Vol. 1(4), 103-109

Journal of Energy & Environmental Policy Options

Examining the Causality of Energy Between Growth in Asian Countries: Panel Data Analysis

Jayaraman Kumar[a]

Abstract

Examining the ramifications of energy consumption on economic growth holds paramount significance in crafting comprehensive strategies for energy and environmental policymaking. A nuanced understanding of the intricate interplay between energy utilization and economic development is imperative to inform judicious policy decisions. In light of this advancement, the present paper undertakes an empirical reassessment, scrutinizing the direction of causality and the sign within a panel framework between energy consumption and gross domestic product (GDP) across seventeen meticulously chosen Asian countries. The findings disclose the presence of long-run stable equilibriums within these nations, with energy consumption (EC) exerting a positive influence on gross domestic product (GDP). In the short run, causality is observed from energy consumption to GDP, whereas in the long run, a causal relationship is identified from GDP to energy consumption. The temporal dynamics revealed in the study suggest a nuanced relationship between energy consumption and economic growth. In the short run, energy emerges as a potent driver of economic expansion, highlighting its immediate impact on the gross domestic product (GDP). This underscores the critical role of energy in powering various sectors and activities that contribute to short-term economic development. Contrastingly, the observed long-run causality from GDP to energy consumption implies a more complex and sustained interdependence. In this scenario, economic growth becomes a driving force shaping the trajectory of energy consumption patterns over an extended period. This intricate relationship suggests that as economies evolve and mature, the structural shifts in production and consumption patterns become influential determinants of energy use. Efficient coordination and cooperation towards the implementation of energy conservation policies to support Inclusion of efficient coordination and collaborative efforts in the regional agenda is imperative for the effective implementation of energy conservation policies, thereby fostering sustainable economic development.

Keywords: energy consumption, economic growth, causality
JEL Codes: Q13, P28

1. INTRODUCTION

The escalating trend in energy consumption across Asian countries has been a consistent phenomenon over the past few decades, driven by factors such as population growth and rapid industrial expansion. Projections indicate a trajectory of continued increase, with anticipated energy consumption reaching 159.3 quadrillion BTU in 2015, 187.8 quadrillion BTU in 2020, 217.0 quadrillion BTU in 2025, 246.9 quadrillion BTU in 2030, and 277.3 quadrillion BTU in 2035. These figures underscore the pressing need for strategic and sustainable energy management policies to address the growing demands and ensure the resilience of energy systems in the face of expanding societal and industrial needs. From 2007 to 2035, Asia exhibits a noteworthy average annual percentage change in energy consumption at 2.8 percent, surpassing that of other regions. In comparison, the Middle Eastern countries show a rate of 2.2 percent, while Central and South America, as well as Africa, both register a lower average annual percentage change at 1.8 percent. These regional differentials underscore the dynamic and robust nature of energy consumption trends in Asia, necessitating tailored and proactive measures for sustainable energy planning and resource management.

China and India, as the primary drivers of both global economic growth and escalating energy demand, stand out as the major consumers of energy. Their persistent leadership in these aspects is evident, with China and India jointly representing approximately 10 percent of the world's total energy consumption in 1990, a figure that surged to 20 percent by 2007. This remarkable increase underscores the substantial role these two nations play in shaping global energy dynamics and emphasizes the need for strategic and sustainable energy management strategies on an international scale. The substantial increases in energy consumption by China and India can be attributed to several factors, notably their rapid population growth, accelerated economic expansion, and extensive industrial development extending into various regions of Asia. The confluence of these elements has propelled both countries to the forefront of energy demand, underscoring the intricate interplay between demographic shifts, economic activities, and the broader regional implications of their energy consumption patterns. Recognizing and understanding these dynamics is pivotal for devising effective and regionally responsive energy policies that align with the evolving landscape of Asia's economic and industrial prowess. The intermittent energy crises, coupled with

