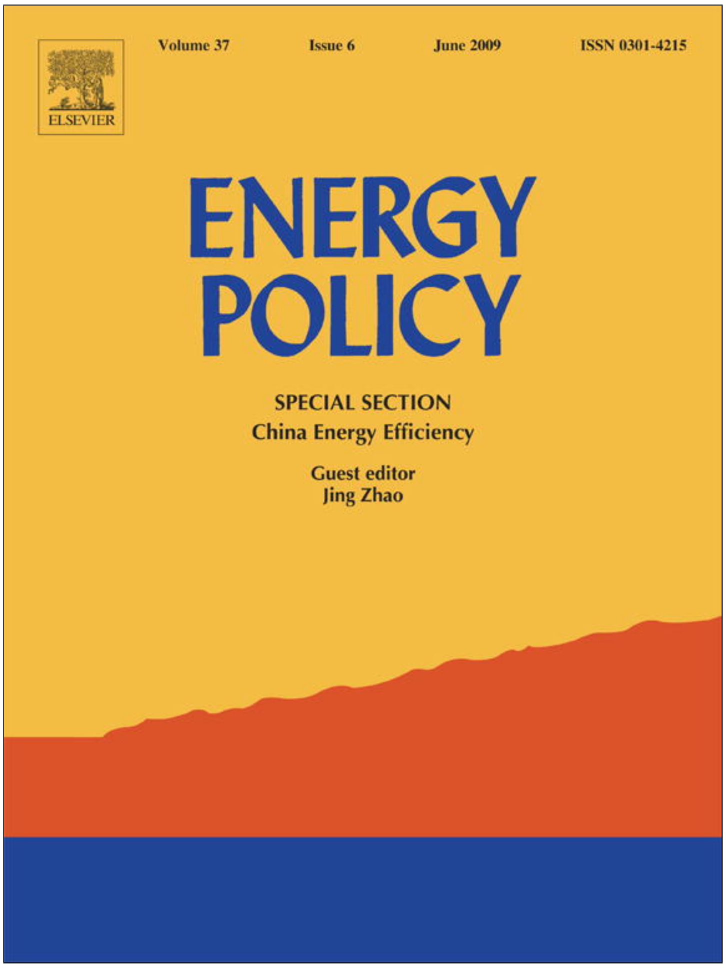
Volume 37
Issue 6
June 2009
ISSN 0301-4215
ELSEVIER
ENERGY POLICY
SPECIAL SECTION
China Energy Efficiency
Guest editor
Jing Zhao

Energy Policy 37 (2009) 2318–2326

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Are fluctuations in energy consumption per capita transitory? Evidence from a panel of Pacific Island countries

Vinod Mishra [a], Susan Sharma [b], Russell Smyth [c,*,1]

[a] Department of Economics, Monash University, Clyde Road Berwick, VIC. 3086, Australia
[b] School of Economics, University of the South Pacific, Suva, Fiji
[c] Department of Economics, Monash University, 900 Dandenong Road, Caulfield East, VIC. 3145, Australia

ARTICLE INFO

Article history:
Received 7 October 2008
Accepted 17 February 2009
Available online 20 March 2009

Keywords:
Energy consumption
Panel stationarity
Pacific islands

ABSTRACT

This study applies the panel stationarity test developed by [Carrion-i-Silvestre et al 2005. Breaking the panels: An application to GDP per capita. Econometrics Journal 8, 159–175] to examine the stationarity of energy consumption per capita for a panel of 13 Pacific Island countries over the period 1980–2005. This test has the advantage that it allows for multiple structural breaks at unknown dates that can differ across countries and can account for all forms of cross-sectional correlation between countries. The conclusion from the study is that energy consumption per capita in approximately 60% of countries is stationary and that energy consumption per capita for the panel as a whole is stationary. The study offers several suggestions for modelling energy consumption and policy-making in the Pacific Islands.

1. Introduction

There has been a surge in interest in applying panel unit root and panel stationarity tests to examine the stationarity properties of energy consumption (see Lee, 2005; Al-Iriani, 2006; Narayan and Smyth, 2007; Chen and Lee, 2007; Hsu et al, 2008; Joyeux and Ripple 2007; Lee and Chang, 2008). Interest in whether energy consumption is stationary is motivated by several factors. First, if energy consumption is stationary, shocks to energy consumption will be temporary; however, if energy consumption contains a unit root, shocks to energy consumption will have permanent effects. Second, if shocks to energy consumption are permanent, given the importance of energy to other sectors in the economy, key macroeconomic variables can be expected to inherit that non-stationarity. As Hendry and Juselius (2000) note, "variables related to the level of any variables with a stochastic trend will inherit that non-stationarity, and transmit it to other variables in turn".

Specifically, if energy consumption contains a unit root, through the transmission mechanism to real income, real output can be expected to contain a unit root. To consider this point in more detail, following the approach in Hamilton (2007), a simple framework for examining the relationship between energy consumption and real income is to consider a production function relating output (Y) produced by a firm to inputs of labour (L), capital (K) and energy consumption (E) (see also Maslyuk and Smyth, 2009; Narayan et al., 2008):

$$Y = F(L, K, E)$$

If output is sold for a nominal price of P dollars per unit, labour is paid a nominal wage W, the nominal cost of energy is Q and capital is rented at a nominal rate r, the profits of the firm can be calculated as follows:

$$PY - WL - rK - QE$$

A price-taking, profit-maximizing firm will purchase energy up to the point where the marginal product of energy is equal to its relative price

$$F_E(L, K, E) = Q/P$$

where $F_E(L,K,E)$ denotes the partial derivative of $F(\cdot)$ with respect to E. Multiplying both sides of the equation by E and dividing by Y one gets

$$\partial \ln F/\partial \ln E = QE/PY$$

This suggests that the elasticity of output with respect to a given change in energy consumption can be inferred from the dollar share of energy expenditure in total output.

Third, whether key macroeconomic variables are stationary has important implications for alternative economic theories, which suggest different conclusions on the issue of the desirability and efficacy of government intervention through the use of macroeconomic stabilization policies. If there is a unit root in real output, it suggests that following a negative shock automatic

* Corresponding author. Tel.: +61 3 9903 2134; fax: +61 3 9903 1128.
E-mail address: Russell.Smyth@BusEco.monash.edu.au (R. Smyth).
[1] We thank Josep Lluís Carrion-i-Silvestre for providing his GAUSS code and a referee for helpful comments.

0301-4215/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2009.02.022

return to a normal trend may not occur, and, therefore, Keynesian stabilization policies to stimulate demand and move the economy towards full employment have a role to perform (Libanio, 2005). Alternatively, if real output is stationary, stabilization policies will be ineffective as output will revert to a natural rate, meaning Keynesian policies may only have temporary effects on output levels (Chang et al, 2005).

