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Author(s)	Le, Thai-Ha; Chang, Youngho; Park, Donghyun
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ENERGY DEMAND CONVERGENCE IN APEC:

AN EMPIRICAL ANALYSIS

Thai-Ha Le[a], Youngho Chang[b]*, and Donghyun Park[c]

Abstract

This paper empirically examines the cross-country convergence of per-capita energy and electricity usage in APEC, a significant economic bloc. To this end, the study applies conventional panel unit root tests and Sequential Panel Selection Model (SPSM) procedure based on the Panel KSS unit root with a Fourier function for robustness analysis. The results from conventional unit root test results indicate that per capita energy usage and electricity consumption are converging for all APEC countries, in line with improving living standards in APEC. The findings also provide some support for policies to promote energy integration among APEC countries. According to SPSM analysis, evidence of energy convergence is found for 15 out of 19 APEC countries and evidence of electricity convergence is found for 17 out of 19 APEC countries. Pursuit of policies to achieve energy supply stability can move divergent countries toward convergence.

JEL Classifications: Q43.

Keywords: Cross-country convergence, energy usage, electricity consumption, APEC.

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* Corresponding author. Division of Economics, School of Humanities and Social Sciences, Nanyang Technological University, HSS-04-65, 14 Nanyang Drive, Singapore 637332. Tel: +65-6513-8107; Fax: +65-6795-5797. Email: isyhchang@ntu.edu.sg

[a]: RMIT University, Vietnam; [b]: Nanyang Technological University, Singapore; [c]: Asian Development Bank, Philippines.

1. Introduction

Convergence between advanced and developing economies has long been an issue of interest among economists. Convergence is generally defined as the tendency of the often large gap in living standards across countries to decrease over time (Maza and Villaverde, 2008). Such convergence is consistent with the improvement in living standards and welfare of developing economies. Many studies treat per capita GDP as the measure of economic welfare or development, and hence a large literature has emerged to examine the convergence of per capita income across countries and regions (for instance, Guetat and Serranito, 2007; Ranjpour and Zahra, 2008; Cavenaile and Dubois, 2011; Ranjbar et al, 2014).

There are, however, a number of alternative indicators of economic development. For example, per capital electricity consumption is one of the most meaningful indicators of economic development (Joyeux and Ripple, 2007). The quality of life improves dramatically with the introduction of electricity. Furthermore, even a cursory observation suggests that per capita electricity consumption and economic development are strongly correlated (see, Payne, 2010). Using a sample of over one hundred countries, representing over 99% of the global economy, Ferguson et al (2000) argue that in the technological world of the late 20th century, economic development occurred hand in hand with electricity consumption and, in particular, with an increase in the proportion of energy used in the form of electricity.

Another plausible indicator of economic development is energy consumption (Mohammadi and Ram, 2012). Energy is a vital input in the production of goods and services, and indeed the functioning of economies and societies. However, the relationship between energy and sustainable development is complex, and can be either positive or negative. On the positive side, the services that energy enables often advance sustainable development. Better cooking, lighting, space conditioning, transportation, communications, income generating processes, and other services are the means by which energy improves human, social, economic and environmental conditions. On the negative side, energy can be produced and deployed in ways that pollute the environment and increase greenhouse gas emissions. The development of various energy sources, including not only oil, gas and, coal but even renewable energy, can disrupt ecosystems unless carefully planned (Kaygusuz, 2012). As such, a study on the cross-country convergence in per capita energy and electricity consumption is meaningful from the perspective of sustainable economic development (Mohammadi and Ram, 2012).

The concept of sustainable development has evolved from rather vague notions of sustaining the welfare of the current generation without decreasing that of the future generations to more precise specifications that include the three pillars of sustainability, namely, social, economic, and environmental sustainability (Moldan et al, 2012). Both economic and social sustainability have their merits, but the main interest in this study lies in environmental sustainability. Environmental sustainability can be defined in terms of bio-geophysical aspects, which means maintaining or improving the integrity of the Earth's life supporting systems (Moldan et al, 2012). While rapid growth has clearly been a boon for Asia-Pacific Economic Cooperation (APEC) countries, it has placed enormous pressure on the ecological carrying capacity of the region. Future generations will suffer from the resulting inadequacy of environmental resources and the key challenge is thus to achieve environmentally-sustainable economic growth.

In light of the relation between energy usage and environmental quality, it is worthwhile to examine cross-country patterns of energy consumption. Evidence of rapid convergence in per capita energy consumption would suggest that economies can grow while managing energy consumption (Mishra and Smyth, 2014). Policy harmonization may not be possible in the absence of energy convergence. Evidence of energy demand convergence across countries within a region would support policies to promote energy integration in the region. Regional countries could take a harmonized approach in energy policies and strategies to increase the efficiency of energy management and hence pollutant emissions management.

In sum, convergence has implications about whether energy conservation and environmental protection are significant dimensions of sustainability.[1] Evidence of convergence in energy demand, along with the cross-border nature of many environmental and energy issues, would strengthen the case for harmonization of energy and electricity markets. This can be done by bringing legislation in line with APEC's common standards and requirements.

The issue of energy convergence per capita thus has implications for sustainable energy consumption as well as efforts to curtail emissions of carbon dioxide and other pollutants. Many countries have adopted policies to lower energy intensity and promote energy efficiency. At the same time, there has been a concerted effort to reduce carbon dioxide emissions. Reduction in disparities in per capita energy consumption among countries is evidence of the effectiveness of management policies (Mishra and Smyth, 2014).

The literature on cross-country energy convergence consists largely of research related to per capita carbon dioxide emissions, energy productivity, and energy or electricity intensity (for example, Aldy, 2006; Markandya et al, 2006; Ezcurra, 2007a,b; Maza and Villaverde, 2008; Liddle, 2009, 2010; Le Pen and Sevi, 2010; Duro and Padilla, 2011). There have been, however, significantly fewer studies on cross-country convergence in per capita energy usage and electricity consumption, although these studies complement the research on per-capita carbon-dioxide emissions and energy and electricity intensities (Mohammadi and

[1] Greenhouse gas emissions, global warming, and emissions-related international initiatives are understood as other significant dimensions.

Ram, 2012). In addition, it is worth noting that energy intensity has been declining recently while per capita energy usage has been increasing. This might indicate that energy efficiency has improved, which, in turn, causes different convergence patterns across countries (Mohammadi and Ram, 2012).

