©*The Pakistan Development Review*
46 : 4 Part II (Winter 2007) pp. 1065–1073

Energy Use for Economic Growth: Cointegration and Causality Analysis from the Agriculture Sector of Pakistan

KHALID MUSHTAQ, FAISAL ABBAS, ABEDULLAH, and ABDUL GHAFOOR

1. INTRODUCTION

Productivity is closely associated with direct and indirect use of energy as an input. The importance of energy can not be denied as one of the basic inputs to economic growth process. The consumption of energy has been among the critical indicators of the level of development of any country. It is observed that usually the developed countries use more energy per unit of economic output and far more energy per capita than developing countries. This reflects the adoption of increasingly more efficient technologies for energy production and utilisation as well as changes in the composition of economic activities. This, largely, needs a shift in energy use [Cheng and Lai (1997)]. When this shift in the composition of final energy use is taken into account energy use and the level of economic activity are found to be tightly coupled.

The prospect of large reduction in the energy use intensity of economic activity seems limited. So, the accelerated demand results in the scarcity of energy and increasing cost have severe implications for economic growth. This ever increasing role of energy in the present day scenario underlines the need to increase the supply of energy and to find some new alternative energy sources and energy conservation techniques.

In order to meet the expected growth momentum of the economy (more than 6 percent over the past few years and projected to be more in the coming years), Pakistan needs a comprehensive National Energy Plan to meet her future needs [Pakistan (2005)]. It is also clear that energy is one of the important inputs for production, conversion, processing and commercialisation activities. Like other developing countries, Pakistan is also an energy intensive economy and as in most other non-petroleum producing countries its energy needs met by imports. The consumption of petroleum products has been increasing by an average rate of 2.5 percent per annum from 1990-91 to 2003-04. While the consumption of gas and electricity has increased at an average rate of 4.9 and 5.1 percent per annum respectively.

Khalid Mushtaq <khalidmushtaq69@yahoo.com> is Assistant Professor, Department of Agricultural Economics, University of Agriculture, Faisalabad. Faisal Abbas <fabbas@uni-bonn.de> is Junior Researcher, Department of Economic and Technological Change, Centre for Development Research (ZEF), University of Bonn, Germany. Abedullah is Assistant Professor, Department of Environmental and Resource Economics, University of Agriculture, Faisalabad. Abdul Ghafoor <ghafooruaf@hotmail.com> is Lecturer, Department of Marketing and Agribusiness, University of Agriculture, Faisalabad.

Even though, the present use of energy inputs in agriculture is not strictly commensurate with energy consumption trends in developed countries, our agricultural productivity heavily depends on proper availability and prices of energy inputs. Most importantly, almost 67.5 percent of country's population living in rural areas is directly or indirectly[1] depend on agriculture for their livelihood [Pakistan (2005)].

The share of energy consumption in agriculture has continuously decreased from 19 percent and 14 percent in 1972 to 11 percent and 1 percent in 2005 in the case of electricity and petroleum respectively. The share of gas consumption in fertiliser production in the country has also decreased from 19.9 percent in 1972 to 16.4 percent in 2005 [Pakistan (2005)]. Besides these trends in agricultural energy consumption, the share of costly energy inputs in total farm expenses also has severe implications for future energy policies for agriculture sector.

In Pakistan, per capita energy consumption in the agriculture sector is low and this is one of the basic reasons behind continued low productivity and thus impaired economic growth. As economic growth process is highly energy-intensive, therefore, energy supplies in the country must avoid constraints, but Pakistan faces both energy constraints from the supply side and demand management policies [Riaz (1984)].

Sharp increases in energy prices in recent years have renewed interests in the effects of energy on economic growth. Although, it is well known that a strong correlation exist between energy consumption and growth. The significance of any direction of causality, either bi-directional or unidirectional, may provide an insight for the policy makers. For example, if the causality running from energy consumption to income, then this denotes an energy-dependent economy such that energy is an impetus for income increase, implying that a shortage of energy may negatively affect income [Masih and Masih (1998)]. On the other hand, if causality is running from income to energy, this denotes a less energy-dependent economy such that energy conservation policies may be implemented with little adverse or no effects on income [Jumbe (2004)]. Finally, the finding of no causality in either direction, the so-called 'neutrality hypothesis' means that energy conservation policies do not affect income [Yu and Choi (1985)].

Following the importance of energy in the agrarian economy like Pakistan, the present study aims empirically estimating the long-run relationship of agricultural energy consumption, agricultural GDP and energy prices. Further, the direction of causality is checked between agricultural energy consumption and economic growth. The paper is organised as follows: Section 2 presents brief literature review, Section 3 discusses the empirical approach, Section 4 discusses the data and results, while Section 5 concludes.

2. BRIEF REVIEW OF LITERATURE

The association between energy consumption and economic growth has been extensively investigated since the late 1970s. The pioneering study of Kraft and Kraft

[1]Direct use of energy in agriculture can be seen as in agricultural mechanisation e.g. tractor use in a number of land preparation functions and harvesting/carriage of agricultural produce, tube wells, bulldozers, combine harvesters; and plants/factories engaged in processing of agricultural produce e.g. ginners, sugar mills etc. Indirect consumption of energy in agriculture sector is primarily described as gas consumption in fertiliser plants for the production of nitrogen based chemical fertilisers. Petroleum and gas use in rural transportation and household fuel can also be categorised under indirect energy consumption in agriculture sector.