Whether energy consumption and therefore output, via the transmission mechanism, is stationary also has implications for the validity of macroeconomic theories premised on output being stationary. As Cochrane (1994, p. 241) noted, if real output contains a unit root, this "challenges a broad spectrum of macroeconomic theories designed to produce and understand transitory fluctuations". Studies have linked oil price shocks, via their effect on a country's energy consumption, to inflation (Cunado and Perez de Gracia, 2003) and movements in stock prices (Sardosky, 1999; Papapetrou, 2001). For example, conventional sticky-price models, such as Dornbusch (1976) and Taylor (1979), depend on stationarity of the price level. While 'higher order' Phillips curves associated, for instance, with Ball (1993) are consistent with a unit root in price, they are not consistent with a unit root in inflation (see Narayan and Smyth, 2007). In finance, the unit root properties of stock prices have important practical implications for investors. If stock prices are mean reverting, it follows that the price level will return to its trend path over time and that it might be possible to forecast future movements in stock prices based on past behaviour, but if stock prices follow a random walk process, any shock to prices will be permanent (Chaudhuri and Wu, 2003).

Fourth, the issue of whether energy consumption is stationary has important implications for modelling. There is a large literature examining the causal relationship between energy consumption and real output. The findings from these studies have important policy implications. If unidirectional causality runs from energy consumption to real output, it follows that reducing energy consumption could lead to a fall in income; however, if causation runs in the opposite direction this provides strong justification for implementing energy conservation policies because economic growth is not dependent on energy consumption. To increase power, many of these studies now use panel frameworks (see Lee 2005; Al-Iriani, 2006; Chen et al., 2007; Joyeux and Ripple 2007; Mahadevan and Asafu-Adjaye 2007; Mehrara, 2007; Lee and Chang, 2008; Narayan and Smyth, 2008, 2009). The correct modelling approach, and thus having accurate empirical findings to inform policy-making, in such studies depends on the panel stationarity properties of energy consumption.

Fifth, the issue of whether energy consumption is stationary has important implications for forecasting energy consumption. Energy forecasts can be regarded as a basic tool for energy planning and policy formulation. Thus, having accurate forecasts of energy consumption is essential to formulate policies for the future. If energy consumption is stationary, it is possible to forecast future movements in energy consumption based on past behaviour. However, if energy consumption is non-stationary then past behaviour is of no value in forecasting future demand and one would need to look at other variables explaining energy consumption to generate forecasts of energy demand into the future.

A limitation of most existing studies of the stationarity properties of energy consumption, however, is that they either do not adequately address the problem of cross-sectional correlation in the data and/or allow for structural breaks in the data. O'Connell (1998) demonstrated that ignoring cross-sectional dependence in conventional panel unit root tests can result in severe size biases (up to 50%) and loss of power. Since Perron, (1989) seminal study, it has been recognised that failure to take account of structural breaks lowers the power of the unit root test. Energy consumption has been subject to several structural breaks. Over the last quarter century, there are several events that represent potential structural breaks in world energy markets. These events include the second oil price shock in the early 1980s which precipitated a worldwide recession; the 1985 crash in oil prices; the first and second Gulf wars in 1990 and 2003, respectively; the Asian financial crisis and Russian default in 1997–1999; the 9/11 terrorist attacks in New York and Washington and political unrest in Venezuela, a major oil producer, in the first 6 months of 2002.

One study in the existing literature testing the stationarity properties of energy consumption that addresses these limitations is Chen and Lee (2007) who apply the Carrion-i-Silvestre et al. (2005) (hereafter CBL) test to energy consumption in seven regional-based panels. The CBL test has the advantage that it allows for up to five structural breaks at an unknown date; the number and location of structural breaks is allowed to differ between countries in the panel and the CBL test computes bootstrapped critical values that allows for any form of cross-sectional dependence. In this study, we examine the stationarity of energy consumption for a panel of Pacific Island countries. In geographical coverage it differs from Chen and Lee (2007) which do not have a Pacific Islands panel and do not include any Pacific Islands countries. We proceed in three steps. First, and in contrast to the existing literature, we employ the Pesaran (2004) test, which is an explicit test for cross-sectional correlation. Second, in addition to well-known conventional panel unit root tests, we employ the recently developed Pesaran (2007) cross-sectionally augmented version of the Im, Pesaran and Shin (IPS) (2003) test statistic, which is a panel unit root test without structural breaks that explicitly takes account of cross-sectional correlation. Third, following Chen and Lee (2007) we employ the CBL test with bootstrapped critical values that allows for up to five heterogeneous structural breaks and takes account of all forms of cross-sectional correlation.

2. Existing literature

Lee (2005) applied the Levin, Lin and Chu (LLC) (2002) and Im, Pesaran and Shin (IPS) (2003) panel unit root tests and Hadri (2000) panel stationarity test to annual data on energy consumption for 18 developing countries over the period 1975–2001. He found that energy consumption was non-stationary. Al-Iriani (2006) applied the IPS and LLC panel unit root tests to annual data on energy consumption for six Gulf Cooperation Council countries using annual data over the period 1971–2002 and reached the same conclusion as Lee (2005). Narayan and Smyth (2007) applied univariate unit root tests and the IPS panel unit root test to annual data on energy consumption for 182 countries over the period 1979–2000. The univariate unit root tests rejected the null of non-stationarity for just 31% of the sample, but the IPS test found overwhelming evidence that energy consumption is stationary. Hsu et al. (2008) applied the panel seemingly unrelated regressions augmented Dickey–Fuller (ADF) test developed by Breuer et al. (2001) to annual data on energy consumption from 84 countries over the period 1971–2003 and reached the same conclusion as Narayan and Smyth (2007). Chen and Lee (2007) applied the CBL test to energy consumption for seven regional panels over the period 1971–2002 and found energy consumption to be stationary.

There are few studies that have considered any aspect of energy consumption in the Pacific Islands countries. Reddy (1998) and Narayan and Singh (2007) consider the electricity consumption-output nexus in Fiji. Yu and Taplin (1997); Jafar (2000) and Urmee et al. (2009) among others, consider the potential to introduce renewable energy solutions in the Pacific Islands. There are no studies that have considered the stationarity of energy consumption for the Pacific Islands as a group of countries. However, given the extensive dependence on energy consumption in the Pacific Islands, the nature of energy consumption has important implications for their development and growth (Yu and Taplin, 1997). Specifically, at the Pacific Energy Ministers Meeting in the Cook Islands in 2007 it was agreed that energy is a key driver of economic growth with significant bearing on education, the environment, health and social welfare of the Pacific Island nations. This makes it important to further understand the nature of energy consumption in the Pacific Islands.

3. The Pacific islands context

Energy is used in commercial (transport) and non-commercial (public sector) activity. The Pacific Islands are highly dependent on imported petroleum for their commercial energy requirements. Petroleum imports account for over 90% of overall energy requirements, making the Pacific Island countries extremely vulnerable to shocks in international energy markets. Demand in the Pacific Islands countries is small compared to the Asia-Pacific region as a whole. In the early 1990s, demand for petroleum in the Pacific Islands was 50,000 barrels per day compared with 11 million barrels per day for the entire Asia Pacific (Rizer and Hansen, 1992). The Pacific Island countries are also among the world's smallest and geographically most isolated nations. Thus, despite having high dependence on international markets for imports of petroleum, their economic connections with those markets are thin and subject to disruption (ADB, 2008). Diseconomies of scale and transport costs increase the cost of energy in the Pacific Islands. For example, it is estimated that transportation costs add 5–10% to the cost of fossil fuels to main distribution centres in Fiji and Papua New Guinea and 27–40% in secondary distribution points (Rizer and Hansen, 1992).