The main purpose of this study is to contribute to and complement the existing research on cross-country convergence in the development literature in general and the energy literature in particular. Cross-country convergences in both per capita energy usage and electricity consumption are considered. The sample consists of APEC members, from 1989 to 2012. In response to growing interdependence among Asia-Pacific economies, APEC was founded in 1989 by 12 countries: Australia, Brunei, Canada, Indonesia, Japan, South Korea, Malaysia, New Zealand, the Philippines, Singapore, Thailand and the United States (U.S.). Its goal is to advance economic dynamism and sense of community in this fast-growing region. As of January 2016, APEC comprises twenty-one countries that differ substantially in their political systems and level of economic development.

According to Australia's Department of Foreign Affairs and Trade (2015), as of 2014, APEC accounts for approximately 41 percent of the world's population, 54.3 percent of global GDP (in PPP terms), and 44 percent of global trade. APEC consists of the world's biggest economies such as the U.S., China, and Japan as well as emerging markets such as India, Indonesia, Malaysia, and Vietnam. Most countries in the region have experienced high growth rates in GDP and energy usage. APEC's GDP has grown at an average 6.2 percent per annum since 1992 in PPP terms, faster than both non-APEC countries (5.6 percent) and the world (5.9 percent) over the same period. APEC includes four of the world's five largest energy users - China, the U.S., Russia, and Japan - which jointly account for around 60 percent of the world's energy demand. In 2013, the region consumed over 8,000 Mtoe and was a net energy importer, importing over 650 Mtoe, 90% of which was oil (International Energy Agency (IEA), 2015). According to APEC Energy Demand and Supply Outlook (5th Edition), by 2035, APEC members' demand for energy is forecast to increase by 34% above 2013 levels.

According to APEC Energy Demand and Supply Outlook (5th Edition), electricity demand in APEC grew robustly between 1990 and 2009 at an average annual rate of 3.3% per year, from 5720 terawatt-hours (TWh) in 1990 to 10,528 TWh in 2009. Demand grew especially rapidly in developing Asian economies. Vietnam experienced the highest average annual growth rate from 1990 to 2009 (14.2%), followed by China (10.2%), and Malaysia and Indonesia (both 8.6%). In 1990, Australia, Canada, Japan and the U.S. accounted for 69% of the APEC region's total electricity consumption, with the US alone accounting for 46%. However, by 2009, the share of these advanced economies fell to 50%, mainly due to rapidly increasing electricity demand in China and Southeast Asian economies.

China's share of APEC's total demand for electricity rose from 8% in 1990 to 29% in 2009. Electricity demand across APEC is expected to grow by 2.5% per year between 2009 and 2035 (APEC Energy Demand and Supply Outlook, 5th Edition). All of the above factors make energy cooperation an increasingly important agenda item for APEC. The issue of energy convergence is directly related to whether energy market integration promotes more equitable energy access across countries. Energy market integration is seen as a critical vehicle to promote energy efficiency and reduce carbon dioxide emissions (Mishra and Smyth, 2014). In addition, convergence is evidence of 'the sharing of technology, standards and knowledge' that promotes wealth equality and technology equality among countries (Baldwin, 2016). Despite this, there has been no study on this issue for APEC countries.

The main sample for this empirical analysis is the APEC-12, the founding members and most influential members. More importantly, these countries were part of APEC for the whole period of the study (1989-2012). Nevertheless, as a robustness check, this study also delves into a larger sample of 19 APEC countries for which data is available over the same period. In addition to conventional panel unit root tests, this paper performs the Sequential Panel Selection Model (SPSM) procedure using the Panel KSS (Kapetanios, Shin and Snell, 2003, hereafter KSS) unit root with a Fourier function for robustness analysis.

Empirical results from conventional unit root tests indicate that per capita energy usage and electricity consumption for all 19 APEC countries are converging, implying an overall improvement in living standards. However, SPSM results indicate that per capita energy usage is stationary in 15 out of 19 APEC countries while per capita electricity consumption is stationary in 17 out of 19 APEC countries. When allowing for nonlinearities and structural breaks, the null of unit root hypothesis is rejected for more countries. The results thus point to a need to address both structural breaks and nonlinearities in the empirical analysis.

The rest of the study is organised as follows. Section 2 reviews the relevant literature. Section 3 describes the data and methodologies used in the study. Section 4 reports and discusses the empirical results. Section 5 concludes the paper.

2. Literature review

The preceding section described several studies of cross-country energy convergence in order to provide the context of this research. The energy convergence literature contains three strands. The first group of studies looks at convergence in per capita carbon-dioxide emissions. For example, Aldy (2006) used several procedures to examine the convergence of per capita carbon-dioxide emissions during 1960–2000. The results reveal convergence in OECD, but lack of convergence in the broader sample of 88 countries, which suggests that developing economies may not catch up with the carbon emission levels of developed economies. Ezcurra (2007a) applied a non-parametric approach to data set of 87 countries in 1960–1999 and found evidence of convergence in per capita carbon emissions, which indicates improvement in carbon intensity in developing countries. The study also examined determinants of emissions and found temperature and per-capita income to be significant, but trade openness to be insignificant. Interestingly, despite the similarity of their samples and periods, Aldy (2006) and Ezcurra (2007a) find divergent results.

The second strand of studies explored cross-country convergence in energy intensity, defined broadly as energy usage per unit of output, and energy productivity, or the inverse of energy intensity. For instance, Markandya et al. (2006) explored whether energy intensity in 12 transition economies was converging to the EU15 levels using data from 1992 to 2002, and their results indicated β-convergence, which implies that countries are converging toward a common value of energy (electricity) usage per capita. Ezcurra (2007b) found cross-country convergence in energy intensity for a broader sample of 98 countries over 1971–2001. More precisely, they uncover a decline in the dispersion of the distribution, which indicates the variance of the distribution is smaller and energy intensity is closer to the converging value, and thus reflect σ-convergence. Le Pen and Sevi (2010) employed Pesaran's method of pair-wise comparison to judge stochastic convergence of energy intensity among 97 countries over 1971–2003. The results rejected global convergence, but indicated some signs of convergence in the Middle East and possibly in OECD. Liddle (2010) considered energy intensity distributions for 111 countries during 1971–2006 and 134 countries during 1990–2006. The results indicate convergence at the global level but different patterns for different regions. Specifically, different geographical regions converged at different speeds, and some did not converge at all.

The third strand of literature looks at convergence in per capita electricity consumption or intensity of electricity use. For example, Maza and Villaverde (2008) studied convergence in per capita residential electricity usage in panel data of 98 countries in 1980–2007. Their main finding is weak convergence, which is attributable to at least three factors: (1) rapid economic changes experienced by some developing countries, (2) energy conservation policies implemented by most developed countries following the first oil shock, and (3) growing awareness of energy issues in rich countries. The finding implies that large cross-country disparities would persist in the long-run. Liddle (2009) studied convergence in sectoral end-use electricity (and energy) intensity in 22 developed countries during 1960–2006, and uncovered σ-convergence in electricity intensity, but diverse convergence patterns for end-use sectors, in terms of the rates, timing, extent, and ultimate modal structure of distributions.