[a] School of Economics, Faculty of Business and Economics, The University of the South Pacific, Fiji

the depletion of finite energy sources, environmental concerns, and heightened levels of energy consumption, have compelled governments worldwide to intensify their scrutiny and oversight of energy markets, as highlighted by the ECSSR in 2004. This necessitated focus on monitoring and managing energy markets reflects a collective global effort to address the multifaceted challenges posed by energy security, sustainability, and environmental impacts, underscoring the imperative for proactive and informed governance in the realm of energy management. The escalating concerns have garnered heightened attention from governments across Asian countries. This growing focus underscores the recognition of the intricate challenges posed by various facets of energy, such as security, sustainability, and environmental impact. As a response to these multifaceted issues, governments are increasingly prioritizing initiatives and policies aimed at fostering responsible and resilient energy practices. The proactive engagement of Asian governments in addressing these concerns reflects a commitment to navigating the complexities of energy management in a manner that aligns with both national interests and global imperatives. These measures encompass collaborative efforts directed towards energy conservation and the implementation of policies geared towards optimizing energy efficiency. In this context, the examination of the long-term relationship between energy consumption and economic growth has been a subject of vibrant empirical scrutiny. Within the energy economics literature, the question of the direction of causality—specifically, whether the adoption of energy savings hampers or fosters economic growth—has been a highly debated and extensively discussed subject.

A nuanced understanding of the intricate interplay between energy consumption and economic growth holds paramount significance in the formulation of effective and forward-thinking energy and environmental policies. Delving into the multifaceted relationships and causal dynamics between these two factors not only informs policy decisions but also provides a foundation for developing strategies that balance the imperatives of economic development with the imperative of sustainable resource utilization. Such insights become instrumental in fostering a harmonious synergy between economic prosperity and environmental stewardship, ensuring a resilient and responsible trajectory for energy policies that resonate with both present and future needs. In summary, the four discernible patterns encompass: (1) The "growth" hypothesis, positing causality from energy consumption to economic growth. This pattern is observed in energy-dependent countries, as evidenced by various studies, including those conducted by Yu and Choi (1985) for the Philippines, Masih and Masih (1996) for India, Asafu-Adjaye (2000) for India and Indonesia, Soytas and Sari (2003) for Turkey, France, Japan, and Germany, and Lee (2005) for a panel of eighteen developing countries. (2) The "conservation" hypothesis posits a causality in which GDP Granger-causes energy consumption. This pattern is evident in studies such as those conducted by Kraft and Kraft (1978) for the United States (US), Abosedra and Baghestani (1989) for the US, Cheng and Lai (1997) for Taiwan, Cheng (1999) for India, and Ang (2008). With this objective in mind, policies aimed at reducing greenhouse emissions, and consequently lowering energy consumption and waste, may be implemented without adversely affecting real GDP. (3) The "neutrality" hypothesis, which suggests a lack of Granger-causality between energy consumption and GDP, is explored in studies conducted by Yu and Hwang (1984) as well as Altinay and Karagol (2004). This perspective posits that fluctuations or changes in energy consumption do not lead to consequential effects on the Gross Domestic Product (GDP). This hypothesis underscores the complexity of the relationship between energy utilization and economic growth, emphasizing that the two variables may operate independently without one significantly influencing the other in a causal manner. Understanding such neutrality is crucial for policymakers as they navigate the intricate landscape of energy and economic policies, ensuring a nuanced approach that aligns with the specific dynamics observed in different contexts. (4) The "feedback" hypothesis postulates an interdependent relationship between energy consumption and GDP, proposing the existence of bi-directional causality. Studies by Hwang and Gum (1991), Yang (2000), Oh and Lee (2004), and Climent and Pardo (2007) provide insights into this pattern. In this scenario, changes in energy consumption not only impact economic growth but, conversely, variations in GDP also influence energy consumption. The acknowledgment of this feedback loop adds a layer of complexity to the understanding of the dynamic interaction between energy utilization and economic development. Recognizing such bidirectional causality is crucial for policymakers, guiding them in formulating strategies that account for the mutual influence of energy consumption and GDP on each other. The existing literature has not reached a consensus on the inherent nature of causal relationships between energy consumption and economic growth. In this intricate context, policies geared towards the gradual reduction of energy consumption must carefully consider the potential causal linkages between economic growth and energy consumption. Recognizing the diverse patterns and hypotheses surrounding this relationship becomes imperative for the formulation of effective and context-specific strategies that align with the dynamic interplay between energy dynamics and economic development. A nuanced approach to policy formulation, acknowledging the complexity of these linkages, is essential to foster sustainable energy practices without compromising economic growth. In response to this evolving landscape, the objective of this study is to undertake a comprehensive empirical re-examination, delving into the direction of causality and the sign (in the panel sense) between energy consumption (EC) and real GDP across seventeen Asian countries. The determination of causality serves as a crucial foundation, paving the way for the adoption of judicious energy development policies tailored to the specific dynamics of each country. The insights gained from this empirical analysis will contribute to a more informed and nuanced approach to energy policymaking, aligning with the distinctive needs and characteristics of the respective Asian nations under consideration. Accordingly, the subsequent sections of this paper unfold as follows. Section 2 offers a succinct yet intuitive overview of the applied econometric methodology.