Two negative effects of fossil fuel use are ever present throughout the Pacific Islands (ADB, 2008). First, the high and increasing cost of crude oil places considerable strain on the trade balances of the Pacific Island countries, crowding out other imports, increasing the cost of transport fuel and electricity and having an adverse effect on real income and poverty rates. Almost 50% of imported fuel is used for transportation and 37% of imported fuel is used for power generation (Yu and Taplin, 1997). Without cash inflows from foreign aid, remittances from citizens abroad and tourism, many Pacific Island countries would be unable to pay for commercial energy imports (Yu and Taplin, 1997). Several Pacific Island countries are unable to cope with the high cost of oil. For example, in the Marshall Islands, high fuel costs have curtailed the distribution of food and essential services, impinging on that country's ability to sustain normal public services (United Nations, 2008).

Second, because several of the Pacific Island countries are low-lying islands with no hinterland, they are particularly vulnerable to climate change. As an extreme example, the highest elevation of Tuvalu is 5 m above sea level, which gives Tuvalu the second lowest maximum elevation of any country (after the Maldives). Because of this low elevation, Tuvalu is threatened by future sea level rise which is a direct result of global warming. In the event of future sea level rise, it is expected that the entire population of Tuvalu may need to evacuate to New Zealand, Niue or Fiji. Other low-level Pacific Island countries vulnerable to increases in the sea level are Kiribati, Tokelau and the Marshall Islands. Other countries in the Pacific are vulnerable to changing rainfall and seasonal patterns resulting from climate change which have a direct impact on those who depend on agriculture and fisheries for their livelihood and nutritional intake. Higher temperatures are also causing more natural disasters such as cyclones and drought which are common in the Pacific Islands. For example, Tropical Cyclone Ofa in 1990 turned Niue from a food-exporting country to one dependent on imports for the following two years, while Tropical Cyclone Heta in 2004 had an even larger effect on agricultural production in Niue.

While the Pacific Island countries only consume a very small amount of energy on a global scale and are responsible for a miniscule fraction of global greenhouse gas emissions, vulnerability to climate change has placed the Pacific Island countries on the frontline of addressing global warming driven by fossil fuel combustion worldwide. The Pacific Island governments have taken a strong stand on global warming by leading from the front in worldwide attempts to reduce carbon dioxide emissions. Since the early 1990s, the Pacific Island countries have placed emphasis on the need to develop renewable energy (Yu and Taplin, 1997; Jafar, 2000). Lending agencies, such as the Asian Development Bank, are working with the Pacific Island countries to set up programs such as the 'Promoting Energy Efficiency Project' (ADB, 2008) to assist energy end users in the Pacific to reduce wasteful consumption of energy, and thus the environmental and financial costs to the energy sector.

4. Overview of the data

Annual data on energy consumption per capita for American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Nauru, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu for the period 1980–2005 was downloaded from the Energy Information Agency (EIA, 2008). All data were converted to natural logarithmic form prior to implementing the panel tests. But, the descriptive statistics discussed in this section are based on actual data. The specific Pacific Island countries selected for the study and the timeframe was dictated by data availability and the need to ensure a balanced panel.

In Fig. 1, we plot the per capita energy consumption series for the Pacific Island countries. For American Samoa, French Polynesia, Nauru, the Solomon Islands and Vanuatu there is a negative trend. For Nauru, it is very clear that there is a sharp decrease in energy consumption, while for the other countries the trend seems to be affected by structural breaks. For Guam, Kiribati and New Caledonia the trend seems to be declining and it is noticeable that the trend is not as stable as the other countries. For these countries, it is clear that the trend is affected by some structural breaks. In the case of Guam, there is a sharp decline in per capita energy consumption, followed by a period of relative stability, which, in turn, is followed by a rise in per capita energy consumption and then an uneven decline.

Papua New Guinea and Tonga exhibit a positive trend. But there is a vast difference in the trends of these two countries. For Papua New Guinea initially the trend fluctuates over the period 1980–2001, and then displays a sharp increase thereafter. By comparison, in the case of Tonga, there is a continuous increment in the trend over the period 1980–1998, which is when per capita energy consumption is at a maximum. Thereafter, it shows a slight decline followed by a rise. Finally, the Cook Islands, Fiji and Samoa show very unstable trends. The Cook Islands and Samoa seem to have experienced a sharp positive trend initially, which is followed by a sharp decline. For Fiji, there is a sharp decline in the early 1980s, after which consumption has been stable although it was affected by some structural breaks.