The evidence from the above research is mixed. Although many studies delve into drivers of energy consumption, there seems to have been no study on convergence in per-capita energy usage. Although some studies looked at temporal patterns through plots of σ-convergence, kernel estimations, or histograms at various points of time, few studies directly considered temporal patterns in convergence across several periods. In addition, there are no direct comparisons of convergence patterns in usage of energy and electricity. Finally, evidence of convergence in a set of countries does not necessarily imply convergence exists for each and every country within the group. Interpreting the results based on that assumption is likely to mislead policymakers. For example, suppose policymakers in a hypothetical region of 10 countries come across empirical studies showing convergence in their region. Such evidence may encourage policymakers to maintain their current policies. However, it may be that there are actually four out of the ten countries that are not converging. Given more information, policy could be improved by addressing the lack of convergence in the non-converging countries, for example by addressing potential energy supply instability in these countries.

A number of studies have examined the unit root properties (i.e., the stationarities) of energy consumption (Narayan and Smyth, 2007; Smyth, 2013). Meng et al (2013) extended this literature to apply unit root tests for individual time series tests to examine conditional convergence in energy consumption per capita in OECD countries. This study aims to build upon Meng et al (2013) and apply unit root tests to examine conditional convergence in energy usage and electricity consumption in APEC countries.

This study contributes to the literature in a number of ways. First, the study examines whether there is energy convergence among a group of countries that are explicitly committed to greater economic and energy integration. Convergence would be consistent with improvement in the living standards of APEC countries. Specifically, this research explores cross-country convergence in per capita energy usage and electricity consumption in APEC during 1989-2012 for APEC12 and a broader sample of 19 APEC members. Second, this research also studies the status of convergence across several periods in per capita energy usage and electricity usage, and this study is one of the first studies that provide a direct comparison of convergence patterns in per capita energy and electricity usage. Third, the empirical approach used in this study is different from Meng et al (2013). This research employs panel versions of the Lagrange Multiplier (LM) unit root test and KPSS (Kwiatkowski et al, 1992) stationary test which allow for structural breaks. A major advantage of this approach over unit root tests for individual time series tests is that it exploits both the cross-sectional and time series information available in the data on energy usage and electricity consumption, while still taking into account the potential for structural breaks (Mishra and Smyth, 2014). Furthermore, the study supplements the traditional approach by using the SPSM procedure using the Panel KSS unit root test with a Fourier function.

This study is among the the first to utilize the Panel KSS unit root test with a Fourier function through the SPSM procedure to investigate the time-series properties of per capita energy usage and electricity consumption for APEC countries. The SPSM accounts for structural breaks, nonlinearity, cross-section dependency, and cross-country heterogeneity. Moreover, the study classifies the whole panel into a group of stationary series and a group of non-stationary series. By doing so, this study can clearly identify which series are stationary processes. The SPSM approach thus allows for the identification of converging and non-converging countries.

3. Data and Methodology

This section describes the data and methodology used for the empirical analysis.

3.1.Data and Measures

This study examines cross-country convergence in per capita energy usage and electricity consumption among APEC member countries. For this purpose, annual data for per capita energy consumption and electricity consumption were collected for 19 APEC members from the World Development Indicators (WDI). The sample period spans 1989 to 2012, subject to comprehensive data availability. As mentioned above, the baseline results are for APEC-12 since these nations are the founding members of the organisation and remain its most influential members. More importantly, these countries are part of APEC for the whole period of the study (1989-2012). Nevertheless, this study also presents robustness checks for a broader sample of APEC countries for which data is available over the same period. Table 1 presents the two study samples.

[Please place Table 1 here]

The proxy for energy use per capita is primary energy consumption per capita (expressed in kilograms of oil equivalent) and the proxy for electricity consumption per capita is electric power consumption per capita (expressed in kWh). These proxies are fairly standard in the literature and are appropriate for the purpose of this study. Table 2 presents the descriptive statistics of the variables.

[Please place Table 2 here]

Following Meng et al (2013), for each country *i*, a measure of relative per capita energy usage is constructed as the natural logarithm of the ratio of per capita energy usage relative to the average of all selected APEC countries in the sample, as follows:

$$Relative\ Per\ Capita\ Energy\ Usage_{it} = \ln\left(\frac{Per\ Capita\ Energy\ Usage_{it}}{Average\ Per\ Capita\ Energy\ Usage_{t}}\right) \quad (1)$$

Similarly, for each country *i*, a measure of relative electricity consumption is constructed, as follows:

$$Relative\ Per\ Capita\ Electricity\ Consumption_{it} = \ln\left(\frac{Per\ Capita\ Electricity\ Consumption_{it}}{Average\ Per\ Capita\ Electricity\ Consumption_{t}}\right) \quad (2)$$

This study uses these two measures to examine the convergence properties of per capita energy usage and electricity consumption in APEC. Specifically, if relative per capita energy usage is found to be stationary, this supports cross-country convergence in APEC. Similarly, if relative per capita electricity consumption is found to be stationary, this implies cross-country convergence. Importantly, these measures remove cross-sectional shocks that affect all countries in the panel. For instance, any positive shock to energy usage or electricity consumption across all the countries will increase the average by the same proportion and hence leave the relative figures unchanged (Meng et al, 2013). Therefore, any structural breaks would be country specific.

3.2.Methodology

This study first performed the Pesaran (2004) cross-sectional dependence (CD) test on the relative per capita energy usage and relative per capita electricity consumption series. Next, this research applies a number of panel unit root tests to examine the stationarity of the transformed series. Given the large differences in economic structure and income in the sample countries of this study, different types of panel unit root tests which are suitable for the analysis of dynamic heterogeneous panels are employed.

This study first employs the panel LM unit root test as proposed by Im et al (2005). This is a panel extension of the Schmidt and Phillips (1992) test, which allows for structural shifts in series. The test allows for one and two structural shifts in the trend of a panel and of every individual time series. The null hypothesis of this test is that there is a panel unit root which implies that per capita energy usage and electricity consumption do not converge.[2]

In addition, this study uses a new version of the panel stationarity test proposed by Hadri (2000) and extended by Hadri and Rao (2008). Employing this new test approach allows to further control for cross-country dependence among members of panel, serial correlation in errors, and unobserved heterogeneity in the form and date of potential structural breaks in a trend function. This methodology is able to determine whether or not shocks have permanent effects on per capita energy and electricity consumption.[3]

The conventional panel unit root procedures, however, have shortcomings. First, they do not account for nonlinearity and structural breaks. For this reason, stationary tests in a nonlinear framework must be applied. Ucar and Omay (2009) proposed a nonlinear panel unit root test by combining the nonlinear framework in Kapetanios et al. (2003) with the panel unit root testing procedure of Im et al. (2003), which has proved useful in testing the mean reversion of data series. Perron (1989) argued that if there is a structural break, the power to reject a unit root decreases when the stationary alternative is true and the structural break is ignored. Meanwhile, present but ignored structural changes in the data generating process bias the analysis toward accepting the null hypothesis of a unit root.