Section 3 delves into a comprehensive discussion of the results obtained. Subsequently, Section 4 outlines pertinent policy implications and draws conclusions based on the findings.

2. ECONOMETRIC MODELING

The initial and fundamental step in the estimation of dynamic panels involves subjecting the relevant variables to unit root tests. In this context, several seminal studies have utilized joint panel unit root tests to assess the stationarity of these variables. Pioneering works, such as those by Maddala and Wu (1999, MW), Hadri (2000, HADRI), Levin et al. (2002, LLC), and Im et al. (2003, IPS), have significantly contributed to the robustness of the unit root testing framework within the context of dynamic panel analyses. These tests serve as a critical diagnostic tool, guiding researchers in determining the order of integration of the variables and laying the groundwork for subsequent dynamic panel estimations. The null hypothesis common to all joint panel unit root tests, except for the HADRI test, asserts the presence of a unit root in the panel series, indicating non-stationarity. It is worth noting that the HADRI test deviates from the conventional augmented Dickey Fuller (ADF) test. Instead, it adopts an approach akin to the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS)-based LM statistic. In the HADRI test, the null hypothesis asserts level (trend) stationarity, with the alternative hypothesis suggesting difference stationarity within the panel. This distinctive feature of the HADRI test provides a nuanced perspective on stationarity considerations, offering a valuable tool in the assessment of unit roots within dynamic panel analyses. Comparing the outcomes derived from a diverse array of panel unit root tests can offer valuable insights into the stationarity properties of the data under scrutiny. When both procedures either fail to reject the null hypothesis or simultaneously reject it, it yields mixed results, indicating a scenario where the data may not provide sufficient information for conclusive determination. This underscores the nuanced nature of assessing stationarity, prompting a careful consideration of the various unit root tests and their outcomes to arrive at a comprehensive understanding of the data's characteristics.

Conversely, when an ADF-type panel unit root test rejects the null hypothesis while a KPSS-type test fails to reject it, a higher level of confidence emerges, indicating that the series under examination is likely stationary. This divergence in results between ADF and KPSS tests provides a valuable diagnostic tool, offering a more refined understanding of the stationarity properties within the dataset. Such complementary outcomes enhance the robustness of the analysis and contribute to a more nuanced interpretation of the time-series characteristics in question. Given the increasing prevalence of panel-based unit root tests in the literature, readers keen on a more in-depth exploration are encouraged to consult the original articles of these tests. Comprehensive discussions, methodologies, and theoretical underpinnings are often detailed in the primary sources, offering a deeper understanding of the intricacies involved in employing these tests for assessing the stationarity of time-series data in panel settings. Subsequently, our analysis extends to the investigation of potential long-run equilibrium relationships among the variables under scrutiny. To conduct this examination, we employ panel cointegration tests proposed by Pedroni (1999, 2001, 2004) and Kao (1999). These established tests serve as valuable tools in determining the presence of cointegration, a critical aspect indicating a stable and long-term association among the variables, thereby contributing to a more comprehensive understanding of the underlying economic relationships. Pedroni's approach encompasses the consideration of seven distinct statistics, with four rooted in pooling the residuals of the regression along the within-dimension (panel test) of the panel. Simultaneously, the remaining three statistics are derived from pooling the residuals of the regression along the between-dimension (group test) of the panel. This comprehensive set of statistics allows for a robust assessment of panel cointegration, examining both within-group and between-group dimensions to discern potential long-run equilibrium relationships among the variables.