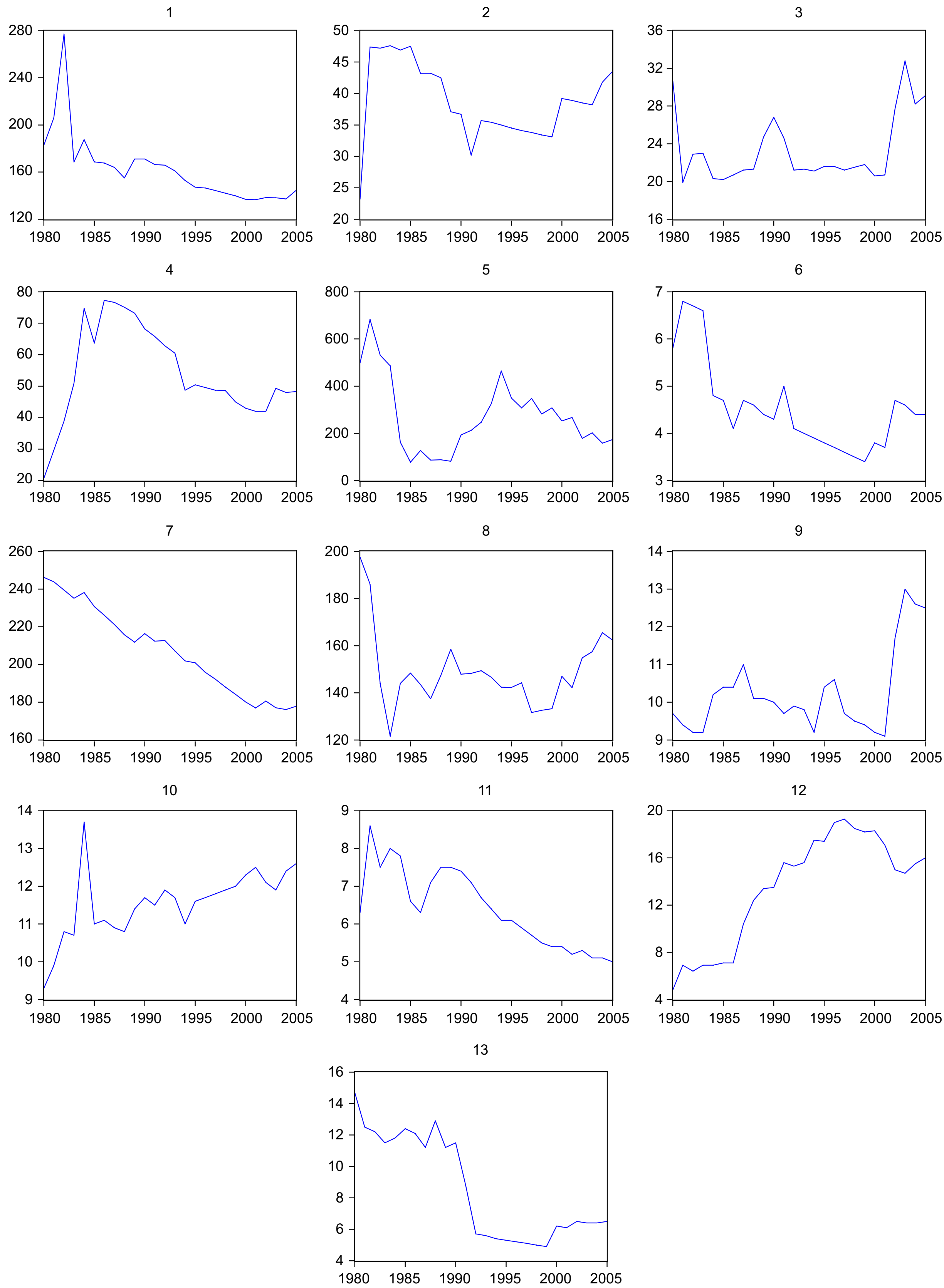

Fig. 1. Energy consumption per capita in 13 Pacific Island countries (1980–2005). *Note*: 1 = American Samoa; 2 = Cook Islands; 3 = Fiji; 4 = French Polynesia; 5 = Guam; 6 = Kiribati; 7 = Nauru; 8 = New Caledonia; 9 = PNG; 10 = Samoa; 11 = Solomon Islands; 12 = Tonga; 13 = Vanuatu.

Table 1
Summary statistics.

Country	Mean	Maximum	Minimum	Standard deviation	Average growth rate (1980–2005)	Average growth rate (2000–2005)
American Samoa	162.163	277.186	136.599	29.483	2.268	0.378
Cook Islands	38.760	47.551	23.154	6.127	0.471	0.079
Fiji	23.348	32.837	19.897	3.616	0.278	0.046
French Polynesia	53.904	77.258	20.683	14.814	1.140	0.190
Guam	272.875	682.419	77.967	156.016	12.001	2.000
Kiribati	4.541	6.810	3.427	0.956	0.074	0.012
Nauru	207.276	246.174	176.100	23.146	1.780	0.297
New Caledonia	149.079	197.643	121.595	15.928	1.225	0.204
Papua New Guinea	10.239	12.991	9.068	1.094	0.084	0.014
Samoa	11.550	13.680	9.336	0.890	0.068	0.011
Solomon Islands	6.407	8.626	4.999	1.041	0.080	0.013
Tonga	13.408	19.260	4.750	4.706	0.362	0.060
Vanuatu	8.591	14.738	4.938	3.287	0.253	0.042

Note: the mean, maximum, minimum and standard deviations are computed for the period 1980–2005.

Table 1 presents descriptive statistics on per capita energy consumption for the panel of 13 countries over the period 1980–2005. There are several aspects of the data that are worth highlighting. We notice that the mean per capita energy consumption over the given period is the highest for Guam, followed by Nauru, American Samoa and New Caledonia, whereas per capita energy consumption is lowest for Kiribati, the Solomon Islands and Vanuatu. Statistically speaking, there is a substantial difference between the lowest and highest mean per capita energy consumption. For Guam the mean is 272.88 btu and for Kiribati it is 4.54 btu. Volatility is highest for Guam and lowest for Kiribati and Samoa.

Guam has the maximum per capita energy consumption by a large margin. Its maximum per capita energy consumption is 682.42 btu, followed by American Samoa at 277.19 btu. Guam has also achieved a per capita energy consumption growth rate of 12% per annum from 1980 to 2005, which is much higher than other countries. Guam's high energy consumption reflects the fact that the US Department of Energy's State Energy Program provides funding to support the work of Guam's State Energy Office to provide direction and set priorities for the State's energy future. The low energy consumption of Kiribati and the Solomon Islands reflects their poor economic growth record. Mean per capita GDP is lowest for Kiribati over the period 1985–2006 at US$481, which reflects poor performance of agriculture and fishing, its two main economic activities (Mishra et al., 2009). This is due to climatic variations not conducive for agricultural production. While Kiribati is a fossil fuel importing country, it has made considerable progress in providing energy to rural and remote islands by developing solar energy given it is located near the equator (Yu et al., 1996). The Solomon Islands has also faced similar problems to Kiribati. In addition, the Solomon Islands have also suffered from periods of political instability and civil unrest as well as bouts of macroeconomic instability, such as inflation and exchange rate depreciation.

Remote locations, low demand, and high cost of fuel imports is reflected in very little energy consumption per capita by the Cook Islands, Fiji, French Polynesia, Papua New Guinea, Samoa, Tonga and Vanuatu. These countries have a low-level of GDP per capita and their economic growth rates have been mediocre over the last couple of decades, which has resulted in subdued demand for energy. Papua New Guinea and Fiji, which are amongst the weakest performing Pacific Island countries, have suffered from a number of social and economic problems. These include HIV/AIDS, poverty, rampant crime and unemployment in Papua New Guinea and three political coups in two decades in Fiji. With the exception of French Polynesia none of the countries had been able to achieve

Table 2
Conventional panel unit root tests.

	Log(energy consumption per capita)	
Name of test	Levels	Differences
IPS	−0.487	−9.631***
LLC	2.102	−10.025***
MW–Fisher ADF	38.282*	155.672***
MW–Fisher PP	73.554***	537.863***

Notes: (1) *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. (2) All the unit root tests were performed with the assumption of constant term and linear trend in the logarithm of the series with the null hypothesis of unit root. (3) The lag length for IPS, LLC and MW–Fisher ADF test was selected using the Modified Hannan–Quinn Criteria. (4) The optimal bandwidth for MW–Fisher PP test was selected by Newey–West method using Bartlett kernel.

an average growth rate of more than 1% over the period 1980–2005. And over the last five years considered in the study (2000–2005), of all the Pacific Island countries, only Guam was able to achieve an average growth rate of 2% per annum, whereas the other countries were unable to achieve 1%. Even for Guam it can be noticed that in the recent period (2000–2005), energy consumption is declining compared to the whole period 1980–2005, when it realized 12% per annum average growth in energy consumption per capita.

5. Econometric methodology and results

5.1. Panel unit root tests that do not account for structural breaks

As a benchmarking exercise we begin through applying the LLC, IPS and Maddala and Wu (MW) (1999) panel unit root tests to energy consumption per capita for the panel of 13 countries. Table 2 reports the results of the LLC, IPS and MW panel unit root tests (for technical details of these tests see Hurlin, 2009). The LLC test assumes that all countries converge towards the equilibrium value at the same speed under the alternative hypothesis. The IPS test has the advantage over the LLC test that it does not make this assumption, and thus is less restrictive. Karlsson and Lothgren (2000) perform Monte Carlo simulations which show that in most cases the IPS test outperforms the LLC test. Im et al. (2003) seek to address the problem of cross-sectional dependence by subtracting the cross-sectional means and then applying the t-bar statistic to the transformed data. However, Strauss and Yigit (2003) show that demeaning across the panel does not usually eliminate cross-sectional dependence. In the MW Fisher (1932) type tests, the null

Table 3
Cross-section correlation of the errors in the ADF(p) regression for energy consumption per capita in Pacific Island countries.