[2] Since Im et al (2005) test is well-known in the literature, their details are not reproduced here to conserve space.
[3] Since the Hadri and Rao (2008) test is well-known in the literature, their details are not reproduced here to conserve space.

Second, conventional panel unit root procedures lack the ability to classify which panel members or how many panel members are responsible for the rejection of the null hypothesis of a unit root. In short, these procedures are basically designed to jointly test the null hypothesis of a unit root for all of the members of a panel. To mitigate the problems associated with the conventional panel unit root tests, the SPSM is applied to identify which and how many panel members belong to the stationary and to the nonstationary group.

Panel KSS unit test with a Fourier function is adopted. In each trial of SPSM, tests for unit roots that account jointly for structural breaks and non-linear adjustment are developed. Structural breaks are modeled by means of a Fourier function that allows for infrequent smooth temporary mean changes. Both Becker et al. (2004, 2006) and Enders and Lee (2012) develop tests which model any structural break of an unknown form as a smooth process via means of Flexible Fourier transforms. Many studies, including Gallant (1981), Becker et al. (2004), and Enders and Lee (2012), show that a Fourier approximation can often capture the behavior of an unknown function even if the function itself is not periodic. As such, the SPSM proposed by Chortareas and Kapetanios (2009), combined with the Panel KSS unit root tests with a Fourier function, were used to test for the stationarity of per capita energy usage and electricity consumption for the baseline sample of 12 APEC founding members and the broader sample of 19 APEC members.

In line with Kapetanios et al. (2003), the KSS unit root test is based on detecting the presence of non-stationarity against a nonlinear but globally stationary exponential smooth transition autoregressive (hereafter, ESTAR) process. The model is given by:

$$\Delta X_t = \gamma X_{t-1}\{1 - exp(-\theta X_{t-1}^2)\} + v_t \qquad (3)$$

where X_t is the data series of interest, v_t is an i.i.d (identically and independently distributed) error with zero mean and constant variance, and $\theta \geq 0$ is the transition parameter of the ESTAR model and governs the speed of transition. Under the null hypothesis X_t follows a linear unit root process, but X_t follows a nonlinear stationary ESTAR process under the alternative. One shortcoming of this framework is that the parameter γ is not identified under the null hypothesis. Kapetanios et al. (2003) have used a first-order Taylor series approximation for $\{1 - exp(-\theta X_{t-1}^2)\}$ under the null hypothesis $\theta = 0$ and have then approximated Eq. (3) by using the following auxiliary regression:

$$\Delta X_t = \xi + \delta X_{t-1}^3 + \sum_{i=1}^{k} \theta_i \, \Delta X_{t-i} + v_t \qquad t = 1,2,\ldots,T. \qquad (4)$$

In this framework the null hypothesis and alternative hypotheses are expressed as $\delta = 0$ (non-stationarity) against $\delta < 0$ (non-linear ESTAR stationarity). Then, Ucar and Omay (2009) have expanded a nonlinear panel data unit root test based on regression (3). The regression is:

$$\Delta X_{i,t} = \gamma_i X_{i,t-1}\left\{1 - exp\left(-\theta_i X_{i,t-1}^2\right)\right\} + v_{i,t} \qquad (5)$$

Ucar and Omay (2009) have also applied first-order Taylor series approximation to the Panel ESTAR model around $\theta_i = 0$ for all *i*, and have obtained the auxiliary regression:

$$\Delta X_{i,t} = \xi_i + \delta_i X_{i,t-1}^3 + \sum_{j=1}^{k} \theta_{i,j} \, \Delta X_{i,t-j} + v_{i,t} \qquad (6)$$

where $\delta_i = \theta_i \gamma_i$ and the hypotheses for unit root testing based on regression (6) are as follows:

H_0: $\delta_i = 0$, for all i (linear nonstationarity)

H_0: $\delta_i < 0$, for some i (nonlinear stationarity) (7)

Furthermore, the system of the KSS equations with a Fourier function that is estimated here is:

$$\Delta X_{i,t} = \xi_i + \beta_i t + \delta_i X_{i,t-1}^3 + \sum_{j=1}^{k1} \theta_{i,j}\, \Delta X_{i,t-j} + a_{i,1} \sin\left(\frac{2\pi kt}{T}\right) + b_{i,1} \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_{i,t} \quad (8)$$

where $t = 1, 2, \ldots., T, k$ represents the frequency selected for the approximation, $[a_i, b_j]'$ measures the amplitude and displacement of the frequency component, and the rationale for selecting $[sin(2\pi kt/T), cos(2\pi kt/T)]$ is based on the fact that a Fourier expression is capable of approximating absolutely integrable functions to any desired degree of accuracy. It also follows that at least one frequency component must be present if there is a structural break. Gallant (1981), Becker et al. (2004) and Enders and Lee (2012), and Pascalau (2010), show that a Fourier approximation can often capture the behavior of an unknown function even if the function itself is not periodic. Since there is no a priori knowledge concerning the shape of the breaks in the data, a grid-search is first performed to find the best frequency.

The SPSM proposed by Chortareas and Kapetanios (2009) is based on the following steps:

(1) The Panel KSS test with a Fourier function is first performed on all the series in the panel. If the unit-root null cannot be rejected, the procedure is stopped, and all the series in the panel are nonstationary. If the null hypothesis is rejected, go to Step 2.

(2) Remove the series with the minimum KSS statistic since it is identified as being stationary.

(3) Return to Step 1 for the remaining series, or stop the procedure if all the series are removed from the panel.

Final result is a separation of the whole panel into a set of mean-reverting series and a set of non-stationary series.

4. Empirical results

This section reports and discusses the main empirical results.

The results of the Pesaran (2004) CD test are reported in Table 3. For the relative per capita energy usage series, the Pesaran CD statistic is highly significant at the first 3 lags, implying a strong rejection of the null of cross-sectional independence but it becomes insignificant at lags (4) and (5). On the other hand, for the relative per capita electricity consumption series, the CD statistics fail to reject the null hypothesis of cross-sectional independence even at 10 percent, except for the panel of APEC-12 at lag (3). These results suggest that there is no cross-sectional dependence in the data. As such, there is mixed evidence on the existence of cross-sectional dependence in relative per capita energy usage and electricity consumption. This justifies the use of both first- and second-generation panel unit root tests for a good cross check.

