world electricity consumption will almost double between 2007 and 2035, while the International Energy Agency predicts that by 2040 world energy consumption will be 30 per cent higher than in 2010 (Vandel, 2012). Fossil fuels are the major cause of climate change and global warming (Stern, 2006). Given that burning fossil fuels is the major way of generating electricity, this raises serious concerns about how the projected growth in world electricity consumption will effect the environment under steady state assumptions.

It is in this context that it is often argued that hydropower represents a clean alternative source of electricity to burning fossil fuels and that increasing the proportion of electricity generated from hydropower would be beneficial for the environment (see e. g. Bakis, 2007; Jia et al., 2012; Vandel, 2012). There is plenty of scope to further develop hydropower use. As a proportion of potential availability, current electricity generated from hydropower is 11 per cent in Africa, 25 per cent in Asia, 45 per cent in Oceania, 71 per cent in Europe, 65 per cent in North America and

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40 per cent in South America (Jia et al., 2012). Perhaps the main benefit of increasing hydropower is that compared to burning coal, hydroelectricity produces virtually no air pollution (Bakis, 2007; Chamberland and Levesque, 1996; Childress, 2009; Rosa, 2001). Among the various sources of energy, hydropower has the highest energy payback and lowest greenhouse gas emission (Jia et al., 2012).

The purpose of this study is to examine the integration properties of hydroelectricity consumption for 55 countries/subregions using univariate and panel unit root tests, with and without structural breaks.[1] There has been a surge in studies that examine the unit root properties of energy consumption, to the point that testing for a unit root in energy consumption has been described "as a new branch of research in energy economics" (Narayan et al., 2010, p. 1953). However, most studies have focused on aggregate energy consumption or consumption of specific fossil fuels and have used data from the United States. This study responds to calls for more studies that examine the unit root properties of disaggregated renewable energy consumption and consider countries other than the United States (Smyth, 2013). The use of a relatively large number of countries has the advantage that it is possible to use both a panel and allow for structural breaks, which has been recommended as providing the most reliable evidence of the order of integration of energy variables (Smyth, 2013).

The issue of whether hydroelectricity consumption contains a unit root speaks directly to the efficacy of policies, such as construction of large-scale water storage infrastructure, promotion of small hydropower plants and investment in new hydro technologies such as hydrokinetics, designed to increase the proportion of electricity generated from hydropower. Large-scale dams, in particular, often represent the single largest structure in terms of basic infrastructure in all countries and become major landmarks in the countries in which they are located (Bakis, 2007; Jia et al., 2012). Hence, each of these policies is designed to bring about permanent changes in the electricity mix and are, by their varying nature, long-term because they typically entail making large-scale investments. If hydroelectricity consumption contains a unit root, a shock to the long run growth path of hydroelectricity consumption will have permanent effects. This implies that policies involving large-scale investment, the purpose of which is to engineer positive shocks to hydroelectricity consumption, will result in continuing annual shocks and, as such, will be effective. On the other hand, if hydroelectricity consumption is stationary, following a policy-induced shock, hydroelectricity consumption will return to its long run growth path and policies designed to engineer permanent changes to consumption will be ineffective.

The rest of the paper is organised as follows. The next section provides an overview of the literature on the unit root properties of energy consumption. The econometric methodology and data are discussed in Sections 3 and 4. The results are presented in Section 5. Foreshadowing the main results, we find that the null hypothesis of a unit root is rejected for approximately 80 per cent of the individual countries, as well for the world and regional panels. The implication is that for most countries, and for the panels, shocks to hydroelectricity consumption will only result in temporary deviations from the long-run growth path. The implications of these findings are discussed in Section 6. The final section concludes by summarizing the main results and offering suggestions for future research.

[1] The sample consists of 50 countries plus five residual series/sub-regions corresponding to five of the six regions considered (Other South and Central America, Other Europe and Eurasia, Other Middle East, Other Africa and Other Asia-Pacific). For simplicity, hereafter, we refer to 'countries'.