	1980–2005 ($T=26$, $N=13$)			
	$P=1$	$P=2$	$P=3$	$P=4$
Log(energy consumption per capita)				
$\bar{\rho}$	0.087	0.075	0.077	0.073
CD	3.622***	3.091***	3.197***	3.038***

Notes: The CD test statistics is proposed in Pesaran (2004) for testing for cross-sectional dependence in panels. The null hypothesis is that output innovations are cross-sectionally independent. The CD statistic follows a $N(0,1)$ distributions and the 10%, 5% and 1% critical values are 1.64, 1.96 and 2.57, respectively. *, **, *** denotes statistical significance at the 10%, 5% and 1% levels, respectively.

and alternative hypotheses are the same as in IPS. However, in these tests, the strategy consists of combining the observed significance levels from the individual unit root tests. The LLC, IPS and MW Fisher Augmented Dickey–Fuller panel unit root tests give the same result; namely, energy consumption per capita contains a panel unit root at the 5% level. The MW Fisher PP test is the odd one out and suggests that energy consumption per capita is stationary.

If the data contains cross-sectional dependence across countries, it is well-recognised that these conventional panel unit root tests will show large size distortions (see O'Connell, 1998; Maddala and Wu, 1999; Strauss and Yigit, 2003; Banerjee et al., 2005). As a first step to ascertain the cross-sectional dependence in the data, we perform the individual ADF(p) regression for lag lengths $p=1$, 2, 3 and 4. We collect the regression residuals from the ADF(p) regression and calculate the pair-wise cross-section correlation coefficients of the residuals (denoted by $\hat{\rho}_{ij}$). Then, we calculate a simple average of these correlation coefficients across all the pairs and call it $\bar{\hat{\rho}}$. According to Pesaran(2004), $\bar{\hat{\rho}}$ and the associated cross-section dependence (CD) test statistic, follow a $N(0,1)$ distribution. In this case, the null hypothesis that output innovations are cross-sectionally independent is rejected at the 1% level. The results are presented in Table 3.

The cross-sectionally dependent unit root test and its panel counterpart (CIPS), taken from Pesaran (2007), can be summarised as follows. Suppose y_{it} is a typical observation generated according to the simple dynamic panel data model, given by the following equation:

$$y_{it}=(1-\phi_i)\mu_i+\phi_i y_{i,t-1}+u_{it},\ i=1,\ldots\ldots,N;t=1,\ldots\ldots,T \quad (1)$$

Assuming that the error term, u_{it}, has the following single factor structure $u_{it}=\gamma_i f_t+\varepsilon_{it}$, such that f_t is the unobserved common effect, and ε_{it} is the individual-specific error, we can transform Eq. (1) into the following more convenient form

$$\Delta y_{it}=\alpha_i+\beta_i y_{i,t-1}+\gamma_i f_t+\varepsilon_{it} \quad (2)$$

This, the null hypothesis of a unit root ($\phi_i=1$) can be expressed as H_0:$\beta_I=0$ for all i.

Following Pesaran (2006), the common factor can be proxied by the cross-section mean of y_{it}, namely $\bar{y}_t=N^{-1}\sum_{j=1}^{N}y_{jt}$, and its lagged value(s), $\bar{y}_{t-1}$,$\bar{y}_{t-2}$, ... if N is sufficiently large. The unit root hypothesis can be tested on the t-ratio of the OLS estimate of b_i in the cross-sectionally augmented Dicky–Fuller (CADF) regression

$$\Delta y_{it}=a_i+b_i y_{i,t-1}+c_i\bar{y}_{t-1}+d_i\Delta\bar{y}_t+e_{it} \quad (3)$$

And the t-ratio can be given by

$$t_i(N,T)=\frac{\Delta y'_i\bar{M}_w y_{i,-1}}{\hat{\sigma}_i(y'_{i,-1}\bar{M}_w y_{i,-1})^{1/2}} \quad (4)$$

Table 4
CIPS test statistics for individual countries for energy consumption per capita.

1980–2005 ($T=26$)				
	$P=1$	$P=2$	$P=3$	$P=4$
Log(energy consumption per capita)				
American Samoa	−5.582***	−3.816*	−3.231	−2.589
Cook Islands	−1.068	−0.282	−0.081	−0.250
Fiji	−1.863	−1.973	−0.734	−1.347
French Polynesia	−5.241***	−4.607**	−4.597**	−3.932*
Guam	−1.419	−1.788	−2.583	−2.620
Kiribati	−2.955	−1.154	−0.629	−0.032
Nauru	−2.925	−4.390**	−3.261	−5.269***
New Caledonia	−3.307	−2.796	−1.570	0.527
Papua New Guinea	−1.795	−2.128	−1.705	−3.735*
Samoa	−5.203***	−4.539**	−4.526**	−3.644*
Solomon Islands	−2.371	−3.795*	−2.074	−2.769
Tonga	−0.844	−1.372	−1.441	−0.712
Vanuatu	−0.740	−0.992	−0.860	−0.922

Notes: The null hypothesis is that the series has a unit root. The test was performed under the assumption there is an intercept and linear trend in the series (Case III in Pesaran, 2007). The 10%, 5% and 1% critical values for Case III with $T=30$, $N=15$ from Pesaran (2007) are −3.49, −3.88 and −4.67, respectively. *, **, *** denotes statistical significance at the 10%, 5% and 1% levels, respectively.

where

$$\Delta y_i=(\Delta y_{i1},\Delta y_{i2},\ldots\ldots,\Delta y_{iT})',\Delta y_{i,-1}=(y_{i0},y_{i1},\ldots\ldots y_{i,T-1})'$$
$$\bar{M}_w=I_T-\bar{W}(\bar{W}'\bar{W})^{-1}W'',\bar{W}=(\tau,\Delta\bar{y},\bar{y}_{-1})$$
$$\tau=(1,1,\ldots\ldots,1)',\Delta\bar{y}=(\Delta\bar{y}_1,\Delta\bar{y}_2,\ldots\ldots\ldots,\Delta\bar{y}_T)',$$
$$\bar{y}_{-1}=(\bar{y}_0,\bar{y}_1,\ldots\ldots\ldots,\bar{y}_{T-1})'$$
$$\hat{\sigma}_i^2=\frac{\Delta y'_i M_{i,w}\Delta y_i}{T-4}$$

and

$$M_{i,w}=I_T-G_i(G'_{ii}G_i)^{-1}G'_i,G_i=(\bar{W},y_{i,-1})$$

The above statistics can also be extended for the more general case of the panel unit root. A cross-sectioanlly augmented version of the IPS test can be expressed as

$$CIPS(N,T)=t-bar=N^{-1}\sum_{i=1}^{N}t_i(N,T) \quad (5)$$

Pesaran (2007) points out that the CIPS statistic obtained in Eq. (5) is not analytically tractable; hence Eq. (5) is simulated to generate the critical values. Full details are provided in Pesaran (2007). Here we give a brief summary. The steps in the simulation process involve setting different values of T and N for different cases; namely, Case I: no intercept and no trend, Case II: intercept only, Case III: intercept and trend, and generating the values of the CIPS statistic 50,000 times. The values obtained after these replications are used to calculate the empirical density of the CIPS statistics and the 1%, 5% and 10% critical values are obtained from the empirical density function.

