**International Journal of Energy Economics and Policy**
**Vol. 2, No. 3, 2012, pp. 92-96**
**ISSN: 2146-4553**
**www.econjournals.com**

# Are Fluctuations in Energy Consumption Transitory or Permanent? Evidence From a Panel of East Asia & Pacific Countries

**Hakan Kum**
Faculty of Economics and Administrative Sciences,
Department of Economics, Nevsehir University,
Nevsehir, Turkey. Email: hakan.kum@nevsehir.edu.tr

**ABSTRACT:** This paper examines the unit root properties of energy consumption per capita for 15 East Asia & Pacific countries employing the Lagrange Multiplier (LM) panel unit root test with one structural break for 1971-2007. When we apply the LM univariate test without break, we find a unit root in per capita consumption for Brunei Darussalam, Indonesia, Japan, North Korea, South Korea and Myanmar. However, when we apply LM unit root with structural break, we find overwhelming evidence that there is no unit root in per capita energy consumption for these 15 East Asia & Pacific countries.

**Keywords:** Energy consumption; Unit root; Stationarity; Lagrange Multiplier; Panel unit root test.
**JEL Classifications:** C23; Q43

## 1. Introduction

The stationarity properties of energy consumption have important implications for economic policies. If energy consumption follows a stationary process, energy demand management policies designed to reduce energy consumption will have transitory effects as energy consumption will return to its trend path. By contrast, failure to reject the null hypothesis implies a non-stationary series where shocks to energy consumption have permanent effects. Furthermore if energy consumption does not contain a unit root, then the past behavior of energy consumption will be of use in formulating forecasts.

Previous studies that focus exclusively on whether or not energy consumption is stationary have yielded mixed results in different countries which are summarized in Table 1. Following literature, this article will use LM univariate and panel data unit root tests to increase the power of the unit root and stationarity tests; however, will differ from previous studies with the emphasis on East Asia & Pacific countries. To this end, the paper is organized as follows. Section 2 explains the data and methodology. Section 3 discusses the empirical results. The final section gives conclusion.

**Table 1. Empirical results from various unit root tests for energy consumption**

| Author(s) | Countries | Test | Period | Conclusion |
|---|---|---|---|---|
| Narayan and Smyth (2005) | Australia | Zivot Andrews | 1966–1999 | Non-stationarity |
| Lee (2005) | 18 developing countries | Several Panel Unit Root Tests | 1975- 2001 | Non-stationarity |
| Al-Iriani (2006) | Six Gulf Cooperation Council countries | Several Panel Unit Root Tests | 1971–2002 | Non-stationarity |
| Soytas and Sari (2006) | Turkey | ADF, DF-GLS, PP, KPSS, NP | 1968–2002 | Some conflicting results among tests, with different lag selection procedures |
| Zachariadis and Pashourtidou (2007) | Cyprus | Perron (1989) | 1960–2004 | Non-stationarity |

| | | | | |
|---|---|---|---|---|
| Narayan and Smyth (2007) | 182 countries | Univariate and panel unit root tests | 1979–2000 | stationary |
| Chen and Lee (2007) | 104 countries | Carrion-i-Silvestre et al. (2005) test | 1971 - 2002 | Stationary |
| Narayan et al. (2008) | 60 countries | Im et al. (2005) panel unit root test with one structural break | 1971- 2003 | stationarity |
| Hsu et al. (2008) | 84 countries | Panel SURADF unit root test | 1971-2003 | Non-stationarity |
| Mishra et al. (2009) | 13 Pacific Island countries | Carrion-i-Silvestre et al. (2005) test | 1980–2005 | stationary |
| Narayan et al. (2010) | Australia and its six states | Lee and Strazicich (2003) two-break unit root test | 1973-2007 | stationary |
| Apergis et al. (2010a) | 50 US states | Panel unit root and stationarity tests with endogenously determined structural breaks | 1982–2007 | stationary |
| Apergis et al. (2010b) | 50 US states | Panel unit root and stationarity tests with endogenously determined structural breaks | 1980-2007 | stationary |

## 2. Data and Methodology

The East Asia & Pacific countries are Australia, Brunei Darussalam, China, Hong Kong-China, Indonesia, Japan, North Korea, South Korea, Malaysia, Myanmar, New Zealand, Philippines, Singapore, Thailand and Vietnam which are dictated by data availability. Energy consumption (kg of oil equivalent per capita) data for 1971-2007 is taken from World Development Indicator database.