[Please place Table 3 here]

Table 4 reports the results of panel unit root test by Im et al (2005) for both relative per capita energy usage and electricity consumption of APEC-12 and all 19 APEC members, except Papua New Guinea and Taipei, China, for which data are not available. These tests are LM unit root tests which account for one or two structural breaks chosen using the minimum

LM statistics of Lee and Strazicich (2003, 2013). For both variables in both groups of countries, the null of no convergence is rejected at 1% significance level. Panel unit root test of Hadri and Rao (2008) is then applied, and the results are reported in Table 5. The null of convergence is accepted at all significance levels. These findings are consistent with those from Im et al (2005)'s panel unit root tests, which confirm that per capita energy usage and electricity consumption is converging in both APEC-12 and 19 APEC members.[4]

[Please place Tables 4 and 5 here]

While the finding of convergence for APEC-12 could be expected due to relatively similar economic structures, the finding of convergence for all 19 APEC members warrants some explanation. In terms of policy coordination, APEC members have been pursuing economic and energy integration via APEC Energy Ministerial Meeting, APEC Energy Working Group (EWG), and Asia Pacific Energy Research Centre (APERC). Such initiatives may contribute to convergence in energy-related variables.

In particular, Energy Ministers' Meeting (EMM) was first held in 1996 in Sydney, Australia in order to provide policy orientation for the APEC's Energy Working Group (EWG) launched in 1990. The group's mission is to build the capacity of APEC members to strengthen domestic and regional energy security and lower the carbon intensity of energy supply and use across the region. EMMs are generally held every two years to ensure that EWG operate in accordance with the goals set out by APEC leaders.

APEC energy cooperation is conducted under the framework of the Energy Security Initiative (ESI), which was first put forward by the EWG in 2000. ESI consists of measures to respond to temporary supply disruptions as well as longer-term policy responses to address

[4] Following one referee's suggestion, this study also conducted the Bai and Carrion-I-Silvestre (2009)'s panel unit root test. The results appear to confirm the findings from the two conventional procedures employed in this study. The suggestion is appreciated.

the broader challenges facing the region's energy supply. The ESI also addresses energy for sustainable development by promoting the security and reliability of affordable energy. Since its establishment, the ESI has been reviewed, enhanced and expanded, most recently in November 2004. Specifically, APEC Economic Leaders endorsed the CAIRNS Initiative (Comprehensive Action Initiative Recognizing the Need for Strengthening the APEC Energy Security Initiative) to strengthen the ESI under the themes of energy security, sustainable development, and common prosperity.

Furthermore, other characteristics of APEC members have also contributed to per capita energy convergence. First, lower-income APEC countries grew rapidly during the sample period. Second, there is increased awareness of energy conservation measures in the more developed APEC countries. Third, related to second, there is growing international pressure to lower the carbon intensity of energy supply and use across the region.

The findings of this study provide some support for policies to promote energy integration in APEC. The objectives of APEC include ensuring rational and equitable consumption of energy across the region (Ariff, 1998). The findings provide some cause for optimism that the objectives of energy integration in APEC are attainable. Furthermore, the evidence of per capita energy convergence in APEC found in this study is consistent with this objective. Energy market integration, in turn, can promote more equitable growth across countries (Sheng and Shi, 2013). Policies to further promote efficiency savings and reduce carbon dioxide emissions, such as the promotion of renewable energy, can lead to further per capita energy convergence (Maza and Villaverde, 2008; Meng et al, 2013).

Overall, this study finds evidence of convergence in energy usage and electricity consumption per capita for the APEC-12 and 19 APEC members in the sample when panel unit root tests that accommodate structural breaks are employed. This finding holds irrespective of whether the null is specified to be convergence or non-convergence. However, the drawbacks of panel-based unit root tests includes failure to determine the mix of I(0) and I(1) series in a panel setting and failure to incorporate structural breaks into the model. All of these affect the power to detect mean reversion of per capita energy usage and electricity consumption. Therefore, this study utilizes the SPSM combined with the Panel KSS unit root test with a Fourier function to investigate the time-series properties of the series for the APEC-12 and 19 APEC countries. The SPSM classifies the whole panel into a group of stationary series and a group of non-stationary series. By doing so, the study can clearly identify how many and which series in the panel are stationary processes.

Table 6 reports the results of Panel KSS unit root test with a Fourier function (with both constant and trend included) on the per capita energy and electricity consumption in APEC-12. It also gives a sequence of the Panel KSS statistics with their bootstrap p-values on a reduced panel, the individual minimum KSS statistic, and the stationary series identified by this procedure each time. The null hypothesis of unit root in per capita energy usage was rejected when the Panel KSS unit root test was first applied to the whole panel, producing a value of −3.142 with a very small p-value of 0.000.

[Please place Table 6 here]

After implementing the SPSM procedure, the Philippines is found to be stationary with the lowest KSS value of −4.113. The Philippines was then removed from the panel and the Panel KSS unit root test was performed on the remaining series. After that, the results suggest that the Panel KSS unit root test rejected the unit root null with a value of −3.055 (p-value of 0.000), and Australia was found to be stationary with the lowest KSS value of −3.917. Australia was then removed from the panel and the Panel KSS unit root test was performed on the remaining series. The procedure was repeated until the Panel KSS unit root test failed to reject the unit root null hypothesis at the 10% significance level, and this procedure stopped at the 8th sequence, when the per capita energy usage for eight countries, except South Korea, the U.S., Malaysia and Japan, were removed from the panel. To check the robustness of the test, the procedure was continued until the last sequence.

The results reveal that the Panel KSS statistic all failed to reject the unit root null hypothesis for the remaining sequences. The SPSM procedures using the Panel KSS unit root test with a Fourier function (with both constant and trend included) provided relatively strong evidence of stationary per capita energy usage for APEC-12. Therefore, it seems that stationarity in per capita energy usage holds in 8 out of the 12 APEC founding members, and there is evidence of non-convergence in the remaining four countries - South Korea, Japan, the U.S. and Malaysia.

These four countries are all major economies in the region. South Korea and Japan share similar energy profiles. Despite having minimal natural energy resources, they are globally significant energy consumers. Consequently, the two countries are among the world's top importers of energy resources, including oil, coal and liquefied natural gas (LNG), and are also big producers of nuclear power. At the same time, South Korea and Japan have been among the global leaders in terms of energy efficiency and emissions control (Wu, 2012). In particular, Japan has led the world in industrial energy efficiency and pioneered the development of more fuel-efficient vehicles and more recently, hybrid vehicles (Kalicki and Goldwyn, 2013).