Table 4 presents the CIPS test proposed by Pesaran (2007) for individual countries. Table 5 presents the CIPS test for the panel as a whole. The results in Table 4 suggest that at the 5% level or better the unit root null is rejected at three out of four lags for French Polynesia and Samoa; two out of four lags for Nauru and one out of four lags for American Samoa. Table 5 suggests that at the 5% level or better energy consumption contains a panel unit root at all four lags. Thus, the CIPS test suggests that energy consumption per capita contains a unit root for the panel as a whole as well as for most of the individual countries.

Table 5
CIPS test statistics for the panel of countries for energy consumption per capita.

CIPS Test statistics for the Panel of Pacific Island countries 1980–2005 ($T=26$, $N=13$)				
	$P=1$	$P=2$	$P=3$	$P=4$
Levels				
Log(energy consumption per capita)	−2.716*	−2.587	−2.099	−2.100
First difference				
Δ Log(energy consumption per capita)	−5.777***	−4.010***	−3.196***	−2.933**

Notes: The null hypothesis is that the panel has a unit root. The test was performed under the assumption there is an intercept and linear trend in the series (Case III in Pesaran, 2007). The 10%, 5% and 1% critical values for Case III with $T=30$, $N=15$ from Pesaran (2007) are −2.66, −2.76 and −2.96, respectively. *, **, *** denotes statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6
Country specific KPSS stationarity test applied to energy consumption per capita for 13 Pacific Island countries with statistically significant break dates.

Country	*t*-statistic (Quadratic)	TB_1	TB_2	Finite Sample Critical values			
				90	95	97.5	99
American Samoa	0.401****	1982	1993	0.130	0.154	0.176	0.205
Cook Islands	0.103	1980	1988	0.183	0.231	0.278	0.337
Fiji	0.057	1980	2001	0.256	0.333	0.413	0.499
French Polynesia	0.228****	1982	1993	0.130	0.155	0.178	0.207
Guam	0.295***	1983	1989	0.159	0.203	0.245	0.296
Kiribati	0.082	1983	1991	0.135	0.168	0.199	0.239
Nauru	0.160***	1986	1996	0.102	0.118	0.134	0.152
New Caledonia	0.152	1981	2001	0.234	0.301	0.372	0.454
Papua New Guinea	0.081	1997	2001	0.193	0.249	0.300	0.366
Samoa	0.171	1983	1984	0.255	0.331	0.411	0.509
Solomon Islands	0.748****	1992	1987	0.120	0.149	0.177	0.214
Tonga	0.087	1986	1990	0.146	0.184	0.220	0.266
Vanuatu	0.347	1991	1999	0.111	0.134	0.158	0.185

Notes: The finite sample critical values were computed by means of Monte Carlo simulation using 20,000 replications. ***, **** denote significance at the 2.5% and 1% levels, respectively.

5.2. *Panel stationarity test with structural breaks*

There are two limitations with each of these panel unit root tests. The first limitation is that they assume the null of a unit root. As noted by Bai and Ng (2004), for many applications in economics it is more natural to take stationarity as the null hypothesis, rather than non-stationarity. The second limitation is that none of these tests accommodate structural breaks, which are likely to be a feature of energy consumption per capita in the Pacific Island countries given these countries import most of their energy. To address these limitations, we implement the CBL panel stationarity test with structural breaks. This test is a generalization for the case of multiple changes in level and slope of the panel stationarity test of Hadri (2000), which is computed as the average of univariate Kwiatowski, Phillips, Schmidt and Shin (KPSS) (1992) stationarity tests. It is a panel stationarity test that allows for structural shifts in the trend of the individual time series. This test, therefore, allows for heterogeneity, which permits each country in the panel to have a different number of breaks at different dates. In addition to the panel test statistic, the CBL test produces results for individual countries.

In contrast to commonly applied univariate structural break unit root tests, such as the Zivot and Andrews (1992) and Lumsdaine and Papell (1997) tests, the CBL test only generates the statistically significant breaks. To estimate the break dates, CBL apply the Bai and Perron (1998) technique. Trimming is necessary when computing estimates of break dates. The trimming region used here is $T[0.1,0.9]$. Once all possible dates are identified, CBL recommend that the optimal break dates be selected using the Liu et al. (1997) modified Schwartz Information Criterion for trending regressors. This method involves sequential computation and detection of the breaks using a pseudo F-type test statistic. The CBL test allows for a maximum of five structural breaks. The country-specific results testing the null of stationarity allowing for structural breaks in energy consumption per capita for each of the 13 countries are reported in Table 6. The table reports the test statistics, the finite sample critical values based on Monte Carlo simulations with 20,000 replications and break dates.

In contrast to the results of the CIPS test for which energy consumption per capita for few countries was stationary, with the CBL test we are able to reject the null of stationarity for just five of the 13 countries; namely, American Samoa, French Polynesia, Guam, Nauru and the Solomon Islands. This result is somewhat similar to that of Chen and Lee (2007) who are also only able to reject the null of stationarity for a few countries from each regional panel with the CBL test. Hsu et al. (2008) found that energy consumption was more likely to be non-stationary in countries which were large energy consumers. The rationale is that for large consumers, shocks will result in a bigger deviation from the long-run equilibrium path, making it more difficult to return to long-run equilibrium. Our results are consistent with the findings of Hsu et al. (2008). In particular, the largest energy consumers on a per capita basis in the panel are in order Guam, Nauru, New Caledonia, American Samoa and French Polynesia. Four of the five countries which are the largest energy consumers and for which energy consumption is non-stationary overlap. Narayan et al. (2008) and Maslyuk and Smyth (2009) speculate that countries which experience high volatility in production are more likely to exhibit a unit root in production. The reasoning is that in countries with volatile production deviations from the

Table 7
Panel KPSS stationarity test applied to energy consumption per capita.

Panel of 13 countries	Bartlett test (*p*-value)	Bootstrap critical values		
		5%	2.5%	1%
No Breaks (Homogenous)	14.248 (0.000)***	5.853	7.469	8.838
No Breaks (Heterogeneous)	27.393 (0.000)***	8.411	10.635	12.374
Breaks (Homogenous)	5.760 (0.000)	7.350	8.559	10.153
Breaks (Heterogeneous)	7.342(0.000)	13.579	15.551	19.260
	Quadratic Test (*p*-value)	Bootstrap critical values		
No Breaks (Homogenous)	16.820 (0.000)***	5.657	6.758	8.118
No Breaks (Heterogeneous)	27.491 (0.000)***	7.515	9.075	11.965
Breaks (Homogenous)	6.214 (0.000)	7.052	8.023	9.533
Breaks (Heterogeneous)	7.474 (0.000)	13.577	15.630	18.288

Notes: ***denotes statistical significance at the 1% level based on the bootstrapped critical values; *p*-values provided for comparison purposes are based on critical values from Carrion-i-Silvestre et al. (2005). The bootstrap distribution is based on 2000 replications (see Maddala and Wu, 1999).

long-run equilibrium growth path, due to shocks that create volatility in the first place, will be larger and thus the departure from the equilibrium path will be less likely to be temporary. The same reasoning potentially applies to energy consumption. Our results are generally consistent with this conjecture; specifically, of the five countries for which energy consumption is non-stationary, for three of the countries – Guam, American Samoa and Nauru – energy consumption is most volatile of all the countries in the panel.