2. Existing literature

Beginning with Narayan and Smyth (2007), a large literature has evolved which tests for a unit root in energy consumption. Here, we briefly review the main developments in this literature. Smyth (2013) provides a more comprehensive overview. One set of studies has applied univariate unit root tests without structural breaks to aggregate energy consumption for a large number of countries (Hasanov and Telatar, 2011; Narayan and Smyth, 2007). These studies have found that energy consumption is stationary for about one-third of countries studied. A problem with these studies is that failure to accommodate a structural break potentially reduces the power to reject the null hypothesis of a unit root (Perron, 1989).

To address this issue, studies have applied univariate unit root tests with structural breaks (Apergis and Payne, 2010a; Narayan et al., 2010; Aslan and Kum, 2011; Aslan, 2011; Agnolucci, and Venn, 2011; Kula et al., 2012; Ozturk and Aslan, 2011; Lean and Smyth, 2013b; Kum, 2012; Shahbaz et al., 2012a; Maslyuk and Dharmaratna, 2012). Most of these studies have found more evidence of stationarity (Apergis and Payne, 2010a; Narayan et al., 2010; Aslan and Kum, 2011; Agnolucci, and Venn, 2011; Kula et al., 2012; Ozturk and Aslan, 2011; Kum, 2012; Shahbaz et al., 2012a), although some have reached mixed conclusions or failed to reject the unit root null hypothesis (Aslan, 2011; Lean and Smyth, 2013b; Maslyuk and Dharmaratna, 2012).

An alternative approach focused on addressing the low power of conventional unit root tests to reject the unit root null in the presence of non-linearities, has been to apply non-linear unit root tests to aggregate energy variables (Hasanov and Telatar, 2011; Aslan and Kum, 2011; Aslan, 2011; Maslyuk and Smyth, 2008). Generally, these studies have concluded that aggregate energy is non-stationary. Yet another approach has been to apply fractional integration unit root tests to energy consumption or production (Lean and Smyth, 2009; Gil-Alana et al., 2010; Apergis and Tsoumas, 2011; Apergis and Tsoumas, 2012; Barros et al., 2011, 2012, 2013a, 2013b). Overall, the results from studies which have applied fractional unit root tests vary, depending on energy type and sector (see Smyth, 2013 for more details).

A fourth approach has been to apply panel tests with, and without, structural breaks, to address the short time span of data with univariate unit root tests (Chen and Lee, 2007; Mishra et al., 2009; Narayan and Smyth, 2007; Agnolucci and Venn, 2011; Hsu et al., 2008; Narayan et al., 2008; Apergis et al., 2010a, 2010b; Shahbaz et al., 2012b). Overall, the results from these studies are also mixed, although studies that have used panel unit root tests which accommodate structural breaks find more evidence of stationarity (see Smyth, 2013).

Many of these studies have employed aggregate energy consumption (Chen and Lee, 2007; Mishra et al., 2009; Narayan and Smyth, 2007; Hasanov and Telatar, 2011; Narayan et al., 2010; Aslan and Kum, 2011; Agnolucci and Venn, 2011; Ozturk and Aslan, 2011; Hsu et al., 2008; Shahbaz et al., 2012b). A limitation on focusing on aggregate energy consumption is that specific types of disaggregated energy consumption might be more likely to be stationary than others (Lean and Smyth, 2009; Yang, 2000). To address this point, increasingly studies have tested for a unit root in one or more types of disaggregated energy. Most of the studies, though, which have examined disaggregated energy by type have focused on one or more specific fossil fuels (Apergis and Payne, 2010a; Aslan, 2011; Maslyuk and Dharmaratna, 2012; Maslyuk and Smyth, 2008; Lean and Smyth, 2009; Apergis and Tsoumas, 2012; Barros et al., 2011; Narayan et al., 2008; Apergis et al., 2010a, 2010b; Congregado et al, 2012).

A relatively small number of studies have examined the unit root properties of renewable energy or other alternative energy sources (Apergis and Tsoumas, 2011; Barros et al., 2012, 2013a,

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