The U.S. too is one of the world's largest energy consumers. The major energy sources consumed by the U.S. are petroleum (oil), natural gas, coal, nuclear energy, and renewable energy (EIA, 2015). Thanks to significant improvement in energy efficiency, the country's energy intensity declined by 50% between 1980 and 2014, from 12.1 thousand

BTU per dollar to 6.1, which averaged at 2.0% per year over this period. Efficiency gains were also partly due to shifts in the US economy away from some energy-intensive sectors such as heavy industry (Nadel, 2015). According to estimates, about 40% of the improvement in energy intensity was due to structural shifts, and 60% was due to efficiency improvements (Nadel, 2015).

Malaysia's energy consumption has risen dramatically over the past 20 years due to industrialization and urbanization, leading to rapid depletion of its energy resources. Therefore, developing alternative energy sources such as solar energy is critical for meeting the country's future energy demand (Malaysia Productivity Corporation, 2016). Malaysia's energy intensity decreased and its energy use efficiency improved since 2000 (Malaysia Productivity Corporation, 2016). Energy policy has been an essential part of the Malaysia Plan (MP) – a comprehensive blueprints prepared by the Economic Planning Unit (EPU) of the Prime Minister's Department and the Finance Ministry of Malaysia with approval by the Cabinet of Malaysia. In particular, the New Energy Policy highlighted under the Tenth Malaysia Plan (10MP: 2011-2015) focuses mostly on energy efficiency that aims to enhance energy security and reliability of supply through the development of hydro sources -liquefied natural gas (LNG), and coal for power (Malaysia Productivity Corporation, 2016).

For electricity, the results indicate that the null hypothesis of a unit root in per capita electricity consumption should be rejected when the panel KSS unit root test was applied to the entire panel. The test statistic of -3.881 (p-value =0.000) indicates that the null hypothesis of a panel unit root should be rejected at 1 percent level. The result from the SPSM procedure indicates that per capita electricity consumption for the U.S. is stationary with the lowest KSS value of -4.993 among the panel. Based on this result, the U.S. was removed from the panel and the test was applied to the remaining countries. The panel KSS unit root was again applied to the remaining panel members.

Per capita electricity consumption for Indonesia was found to be stationary with the lowest KSS value of -4.232. Indonesia was then removed from the panel and the panel KSS unit root test performed again. This process is repeated until the null hypothesis of a unit root could not be rejected at the 10 percent significance level. Taken together, the results indicate that per capita electricity consumption for 11 APEC founding members, namely, the U.S., Canada, Brunei, Indonesia, Philippines, Thailand, Malaysia, Australia, Japan, New Zealand, and Singapore have converged as the series are stationary processes. This study finds evidence of divergence only for South Korea, since its series were found to be unit root processes.

To check the robustness of the results from the panel KSS unit root procedure, this study continues the process until the last sequence. It is found that the Panel KSS statistic all failed to reject the unit root null hypothesis for the remaining sequences. Therefore, SPSM procedures using the Panel KSS unit root test with a Fourier function, with both constant and trend included, provide strong evidence of stationarity in APEC-12. This reinforces the finding that stationary per capita electricity consumption holds in 11 out of the 12 APEC founding members. The evidence of non-convergence in electricity usage in South Korea could be explained as follows. China and India account for 62% of Asia’s power consumption, but in terms of power consumption per capita, they consume much less than Japan or South Korea. However, per capita consumption in South Korea grew very rapidly and surpassing that of even Japan, a possible sign of overconsumption. Per capita figures in Japan have decreased due to demand management and improved efficiency. Electricity consumption per GDP at purchasing power parity shows improved efficiency in all countries in the region, except South Korea.

Furthermore, South Korea provides electricity below the cost of generation, and this contributes to continued growth in demand. Apart from price policies, technological improvements and using the most efficient source of energy will all play a vital role. In addition to investing more in renewable energy, South Korea also plans to build more nuclear power plants (Hong et al, 2014).

For robustness, the SPSM procedures using the Panel KSS unit root test with a Fourier function, with both constant and trend included, was performed for the broader sample of 19 APEC countries. The results are qualitatively the same as APEC-12 for per capita energy usage. Specifically, this study finds relatively strong evidence of stationarity in 15 countries and evidence of divergence for only 4 countries, namely, South Korea, the U.S., Malaysia and Japan. For per capita electricity consumption, this research found evidence of divergence only for Vietnam and South Korea. Rapid growth in electricity demand was especially evident in developing Asian economies. Vietnam experienced the highest average annual growth rate from 1990 to 2009 (14.2%), followed by China (10.2%), and Malaysia and Indonesia (both 8.6%) (APEC, 2013). However, Vietnam scores very poorly on all indices of the World Energy Council's "Energy Trilemma", which measures the security, equity and sustainability of a country's energy situation. About 60% of Vietnam's capacity is generated by fossil fuels and only 7% of capacity is generated by renewables (Asian Power, 2015).

There are economic, policy-related, and technical barriers to the development of Vietnam's power sector. From an economic standpoint, Vietnam is highly reliant on the import of fossil fuels and hence exposed to both price risk and currency risk since about 61%

of the country's generation capacity relies on fossil fuels. The structural situation in Vietnam's power sector also presents challenges. The transmission and distribution capacity is largely held by Electricity Vietnam (EVN), which currently operates as a monopoly. The Vietnamese power market does not yet have independent private firms in various parts of the power supply chain (Asian Power, 2015). There is a lack of opportunity for small power plants, since units which are smaller than 30MW are currently not allowed to sell to the wholesale market.

Alternative sources of energy such as wind, solar and geothermal are usually less than 30MW in size, reducing the incentives to build them. Vietnam also lacks the technology to build more advanced power generation facilities, especially in renewables. Such facilities are more likely to be brought in through foreign investment, which is unlikely to gain significant traction in light of restrictive policies. A number of policy changes may help unlock the sector's potential. For instance, the monopoly of EVN on transmission and distribution is set to end in 2016. Introduction of competition may lower tariff rates and improve returns to power generators, attracting more investment to the country's power sector.

All of this suggests that the findings of the baseline analysis for APEC-12 are relatively robust. Pursuit of policies to achieve energy supply stability can move divergent countries toward convergence. Furthermore, overall, the empirical findings suggest that allowing for nonlinearities and structural breaks results in more rejections of the unit root null hypothesis. The results thus point to a need to incorporate structural breaks and nonlinearities in the analysis of per capita energy consumption series.