The within-dimension tests in Pedroni's methodology factor in common time elements and permit heterogeneity across countries. This approach considers potential cointegration with variations across countries, offering a nuanced perspective on the within-group dynamics. On the other hand, the between-dimension tests, often referred to as group-mean cointegration tests, accommodate the heterogeneity of parameters across countries. By doing so, these tests facilitate an assessment of potential cointegration relationships by accounting for variations in parameters among countries within the panel, contributing to a more comprehensive understanding of the long-run equilibrium relationships among the variables. The within-dimension tests in Pedroni's methodology factor in common time elements and permit heterogeneity across countries. This approach considers potential cointegration with variations across countries, offering a nuanced perspective on the within-group dynamics. On the other hand, the between-dimension tests, often referred to as group-mean cointegration tests, accommodate the heterogeneity of parameters across countries. By doing so, these tests facilitate an assessment of potential cointegration relationships by accounting for variations in parameters among countries within the panel, contributing to a more comprehensive understanding of the long-run equilibrium relationships among the variables. The Fully Modified Ordinary Least Squares (FMOLS) procedure is designed to accommodate the inherent heterogeneity present in both transitional serial correlation dynamics and long-run cointegrating relationships. By acknowledging and addressing these variations, FMOLS provides a robust framework for estimating parameters in the presence of diverse and potentially changing conditions across the panel. This adaptability enhances the reliability of FMOLS in capturing the complexities of panel data, ensuring a more accurate representation of the relationships under investigation. In the examination of panel causality, our approach involves estimating a panel-based Vector Error Correction Model (VECM) that incorporates a dynamic error correction term. This method is informed by the analytical framework

outlined in Holtz-Eakin et al.'s seminal works from 1988 and 1989. The utilization of a panel-based VECM allows for a comprehensive assessment of causality dynamics, taking into account both the contemporaneous relationships and the adjustments toward equilibrium over time across the panel of countries or entities under investigation.

3. EMPIRICAL RESULTS

For the study, annual data spanning from 1980 to 2006 for the 17 Asian countries were employed. Per capita total primary energy consumption (EC) data were sourced from the International Energy Annual 2006 of the Energy Information Administration (EIA), while real GDP data were extracted from the World Development Indicators (WDI) 2008 of the World Bank. To enhance analytical consistency, all variables underwent a logarithmic transformation. This transformation ensures a more suitable scaling of the data and facilitates the exploration of proportional relationships between variables. The results, made available upon request, illustrate that the series of the variables are of an *I(1)* process, as the pooled data are stationary in their first differences. These results enable us to test the cointegration among EC and GDP. From the panel cointegration results in Table 1, we find strong evidence to reject the null hypothesis of no cointegration for all seven statistics provided by Pedroni (1999, 2001, 2004). Similarly, we reject the null hypothesis of no cointegration using the ADF-type statistics from the Kao (1999) panel cointegration tests, suggesting that that the two-dimensional model for the Asian countries is cointegrated and moves together in the long-run. Thus, we find that GDP and EC are cointegrated in the multi-country panel setting for the sample period.