Turning to the breaks, for each country there are two significant breaks. The first break for most countries occurred at the time of the second oil price shock or in the few years afterwards in the early 1980s. This finding is similar to that of Chen and Lee (2007) for countries in a range of regions. The second oil price shock was the catalyst for the development of renewable energy. The Pacific Islands invested almost $US430 million in developing renewable energy through the 1980s following the second oil price shock (Rizer and Hansen, 1992). The first break for the Solomon Islands and Vanuatu and the second break in Guam, Kiribati and Tonga is associated with the first Gulf war, which caused a long, sharp upward swing in oil prices. The first break in Papua New Guinea and the second break in Nauru and Vanuatu occur around the time of the Asian financial crisis and Russian default. The second break in Fiji, New Caledonia and Papua New Guinea occurs in 2001. This was at the time of terrorist attacks in New York and followed a two-year period between 1999 and 2000 in which crude oil prices tripled due to high world demand, OPEC oil production cutbacks, a cold winter in the United States and lower stock levels. It also preceded the second Gulf war. In the months leading up to the second Gulf war, speculation of war with Iraq led to soaring prices due to fears that Iraq's oil fields would be destroyed in the first days of the war.

Table 7 reports the results of the Hadri (2000) panel KPSS test (which assumes no breaks) and the CBL panel KPSS test (which allows for up to five structural breaks) for the panel of 13 Pacific Island countries. We allow for the alternative assumptions that the long-run variance is homogenous or heterogeneous. We compute the bootstrap distribution for both tests with 2000 replications that addresses all forms of cross-sectional dependence (see Maddala and Wu, 1999). The Hadri (2000) test rejects the null of joint stationarity at the 1% level. The results for the Hadri (2000) test are consistent with the conventional panel unit root tests reported in Table 2 and the CIPS test reported in Table 5. However, the CBL test, which allows for structural breaks, fails to reject the null of joint stationarity at the 5% level or better assuming either homogeneity or heterogeneity. This result, which is consistent with those of Chen and Lee (2007), strongly points to the need to take account of structural breaks in the data and address cross-sectional correlations when examining the unit root properties of energy consumption per capita and that conventional panel data tests that do not account for structural change can result in misleading policy conclusions.

6. Policy implications

Several policy implications emerge from our findings that energy consumption per capita is stationary for the panel of Pacific Island countries and, hence, shocks to energy consumption per capita will only result in temporary deviations from the long-run equilibrium path. First, other macroeconomic variables linked to energy demand, via flow-on effects, such as real income will not inherit non-stationarity and transmit it to major economic variables, such as employment (Narayan and Smyth, 2007). In this respect, previous research, suggests that real GDP per capita for a smaller panel of eight Pacific Island countries is stationary based on the CBL test (Mishra et al., 2009). The policy implication is that macroeconomic stabilization policies will be ineffective as output will revert to a natural rate, meaning Keynesian policies may only have temporary effects on output levels (Chang et al., 2005).

A second implication that energy consumption per capita is stationary implies that aggregate energy demand policies may not be over-implemented in the Pacific Island countries. The Pacific Island countries have paid particular attention to policies designed to curtail excessive energy consumption with the active support of lending agencies such as the Asian Development Bank and World Bank since the 1980s. Finding that energy consumption per capita is stationary suggests that a target of non-increasing energy consumption may be feasible and desirable as part of a sustainability strategy (Chen and Lee, 2007).

Third, our findings suggest that it should be easier to conduct forecasting to assist with policy implementation. The fact that energy consumption per capita is stationary indicates that it is feasible to forecast future movements in energy consumption per capita based on past behaviour. Fourth, the results have implications for econometric modelling of the determinants of energy demand and causality between energy demand and other variables such as GDP which have important policy implications themselves. Our results suggest that for the Pacific Island panel, panel cointegration tests involving energy consumption per capita cannot be undertaken, since energy consumption per capita is stationary (Chen and Lee, 2007; Narayan, 2008). If two (or more) time series are stationary in variance, then it might be possible to apply standard ordinary least squares to estimate the parameter, and obtain the long-run relationship (see Narayan, 2008). This issue deserves more attention in econometric modelling of energy consumption and variables such as GDP and in resultant policy-making.

7. Conclusions

This study contributes to the growing literature on testing for a unit root in energy consumption per capita by applying the CBL test to a panel of Pacific Island countries. The value-added in this study is that, unlike most unit root tests that have been applied to examine the stationarity of energy consumption, the CBL test has the advantage in that it allows for multiple structural breaks positioned at unknown dates for each country. Unlike most extant studies, we bootstrapped the critical values to take account of all forms of cross-sectional correlations between countries. We do so for the Pacific Islands, a region that is heavily dependent on energy, but for which there is little relevant literature. The panel unit root and panel stationarity tests without structural breaks, which were applied for benchmarking purposes, suggested that energy consumption per capita contained a unit root. This result is consistent with studies such as Lee (2005) and Joyeux and Ripple (2007) which applied conventional panel unit root tests to energy consumption per capita. However, when we allow for multiple structural breaks we find that energy consumption per capita is panel stationary. This result is consistent with Chen and Lee (2007) and suggests that structural breaks in world energy markets have had a significant effect on energy consumption in the Pacific Island countries. The CBL test also allows us to ascertain whether energy consumption per capita is stationary in individual countries. We find that energy consumption per capita in five of the 13 countries (just under 40% of the sample) contains a unit root. The countries for which energy consumption contains a unit root are the largest consumers of energy in the region and those for which energy consumption is also the most volatile.

References

Al-Iriani, M., 2006. Energy-GDP relationship revisited: an example from GCC countries using panel causality. Energy Policy 34, 3342–3350.

Asian Development Bank (ADB) 2008. Promoting Energy Efficiency in the Pacific. Regional Technical Assistance Report. Project Number 42078. Manilla: Asian Development Bank.

Bai, J., Ng, S., 2004. A new look at panel testing of stationarity and the PPP hypothesis. In: Donald, Andrews, James, Stock (Eds.), Identification and Inference in Econometric Models: Essays in Honour of Thomas J. Rothemberg. Cambridge University Press, Cambridge.

Bai, J., Perron, P., 1998. Estimating and testing linear models with multiple structural changes. Econometrica 66, 47–78.

Ball, L., 1993. The dynamics of high inflation, National Bureau of Economic Research Working Paper No. 4578 (December).

Banerjee, A., Marcellino, M., Osbat, C., 2005. Testing for PPP: should we use panel methods? Empirical Economics 30, 70–91.

Breuer, J.B., McNown, R., Wallace, M.S., 2001. Misleading inferences from panel unit root tests with an illustration from purchasing power parity. Review of International Economics 9, 482–493.

Carrion-i-Silvestre, J.L., Barrio-Castro, T.D., Lopez-Bazo, E., 2005. Breaking the panels: an application to GDP per capita. Econometrics Journal 8, 159–175.

Chang, T., Nieh, C.C., Wei, C.C., 2005. Is per capita real GDP stationary? Evidence from selected African countries based on more powerful nonlinear (logistic) unit root tests. Economics Bulletin 3 (24), 1–9.