5. Conclusions

This study is among the very few studies of cross-country convergence in per capita usage of energy and electricity. It compares convergence patterns in per capita usage of energy and electricity within APEC, a significant economic group aspiring to economic and energy cooperation. The main sample consists of APEC-12 – APEC's founding members which remain its most influential members. More importantly, these countries were part of APEC for the whole period of the study (1989-2012). For robustness, this study also looks at a broader sample of 19 APEC countries for which data are available over the same period.

For the empirical analysis, first the panel LM unit root test with endogenous structural breaks as proposed by Im et al (2005) was employed. In addition, the study used a new version of the Hadri (2000) panel stationarity test, which was extended by Hadri and Rao (2008) to further control for cross-country dependence among members of panel, serial correlation in errors, and unobserved heterogeneity in the form and date of potential structural breaks in a trend function. Finally, this paper performed the SPSM procedure that can detect both nonlinearity and structural breaks in the data generating process.

The results from Im et al (2005)'s and Hadri and Rao (2008)'s panel unit root tests suggest that APEC countries with low energy usage and/or electricity consumption per capita are catching up with APEC countries with higher energy usage and/or electricity consumption per capita. The results from the SPSM procedure improve the understanding of the convergence process for APEC-12 and 19 APEC countries. Specifically, for the sample of 12 founding members, the study finds the evidence of convergence in energy usage for 8 out of 12 countries and evidence of convergence in electricity consumption for 11 out of 12 countries. Meanwhile, for the broader sample of 19 APEC countries, the study finds that per capita energy usage is stationary in 15 out of 19 APEC countries while per capita electricity consumption is stationary in 17 out of 19 APEC countries. The findings suggest that living standards and welfare of developing economies in APEC have improved significantly over time. The evidence also implies that economic and energy integration can help foster economic growth in the region.

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Appendix:

Table 1: List of countries in the study sample

Sample 1: APEC12 (founding members)	
Member	Date of joining
Australia	6-7 Nov 1989
Brunei	6-7 Nov 1989
Canada	6-7 Nov 1989
Indonesia	6-7 Nov 1989
Japan	6-7 Nov 1989
South Korea	6-7 Nov 1989
Malaysia	6-7 Nov 1989
New Zealand	6-7 Nov 1989
Philippines	6-7 Nov 1989
Singapore	6-7 Nov 1989
Thailand	6-7 Nov 1989
United States	6-7 Nov 1989
Sample 2: 19 APEC members	
Member	Date of joining
Australia	6-7 Nov 1989
Brunei	6-7 Nov 1989
Canada	6-7 Nov 1989
Chile	11-12 Nov 1994
China	12-14 Nov 1991
Hong Kong	12-14 Nov 1991
Indonesia	6-7 Nov 1989
Japan	6-7 Nov 1989
South Korea	6-7 Nov 1989
Malaysia	6-7 Nov 1989
Mexico	17-19 Nov 1993
New Zealand	6-7 Nov 1989
Peru	14-15 Nov 1998
Philippines	6-7 Nov 1989
Russia	14-15 Nov 1998
Singapore	6-7 Nov 1989
Thailand	6-7 Nov 1989
United States	6-7 Nov 1989
Viet Nam	14-15 Nov 1998

Source: http://www.apec.org/About-Us/About-APEC/Member-Economies.aspx

Table 2: Descriptive statistics of energy usage (kg of oil equivalent per capita) and electricity consumption (kWh per capita) for APEC members

Country	Observations	Mean	Standard Deviation	Min	Max	Skewness
Energy usage						
Australia	24	5419.792	260.505	4927.782	5763.506	-0.738
Brunei	24	7528.383	1025.727	6125.881	9695.714	0.645
Canada	24	7844.887	346.579	7225.682	8378.829	-0.160
Chile	24	1558.171	313.216	1014.228	2140.068	-0.332
China	24	1164.376	446.692	724.370	2142.812	0.896
Hong Kong	24	1913.803	231.917	1515.886	2426.538	-0.113
Indonesia	24	713.366	109.960	456.710	866.785	-0.554
Japan	24	3857.686	216.457	3350.726	4091.710	-0.746
South Korea	24	3796.635	975.079	1857.298	5268.368	-0.391
Malaysia	24	2117.222	518.659	1172.115	2818.864	-0.209
Mexico	24	1462.694	57.750	1376.025	1572.878	0.347
New Zealand	24	4116.311	181.709	3762.166	4428.734	-0.238
Peru	24	493.365	84.872	408.433	719.628	1.631
Philippines	24	463.525	26.225	416.694	513.139	0.293
Russia	23	4686.213	540.209	3981.492	5928.793	0.904
Singapore	24	5034.452	898.830	2896.501	7370.331	0.268
Thailand	24	1257.636	351.727	656.057	1884.299	0.062
United States	24	7656.608	317.299	6814.823	8056.864	-1.444
Vietnam	24	428.441	147.240	269.302	730.572	0.676
Electricity consumption						
Australia	24	9850.122	938.732	8129.104	10972.844	-0.475
Brunei	24	7260.181	1597.827	4328.536	9092.209	-0.733
Canada	24	16606.801	545.211	15614.609	17630.633	0.338
Chile	24	2494.822	824.756	1220.947	3810.118	-0.157
China	24	1456.874	935.968	487.373	3475.009	0.863
Hong Kong	24	5312.047	640.012	3936.724	6026.193	-0.627
Indonesia	24	400.749	172.575	137.494	729.881	0.200
Japan	24	7603.949	612.040	6236.923	8474.379	-0.808
South Korea	24	6006.190	2648.341	2095.195	10345.601	0.100
Malaysia	24	2626.082	961.740	1065.338	4345.471	0.060
Mexico	24	1635.822	277.828	1161.975	2074.244	-0.252
New Zealand	24	9253.988	343.518	8465.386	9700.091	-0.555
Peru	24	761.051	229.762	475.919	1241.671	0.727
Philippines	24	496.377	107.430	334.963	672.389	-0.103
Russia	23	5747.345	618.451	4848.030	6673.179	0.063
Singapore	24	7159.526	1364.607	4639.189	8689.669	-0.495
Thailand	24	1554.204	536.216	614.501	2464.679	-0.056
United States	24	12948.847	635.202	11531.932	13704.577	-0.769
Vietnam	24	448.939	359.137	94.158	1272.539	0.869

Table 3: Cross-sectional correlation of the errors in the ADF(p) regression for energy usage and electricity consumption per capita across APEC countries

	Energy usage	Electricity consumption
	Statistic	Statistic
APEC-12 countries		
Lag(1)	5.441***	0.816
Lag(2)	3.609***	1.497
Lag(3)	2.212**	1.960**
Lag(4)	0.719	1.613
Lag(5)	0.098	1.550
APEC-All countries		
Lag(1)	10.189***	0.478
Lag(2)	5.511***	-0.719
Lag(3)	2.763***	-0.134
Lag(4)	1.362	-0.403
Lag(5)	0.945	-0.298

Note: LM Pesaran's (2004) cross-section dependence test. H_0: cross-sectional independence.