Table 1: Panel Cointegration Tests Results

Pedroni Residual Cointegration test	
Panel cointegration statistics (within-dimension)	
Panel v-statistic	4.246 (0.000)
Panel PP type -statistic	-2.212 (0.035)
Panel PP type *t*-statistic	-2.318 (0.027)
Panel ADF type *t*-statistic	-4.525 (0.000)
Group mean panel cointegration statistics (between-dimension)	
Group PP type -statistic	2.187 (0.037)
Group PP type *t* –statistic	4.122 (0.000)
Group ADF type *t*- statistic	2.706 (0.010)
B: Kao Residual Cointegration test	
ADF	2.513 (0.006)

Having established cointegration in the long-run, we estimate the long-run parameters of the model by using the FMOLS technique. The FMOLS corrects the standard OLS for bias induced by the endogeneity and serial correlation of the regressors (Lee, 2005). The elasticity of energy consumption is important for understanding the past and assessing future economic dynamics. It represents the weights with which the marginal relative changes of the energy consumption contributes to the relative change of output (Lee *et al.,* 2008). Table 2 reports the results of the long-run estimates for seventeen Asian countries and the panel estimates based on Pedroni's group mean FMOLS estimator. The panel results of the regression equation with GDP as the dependent variable illustrate that the coefficient of the EC is positive and statistically significant at the 5 percent significance level. A one percent increase in energy consumption leads to a 0.21 percent increase in GDP for these seventeen Asian countries. This positive coefficient on EC implies that more energy results in greater outputs, as suggested by Lee, (2005), Narayan and Smyth (2008), Lee and Chang, (2008).

Turning to the country specific evidence, the results also indicate a positive and significant relationship between EC and GDP for all countries. The elasticity estimates range from 0.10 (Hong Kong) to 0.94 (Philippines). The results suggest that the EC contributes most to the Philippines' output, whereas it contributes least to Hong Kong's output. Having inelastic coefficients on EC suggests that the vulnerability of energy prices would not have a significant impact on the consumption patterns in these countries, as it would be considered necessities for the society as a whole.

Once the long-run estimates have been determined, we turn to the causality linkages. The empirical results presented in Table 3 illustrate that the coefficient of the error correction term (ECT) is not statistically significant in the GDP equation, indicating the absence of a long-run causality relationship running from EC to GDP. However, we note the existence of a significant short-run causal relationship running from EC to GDP, since the estimated coefficients of the explanatory variables are statistically significant. The short-run results are supported by Asafu-Adjaye (2000), Soytas and Sari (2003), Lee (2005), Narayan and Smyth (2008), who established evidence of a short-run Granger causality running from EC to GDP.

Table 2: FMOLS Estimates

Countries	Energy Consumption
Bangladesh	0.920 (10.660)*
Bhutan	0.220 (33.840)*
Brunei	0.330 (9.305)*
China	0.370 (2.080)*
Hong Kong	0.100 (27.710)*
India	0.140 (10.250)*
Indonesia	0.660 (5.790)*
Japan	0.390 (3.220)*
Korea	0.160 (9.410)*
Malaysia	0.170 (11.100)*
Maldives	0.380 (1.780)*
Nepal	0.150 (4.790)*
Pakistan	0.230 (38.580)*
Philippines	0.940 (12.200)*
Singapore	0.340 (7.750)*
Sri Lanka	0.180 (14.620)*
Thailand	0.200 (5.630)*
Panel estimates	0.210 (44.330)*

Table 3: Panel Granger Causality Test Results

Dependent Variables	ΔGDP	ΔEC	ECT	
	^{2}-statistics (p-value)		Coefficient	t-ratio
ΔGDP	-	19.661 (0.001)	0.001	0.614
ΔEC	2.108 (0.715)	-	-0.002	-4.056

On the other hand, we find evidence of the existence of a long-run relationship running from GDP to EC, in which the coefficient of the error correction term (ECT) is statistically significant in the EC equation. This result illustrates that energy consumption is determined by economic growth; supporting the conservation hypothesis. This pattern is similar to results from developing countries (Cheng and Lai, 1997; Cheng, 1999; Mahadevan and Asafu-Adjaye, 2007; Ang, 2008).