Chaudhuri, K., Wu, Y., 2003. Random walk versus breaking trend in stock prices: evidence from emerging markets. Journal of Banking and Finance 27, 575–592.

Chen, P.F., Lee, C.-C., 2007. Is energy consumption per capita broken stationary? New evidence from regional based panels. Energy Policy 35, 3526–3540.

Chen, S.T., Kuo, H.I., Chen, C.C., 2007. The relationship between GDP and electricity consumption in 10 Asian countries. Energy Policy 35, 2611–2621.

Cochrane, J.H., 1994. Permanent and transitory components of GNP and stock prices. Quarterly Journal of Economics 109, 241–266.

Cunado, J., Perez de Gracia, F., 2003. Do oil price shocks matter? Evidence for some European countries. Energy Economics 25, 137–154.

Dornbusch, R., 1976. Expectation and exchange rate dynamics. Journal of Political Economy, 1161–1176.

Energy Information Administration (EIA) 2008. International Energy Database. Washington DC: US. Department of Energy.

Fisher, R.A., 1932. Statistical Methods for Research Workers, 4th edition. Oliver & Boyd, Edinburgh.

Hadri, K., 2000. Testing for stationarity in heterogeneous panel data. Econometrics Journal 3, 148–161.

Hamilton, J.D., 2007. Oil and the macroeconomy. In: Durlauf, S., Blume, L. (Eds.), New Palgrave Dictionary of Economics. Palgrave-MacMillan.

Hendry, D.F., Juselius, K., 2000. Explaining cointegration analysis, part 1. Energy Journal 21, 1–42.

Hsu, Y.C., Lee, C.-C., Lee, C.-C., 2008. Revisited: Are shocks to energy consumption permanent or stationary? New evidence from a panel SURADF approach. Energy Economics 30, 2314–2330.

Hurlin, C., 2009. What would Nelson and Plosser find had they used panel unit root tests? Applied Economics, in press.

Im, K.-S., Pesaran, H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. Journal of Econometrics 115, 53–74.

Jafar, M., 2000. Renewable energy in the South Pacific—options and constraints. Renewable Energy 19, 305–309.

Joyeux, R., Ripple, RD., 2007. Household energy consumption versus income and relative standard of living: a panel approach. Energy Policy 35, 50–60.

Karlsson, S., Lothgren, M., 2000. On the power and interpretation of panel unit root tests. Economic Letters 66, 249–255.

Kwiatowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y., 1992. Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics 54, 91–115.

Lee, C.C., 2005. Energy consumption and GDP in developing countries: a cointegrated panel analysis. Energy Economics 27, 415–427.

Lee, C.-C., Chang, C.-P., 2008. Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data. Resource and Energy Economics 30, 50–65.

Levin, A., Lin, C.-F., Chu, C.S.J., 2002. Unit root tests in panel data: asymptotic and finite sample properties. Journal of Econometrics 108, 1–24.

Libanio, G.A., 2005. Unit roots in macroeconomic time series: theory, implications and evidence. Nova Economica Belo Horizonte 15, 145–176.

Liu, J., Wu, S., Zidek, J.V., 1997. On segmented multivariate regressions. Statistica Sinica 7, 497–525.

Lumsdaine, R., Papell, D.H., 1997. Multiple trend breaks and the unit root hypothesis. Review of Economics and Statistics 79, 212–218.

Maddala, G.S., Wu, S., 1999. A comparative study of unit roots with panel data and a new simple test. Oxford Bulletin of Economics and Statistics 61, 631–651.

Mahadevan, R., Asafu-Adjaye, J., 2007. Energy consumption, economic growth and prices: a reassessment using panel VECM for developed and developing countries. Energy Policy 35, 2481–2490.

Maslyuk, S., Smyth, R., 2009. Non-linear unit root properties of crude oil production. Energy Economics 31, 109–118.

Mehrara, M., 2007. Energy consumption and economic growth: the case of oil exporting countries. Energy Policy 35, 2939–2945.

Mishra, V., Sharma, S., Smyth, R., 2009. Are shocks to real output permanent or transitory? Evidence from a panel of Pacific Island countries. Pacific Economic Bulletin, in press.

Narayan, P.K., 2008. Is Asian per capita GDP panel stationary? Empirical Economics 34, 439–449.

Narayan, P.K., Narayan, S., Smyth, R., 2008. Are oil shocks permanent or temporary? Panel data evidence from crude oil and NGL production in 60 countries. Energy Economics 30, 919–936.

Narayan, P.K., Singh, B., 2007. The electricity consumption and GDP nexus for the Fiji Islands. Energy Economics 29, 1141–1150.

Narayan, P.K., Smyth, R., 2007. Are shocks to energy consumption permanent or temporary: evidence from 182 countries. Energy Policy 35, 333–341.

Narayan, P.K., Smyth, R., 2008. Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks. Energy Economics 30, 2331–2341.

Narayan, P.K., Smyth, R., 2009. Multivariate granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern Countries. Energy Policy 37, 229–236.

O'Connell, P., 1998. The overvaluation of purchasing power parity. Journal of International Economics 44, 1–19.

Papapetrou, E., 2001. Oil price shocks, stock market, economic activity and employment in Greece. Energy Economics 23, 511–532.

Perron, P., 1989. The great crash, the oil price shock and the unit root hypothesis. Econometrica 57, 1361–1401.

Pesaran M.H., 2004. General diagnostic tests for cross section dependence in panels. Cambridge Working Papers in Economics No. 435, University of Cambridge, and CESifo Working Paper Series No. 1229.

Pesaran, M.H., 2006. Estimation and inference in large heterogeneous panels with cross section dependence. Econometrica 74, 967–1012.

Pesaran, M.H., 2007. A simple unit root test in the presence of cross-section dependence. Journal of Applied Econometrics 22, 265–312.

Reddy, M., 1998. Energy consumption and economic activity in Fiji. Journal of Pacific Studies 22, 81–96.

Rizer, J., Hansen, J., 1992. Energy in the Pacific Islands: Issues and Statistics. Honolulu: East-West Center.

Sardosky, P., 1999. Oil price shocks and stock market activity. Energy Economics 21, 449–469.

Strauss, J., Yigit, T., 2003. Shortfalls of panel unit root testing. Economics Letters 81, 309–313.

Taylor, J., 1979. Staggered wage setting in a macro model. American Economic Review 69, 108–113.

United Nations 2008. Reeling from impacts of global warming, small island states urge General Assembly to take comprehensive action. United Nations Press Release, 25 September.

Urmee, T., Harries, D., Schlapfer, A., 2009. Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific. Renewable Energy 34, 354–357.

Yu, X., Gilmour, A., Taplin, R., 1996. Current limitations on further introduction of renewable energy systems in the South Pacific: five national case studies. Energy Policy 24, 697–711.

Yu, X., Taplin, R., 1997. Policy perspectives: environmental management and renewable energy in the Pacific Islands. Journal of Environmental Management 51, 107–122.

Zivot, E., Andrews, D., 1992. Further evidence of the great crash, the oil-price shock and the unit-root hypothesis. Journal of Business and Economic Statistics 10, 251–270.