Table 4: Results of the Im et al (2005)'s panel LM unit root test with one and two breaks

Variable	Panel LM test statistic
APEC-12 countries	
Energy usage- One break	-10.114***
Energy usage- Two breaks	-31.344***
Electricity consumption- One break	-10.094***
Electricity consumption - Two breaks	-817.337***
APEC-All countries	
Energy usage- One break	-22.091***
Energy usage- Two breaks	-9.449***
Electricity consumption- One break	-9.142***
Electricity consumption - Two breaks	-98.428***

Note: Null hypothesis: Non stationary. The break date in the Im et al. (2005) test is chosen using the minimum LM statistics of Lee and Strazicich (2003, 2013). In this method, the break date is selected when the t-statistic of possible break points is minimized.

Table 5: Results of Hadri and Rao (2008)'s panel stationarity test with structural breaks

Variable	Hr Statistic	Bootstrap critical values 10%	5%	1%
APEC-12 countries				
Energy usage	0.118	1.48	1.788	2.692
Electricity consumption	0.157	2.298	2.746	3.848
APEC-All countries				
Energy usage	0.198	2.099	2.482	3.329
Electricity consumption	0.153	1.576	1.915	2.662

Note: Bootstrap critical values are based on a Monte Carlo simulation with 20,000 replications. The null hypothesis is stationarity.

Table 6: Panel KSS unit root test with a Fourier function for 12 APEC founding members

ENERGY USAGE				
Sequence	OU stat	P-Value	Min KSS	I(0) series
1.0000	-3.142	0.000	-4.113	Philippines
2.0000	-3.055	0.000	-3.917	Australia
3.0000	-2.970	0.001	-3.609	Singapore
4.0000	-2.767	0.002	-3.313	Indonesia
5.0000	-2.454	0.009	-2.837	New Zealand
6.0000	-2.395	0.013	-2.265	Thailand
7.0000	-2.541	0.010	-1.907	Brunei Darussalam
8.0000	-2.780	0.008	-0.513	Canada
9.0000	-1.523	0.127	-0.336	Korea, Rep.
10.0000	-1.487	0.142	-0.319	United States
11.0000	0.156	0.705	0.615	Malaysia
12.0000	0.214	0.137	0.682	Japan
ELECTRICITY CONSUMPTION				
Sequence	OU stat	P-Value	Min KSS	I(0) series
1.0000	-3.881	0.004	-4.993	United States
2.0000	-4.048	0.004	-4.232	Indonesia
3.0000	-3.280	0.012	-3.759	Philippines
4.0000	-3.166	0.017	-3.541	New Zealand
5.0000	-3.179	0.015	-3.286	Canada
6.0000	-2.544	0.030	-3.278	Brunei Darussalam
7.0000	-2.141	0.036	-3.180	Malaysia
8.0000	-1.955	0.034	-2.124	Australia
9.0000	-1.778	0.059	-1.948	Japan
10.0000	-2.475	0.039	-0.719	Thailand
11.0000	-2.789	0.083	-0.085	Singapore
12.0000	-2.191	0.105	0.220	Korea, Rep.

Note: Panel KSS unit root test with a Fourier function (constant and trend) is conducted. The maximum lag is set to be 5. The asymptotic p-values are computed by means of Bootstrap simulations using 5,000 replications. Fourier (k) is chosen by minimum sum square of residual for Fourier function. OU indicates test proposed by Ucar and Omay (2009).

Table 7: Panel KSS unit root test with a Fourier function for 19 APEC countries

ENERGY USAGE

Sequence	OU stat	P-Value	Min KSS	I(0) series
1.0000	-3.545	0.000	-4.260	Russian Federation
2.0000	-3.401	0.000	-4.113	Philippines
3.0000	-3.360	0.000	-3.917	Australia
4.0000	-3.326	0.000	-3.888	Vietnam
5.0000	-3.289	0.000	-3.609	Singapore
6.0000	-3.181	0.000	-3.576	Hong Kong SAR, China
7.0000	-3.082	0.000	-3.447	Mexico
8.0000	-2.889	0.000	-3.313	Indonesia
9.0000	-2.673	0.001	-2.837	New Zealand
10.0000	-2.653	0.001	-2.265	Thailand
11.0000	-2.779	0.000	-2.247	Chile
12.0000	-2.701	0.002	-1.907	Brunei Darussalam
13.0000	-2.894	0.001	-1.503	China
14.0000	-2.961	0.003	-1.111	Peru
15.0000	-2.780	0.008	-0.513	Canada
16.0000	-1.523	0.127	-0.336	Korea, Rep.
17.0000	-1.487	0.142	-0.319	United States
18.0000	0.156	0.705	0.615	Malaysia
19.0000	0.214	0.137	0.682	Japan

ELECTRICITY CONSUMPTION

Sequence	OU stat	P-Value	Min KSS	I(0) series
1.0000	-3.274	0.000	-4.993	United States
2.0000	-3.140	0.000	-4.357	Canada
3.0000	-3.098	0.000	-3.750	Brunei Darussalam
4.0000	-2.982	0.000	-3.216	Russian Federation
5.0000	-2.813	0.000	-2.949	Indonesia
6.0000	-2.854	0.000	-2.910	Philippines
7.0000	-2.588	0.000	-2.633	Thailand
8.0000	-2.609	0.000	-2.464	Hong Kong SAR, China
9.0000	-2.590	0.000	-2.313	Mexico
10.0000	-2.177	0.002	-2.124	Australia
11.0000	-2.123	0.006	-1.948	Japan
12.0000	-2.400	0.011	-1.816	New Zealand
13.0000	-2.419	0.011	-1.510	Singapore
14.0000	-2.392	0.018	-1.498	China
15.0000	-2.686	0.010	-0.890	Chile
16.0000	-2.186	0.084	-0.876	Malaysia
17.0000	-3.674	0.001	-0.542	Peru
18.0000	-1.373	0.293	-0.436	Vietnam
19.0000	-0.194	0.796	0.220	Korea, Rep.

Note: Panel KSS unit root test with a Fourier function (constant and trend) is conducted. The maximum lag is set to be 5. The asymptotic p-values are computed by means of Bootstrap simulations using 5,000 replications. Fourier (k) is chosen by minimum sum square of residual for Fourier function. OU indicates test proposed by Ucar and Omay (2009).