4. DISCUSSION & CONCLUSION

Employing panel estimation techniques for seventeen Asian countries, this paper conducts an empirical examination of the relationship between energy consumption and gross domestic product (GDP). The panel approach allows for a comprehensive analysis that considers both individual country variations and collective trends, providing valuable insights into the intricate dynamics between energy utilization and economic output across the Asian region. Our analysis indicates that the variables exhibited stationarity in their first differences, suggesting they follow an integrated order of 1, commonly denoted as I(1) processes. Furthermore, the panel cointegration results unveil the presence of a long-run equilibrium relationship between the two variables. This finding underscores the likelihood of a stable and sustained association between energy consumption and gross domestic product across the considered panel of Asian countries. The findings from the Fully Modified Ordinary Least Squares (FMOLS) analysis reveal a positive sign associated with the energy consumption variable. This implies that an increase in gross domestic product (GDP) is associated with a corresponding rise in energy consumption. The positive coefficient suggests a direct and proportional relationship, indicating that economic growth in the context of the examined Asian countries is linked to an augmented demand for energy resources.

The results of the Granger causality test indicate the presence of a short-run unidirectional causal relationship running from energy consumption to gross domestic product (GDP). This suggests that changes or fluctuations in energy consumption have a discernible and statistically significant impact on short-term variations in GDP within the examined context of Asian countries. The Granger causality test provides valuable insights into the temporal dynamics between these two variables, highlighting the directional influence from energy consumption to economic output in the short run. The implications drawn from the Granger causality test results suggest a short-run scenario where energy consumption precedes and influences economic growth. This signifies that, in the short term, the economies of the 17 Asian countries under consideration exhibit a dependency on energy, with fluctuations in energy consumption driving changes in economic output. Furthermore, in the long run, the panel results indicate a causality running from GDP to energy consumption, suggesting that over extended periods, the economic growth of these Asian countries plays a significant role in shaping patterns of energy consumption. The observed long-run causality from GDP to energy consumption in the panel reinforces the proposition that energy consumption is a consequence of economic activity, rather than constituting an intrinsic input to production. This additional evidence

aligns with the notion that economic growth and structural changes in production patterns drive the demand for energy over the extended term in the context of the examined Asian countries. It underscores the intricate relationship between economic dynamics and energy consumption, shedding light on the nature of their interdependence over varying time horizons.

In the short run, the enactment of energy conservation policies in these Asian countries may result in a notable, albeit temporary, negative impact on economic growth. This suggests that the immediate adjustments and transitions associated with energy conservation measures might temporarily constrain economic activity. However, it is essential to recognize that such short-term effects may be followed by long-term benefits, including enhanced energy efficiency, sustainability, and a more resilient economic foundation. Policymakers need to consider this trade-off when formulating strategies that balance the imperative for immediate economic growth with the longer-term goals of sustainable energy practices. Over the long run, economic development in the Asian countries appears to exhibit reduced dependence on energy. Consequently, fostering cooperation among these nations for the implementation of energy conservation policies emerges as an imperative strategy, one that would not adversely impact GDP. Proactive initiatives focused on research and development in the realm of renewable technologies, especially in response to depleting conventional energy sources, offer a promising avenue. Simultaneously, directing efforts towards enhancing energy transportation facilities and improving overall infrastructure could contribute to heightened delivery efficiency, further aligning with sustainable energy objectives while supporting economic development. This comprehensive approach underscores the potential for synergy between economic growth and sustainable energy practices in the Asian context. Against the backdrop of recent unprecedented surges in energy prices, the depletion of conventional energy sources, and global initiatives such as the Kyoto Protocol, it becomes imperative to establish a steadfast commitment towards the successful implementation of energy conservation policies. The challenges posed by escalating energy costs and environmental concerns necessitate a proactive and concerted effort to prioritize and execute policies that promote energy efficiency, sustainability, and adherence to international agreements. Establishing and reinforcing such commitment at national and international levels will be instrumental in navigating the complexities of the contemporary energy landscape while fostering a resilient and environmentally responsible approach to energy management.

REFERENCES

Abosedra, S., Baghestani, H., (1989). New Evidence on the Causal Relationship between United States Energy Consumption and Gross National Product. *Journal of Energy Development* 14, 285 – 292.

Altinay, G., Karagol, E., (2004). Structural break, unit root, and the causality between energy consumption and GDP in Turkey. *Energy Economics* 26, 985-94.