The standard approach to test for a unit root involves performing ADF unit root tests (Dawson and Strazicich, 2009). However, Augmented Dickey-Fuller (1979) (ADF, hereafter) type models are that they do not allow researchers to analyze the impact of structural changes in the economy. Perron (1989) also proved that failure to allow for an existing break leads to a bias that decreases the ability to reject a false unit root null hypothesis. Perron proposed allowing for one known, or 'exogenous,' structural break in the ADF unit root test to deal with this problem. Following Perron (1989), many authors including, Zivot and Andrews (1992) (hereafter ZA) and Perron (1997) suggested determining the break point 'endogenously' from the data. Lumsdaine and Papel (1997) modified the ZA model to accommodate two structural breaks. On the other hand, all these endogenous tests were criticized for their treatment of breaks under the null hypothesis. Given the breaks were absent under the null hypothesis of unit root there may be tendency for these tests to suggest evidence of stationarity with breaks. Lee and Strazicich (2003) propose a two break minimum Lagrange Multiplier (LM) unit root test in which the alternative hypothesis unambiguously implies the series is trend stationary (Glynn and Perera, 2007). In contrast to the ADF test, the LM unit root test has the advantage that it is unaffected by breaks under the null. The LM unit root test can be explained using the following data generating process. Here, e is energy consumption and *Zt* consists of exogenous variables and $\varepsilon_t$ is an error term that follows the classical properties. The LM unit root test allows for structural breaks in the spirit of Perron (1989). The break minimum LM unit root can be described as follows. According to the LM principle, a unit root test statistic can be obtained from the following regression:

$$e_t = \delta' Z_t + X_t, \quad X_t = \beta X_{t-1} + \varepsilon_t \tag{1}$$

Here, $\Delta$ is the first difference operator; $\overline{S}_t = e_t - \hat{\Psi}_x - Z_t\hat{\delta}_t$ t= 2,…..T; $\hat{\delta}$ are coefficients in the regression of $\Delta e_t$ on $\Delta Z_t$; $\hat{\Psi}_x$ is given by $e_t - Z_t\delta$. If energy consumption has a unit root for country *i* then $\phi t$ = 0, which is the null hypothesis tested using the *t*-test against the alternative

hypothesis that $\phi t < 0$. The panel LM test statistic is obtained by averaging the optimal univariate LM unit root t-test statistic estimated for each country. This is denoted as $LM_i^{\tau}$

$$LM_{barNT} = \frac{1}{N}\sum_{i=1}^{N} LM_i^{\tau} \tag{2}$$

Im et al. (2005) constructed a standardized panel LM unit root test statistic by letting $E(L_T)$ and $V(L_T)$ denote the expected value and variance of $LM_i^{\tau}$ respectively under the null hypothesis. Im *et al.* (2005) then compute the following expression:

$$\Psi_{LM} = \frac{\sqrt{N}[LM_{barNT} - E(L_T)]}{\sqrt{V(L_T)}} \tag{3}$$

The numerical values for $E(L_T)$ and $V(L_T)$ are in Im *et al*. (2005). The asymptotic distribution is unaffected by the presence of structural breaks and is standard normal.

**3. Empirical Results**

We begin our empirical analysis by examining the univariate LM tests with and without structural breaks. These results are reported in Table 2.

**Table 2. LM unit roots test results for per capita energy consumption**

| Individual | LM statistic without break | LM statistic with one break |
|---|---|---|
| Australia | -6.284 ***(1) | -7.020*** (1)[1999] |
| Brunei Darussalam | -1.474 (3) | -6.620*** (0) [2002] |
| China | -6.598*** (0) | -6.504*** (0) [1992] |
| Hong Kong, China | -6.211*** (0) | -6.452 ***(0) [1999] |
| Indonesia | -1.503 (4) | -7.993*** (2) [1991] |
| Japan | -1.520 (4) | -5.895*** (0) [1998] |
| North Korea | -1.512 (7) | -6.137***(1) [1983] |
| South Korea | -0.315 (4) | -6.136*** (0) [2003] |
| Malaysia | -4.028*** (5) | -6.744*** (0) [1997] |
| Myanmar | -1.554 (7) | -6.245*** (0) [2004] |
| New Zealand | -3.102** (5) | -6.955*** (1) [2001] |
| Philippines | -6.559*** (0) | -6.831*** (1) [1999] |
| Singapore | -3.761*** (6) | -6.594*** (0) [2002] |
| Thailand | -3.195** (5) | -7.562** *(1) [1984] |
| Vietnam | -5.739 ***(1) | -6.779*** (0) [1982] |
| Panel | -10.228*** | -29.857*** |

Notes: Numbers in the parentheses are the optimal number of lagged first-differenced terms included in the unit root test to correct for serial correlation. The 1%, 5% and 10% critical values for the LM test without a break are -3.63, -3.06, and -2.77, respectively. The corresponding critical values for the panel LM test are −2.326, −1.645 and −1.282 respectively. The 1%, 5% and 10% critical values for the minimum LM test with one break are -4.239, -3.566 and -3.211, respectively.

The results of the unit root tests as shown in Table 2 appear to support that the series are stationary for Australia, China, Hong Kong-China, Malaysia, New Zealand, Philippines, Singapore, Thailand and Vietnam. In other words, shocks to per capita energy consumption have transitory effect for these countries. However, in the cases of Brunei Darussalam, Indonesia, Japan, North Korea, South Korea and Myanmar we are not able to reject the unit root null hypothesis. Table 1 also shows that one structural break is significant in East Asia & Pacific countries. This result can be interpreted that shocks to per capita energy consumption have transitory effect for 15 East Asia & Pacific countries. The outcome of the break dates has some important tools. It is apparent that most structural breaks in

the series occur around the crises (notably the Asian Financial Crisis was a period of financial crisis that gripped much of Asia beginning in 1998).

## 4. Conclusion

The stationarity properties of energy consumption have important consequences for economic policies. A finding that energy consumption per capita is non-stationary means that shocks to energy consumption have a permanent effect, implying unit root hysteresis or path dependency in energy demand. In contrast, a finding of stationarity implies that shocks will have a transitory effect on energy consumption. Therefore, if energy management policies have a long-term focus on the permanent reduction in energy consumption, such policies will only have short-term effects, if indeed, energy consumption is stationary. Also, if shocks to energy consumption are permanent, such shocks may be speeded to other areas of the economy besides to macroeconomic variables.

In this paper we have examined the unit root properties of per capita energy consumption for 15 East Asia & Pacific countries for 1971-2007. The contribution of this paper is that both LM univariate and panel unit root techniques with and without structural break is employed to investigate the unit root properties of energy consumption for this group of countries. When we apply the LM univariate test without break, we find a unit root in per capita consumption for Brunei Darussalam, Indonesia, Japan, North Korea, South Korea and Myanmar. However, when we apply LM unit root with structural break, we find overwhelming evidence that there is no unit root in per capita energy consumption for these 15 East Asia & Pacific countries.

## References

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

Amsler, C., Lee, J. (1995), An LM test for a unit root in the presence of a structural change. Econometric Theory, 11, 359–368.

Apergis, N., Loomis D., Payne J.E. (2010a), Are fluctuations in coal consumption transitory or permanent? Evidence from a panel of US states. Applied Energy, 87, 2424-2426.

Apergis, N., Loomis D., Payne J.E. (2010b), Are shocks to natural gas consumption temporary or permanent? Evidence from a panel of U.S. states. Energy Policy, 38, 4734-4736.

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

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

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.

Glynn, J., Perera, N. (2007), Unit root tests and structural breaks: A survey with applications, Revista de Métodos Cuantitativos para la Economía y la Empresa, 3, 63-79.

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

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

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

Im, K.S., Lee, J., Tieslau, M. (2005), Panel LM unit root tests with level shifts. Oxford Bulletin of Economics and Statistics, 67, 393–419.

Lean, H.H., Smyth, R. (2009), Long memory in US disaggregated petroleum consumption: Evidence from univariate and multivariate LM tests for fractional ıntegration. Energy Policy, 37(8), 3205–3211.

Lee, J., Strazicich, M.C. (2003), Minimum LM unit root test with two structural breaks. Review of Economics and Statistics, 85, 1082–1089.

Lee, J., Strazicich, M.C. (2004), Minimum LM unit root test with one structural break. Working Paper 04-17, Department of Economics, Appalachain State University.

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

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

Lumsdaine, R.L., Papel, D.H. (1997), Multiple trend breaks and the unit-root hypothesis. The Review of Economics and Statistics, 79, 212-218.

Mishra, V., Sharma, S., Smyth, R. (2009), Are fluctuations in energy consumption per capita transitory? evidence from a panel of pacific island countries. Energy Policy, 37, 2318–2326.

Narayan, P.K., Smyth, R. (2005), Electricity consumption, employment and real income in Australia evidence from multivariate Granger causality tests. Energy Policy, 33, 1109-1116.

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

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., Narayan, S., Popp, S. (2010) Energy Consumption at the State Level: the Unit Root Null Hypothesis from Australia. Applied Energy, 82, 1953-1962.

Payne, J.E. (2010), Survey of the international evidence on the causal relationship between energy consumption and growth. Journal of Economic Studies, 37, 53–95.

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

Perron, P. (1997), Further evidence on breaking trend functions in macroeconomic variables. Journal of Econometrics, 80, 355–385.

Robin, L., Lumsdaine, R.L., Papell, D.H. (1997), Multiple trend breaks and the unit-root hypothesis. The Review of Economics and Statistics, 79, 212-218.

Schmidt, P., Phillips, P.C.B. (1992), LM tests for a unit root in the presence of deterministic trends. Oxford Bulletin of Economics and Statistics, 54, 257–287.

Soytas, U., Sari, R. (2006), Can China contribute more to the fight against global warming?. Journal of Policy Modeling, 28, 837–84.

Zachariadis, T., Pashourtidou, N. (2007), An empirical analysis of electricity consumption in Cyprus. Energy Economics, 29, 183-198.

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