Ang, J., (2008). Economic Development, Pollutant Emissions and Energy Consumption in Malaysia. *Journal of Policy Modeling* 30, 271-278.

Asafu-Adjaye, J., (2000). The relationship between energy consumption, energy prices, and economic growth: time series evidence from Asian developing countries. *Energy Economics* 22, 615-625.

Cheng, B.S., (1999). Causality between energy consumption and economic growth in India: an application of cointegration and error correction modeling. *Indian Economic Review* 34, 39-49.

Cheng, B.S., Lai, T.W., (1997). An investigation of cointegration and causality between energy consumption and economic activity in Taiwan. *Energy Economics* 19, 435-444.

Climent, F., Pardo, A., (2007). Decoupling factors on the energy-output linkage: the Spanish case. *Energy Policy* 35, 522-528.

Emirates Center for Strategic Studies and Research (ECSSR), (2004). *Asian Energy Markets: Dynamics and Trend*, Emirates Center for Strategic Studies and Research.

Energy Information Administration (EIA), (2008). *International Energy Outlook 2008*. Washington, D.C.: Energy Information Administration.

Hadri, K., (2000). Testing for stationarity in heterogeneous panel data. *Econometrics Journal* 3, 148-161.

Holtz-Eakin, D., Newey, W., Rosen, H., (1988). Estimating vector autoregressions with panel data. *Econometrica* 56, 1371-1395.

Holtz-Eakin, D., Newey, W., Rosen, H., (1989). The revenues-expenditure nexus: evidence from local government data. *International Economic Review* 30, 415-429.

Hwang, D.B.K., Gum, B., (1991). The Causal Relationship between Energy and GNP: The Case of Taiwan Province of China. *Journal of Energy and Development* 16, 219-226.

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

Kao, C., (1999). Spurious Regression and Residual-Based Tests for Cointegration in Panel Data. *Journal of Econometrics* 90, 1-44.

Kraft, J., Kraft, A., (1978). On the relationship between energy and GNP. *Journal of Energy and Development* 3, 401-413.

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.

Lee, C.C., Chang, C.P., Chen, P.F., (2008). Energy-income causality in OECD countries revisited: the key role of capital stock. *Energy Economics* 30, 2359-2373.

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.

Maddala, G.S. and Wu, S., (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics* 61, 631-652.

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.

Masih, A.M.M., Masih, R., (1996). Energy consumption, real income and temporal causality: results from a multi-country study based on cointegration and error-correction modeling techniques. *Energy Economics* 18, 165-183.

Masih, A.M.M., Masih, R., (1998). A multivariate cointegrated modeling approach in testing temporal causality between energy consumption, real income, and prices with an application to two Asian LDCs. *Applied Economics* 30, 1287-98.

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.

Oh, W., Lee, K., (2004). Causal relationship between energy consumption and GDP revisited: the case of Korea 1970-1999. *Energy Economics*, 26, 51-59.

Pedroni, P., (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics* 61, 653-670.

Pedroni, P., (2000). Fully modified OLS for heterogeneous cointegrated panels. *Advances in Econometrics* 15, 93-130.

Pedroni, P., (2001). Purchasing power parity tests in cointegrated panels. *The Review of Economics and Statistics* 83, 727-731.

Pedroni, P., (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory* 20, 597-625.

Soytas, U., Sari, R., (2003). Energy consumption and GDP: causality relationship in G-7 and emerging markets. *Energy Economics* 25, 33-37.

Squalli, J., (2007). Electricity consumption and economic growth: bounds and causality analyses of OPEC countries. *Energy Economics* 29, 1192-1205.

Yang, H.Y., (2000). A note on the causal relationship between energy and GDP in Taiwan. *Energy Economics*, 22, 309-317.

Yu, E.S.H., Choi, J.Y., (1985). The causal relationship between energy and GNP: an international comparison. *Journal of Energy and Development* 10, 249-272.

Yu, E.S.H., Hwang, B., (1984). The relationship between energy and GNP: further results. *Energy Economics* 6, 186-90.