(1978) found that there is a unidirectional causality running from energy consumption to GNP for the United States for the period of 1947–1974. On the other hand, Akarca and Long (1979) showed no evidence of causality between energy consumption and GDP when the investigated period is shortened. Errol and Yu (1987) employed Sims (1980) and Granger (1988) causality tests and found unidirectional causality running from energy consumption to income for West Germany while bi-directional causality for Italy and Japan, and no evidence of causality for UK, Canada and France.

Hwang and Gum (1992) examined the causality between energy consumption and GNP for Taiwan Province of China. A bi-directional causality was observed in Taiwan for the period of 1955–1993. On the other hand, Cheng and Lai (1997) applied Hsiao's version of Granger causality methodology to investigate the causality between energy consumption and GDP for Taiwan for the period of 1955–1993. The study showed that causality runs from GDP to energy consumption without feedback in Taiwan. Yang (2000) re-examined the causality between energy consumption and GDP for Taiwan using updated data for the 1954–1997 period. The finding of this paper does not confirm the findings of Cheng and Lai (1997) of unidirectional causality from GDP to total energy consumption. They found evidences of bi-directional causality between total energy consumption and GDP.

Aqeel and Butt (2001) investigated the causal relationship between energy consumption, economic growth and employment in Pakistan and resulted that economic growth causes total energy consumption. Soytas and Sari (2003) pointed out that there is bi-directional causality in Argentina and they found that causality runs from energy consumption to GDP in Turkey, France, Germany and Japan. Based on these mixed results, it is improper to make any type of generalisations of the potential relationship between GDP and energy consumption. Thus, in designing a recovery policy aimed at facilitating the energy consumption and promoting economic growth, it is necessary to consider the case of each country separately by keeping its pace and stage of development.

3. EMPIRICAL FRAMEWORK

3.1. Model Specification

The demand for per capita agricultural oil consumption was assumed to be a function of per capita real agricultural GDP and oil prices. In the same manner per capita electricity and gas consumption in agriculture was assumed as a function of per capita real agricultural GDP and their respective prices. Thus the general form of consumption demand function was specified in log form as follows;

$$\ln OC_t = \alpha_0 + \beta_1 \ln Y_t + \beta_2 \ln OP_t + \mu_{0t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$\ln EC_t = \alpha_e + \beta_1 \ln Y_t + \beta_2 \ln EP_t + \mu_{et} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$\ln GC_t = \alpha_g + \beta_1 \ln Y_t + \beta_2 \ln GP_t + \mu_{gt} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Where ln OC_t, lnEC_t, and lnGC_t are the natural logarithms of per capita oil, electricity and gas consumption respectively, lnY_t is the natural logarithm of per capita real GDP in the agriculture sector, $\ln OP_t$, $\ln EP_t$, and $\ln GP_t$ are the natural logarithm of oil, electricity and gas prices, and μ_{it} = Stochastic error term assumed to be identically independently and normally distributed (IID) with zero mean and constant variance.

3.2. Testing for Unit Root

We begin by testing for the presence of unit roots in the individual time series of each model using the augmented Dickey-Fuller (ADF) test [Dickey and Fuller (1981); Said and Dickey (1984)], both with and without a deterministic trend. The number of lags in the ADF-equation is chosen to ensure that serial correlation is absent using the Breusch-Godfrey statistic [Greene (2000), p. 541]. The ADF equation is required to estimate the following by OLS.

$$\Delta Y_t = \alpha_3 + \beta_3 t + (\phi_3 - 1)Y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta Y_{t-1} + u_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Where Y_t is the series under investigation, Δ is the difference operator, t is a time trend and u_t are white noise residuals. The number of lags, k, are unknown and we use the LM-test and a general-to-specific testing procedure with maximum k=4 and the 95 percent confidence level [Holden and Perman (1994), p. 62]. From above equation, we can test the null hypothesis that the series has a unit root, i.e., H_0 : $(\phi_3–1) = 0$, against the alternative hypothesis of stationary i.e., H_A : $(\phi_3–1) < 0$ by using τ_τ-statistics with critical values from Fuller (1976, Table 8.5.2, block 3, p.373). If the calculated τ_τ-value (t-value of the coefficient $\phi_3–1$) is greater than the critical τ_τ-value, then Y_t is non-stationary. From (1) we can also test the null hypothesis of no trend i.e., $\beta_3 = 0$ against the alternative hypothesis of a significant trend i.e., $\beta_3 \neq 0$ by using $\tau_{\beta\tau}$-statistics with critical values from Dickey and Fuller (1981), Table III, p.1062. If the calculated $\tau_{\beta\tau}$-value (t-value of the coefficient β_3) is less than the critical $\tau_{\beta\tau}$-value, the null hypothesis is accepted and Y_t has a insignificant trend. Similarly, from (1) we can also test the joint hypothesis of unit root and no trend i.e., H_0 : $(\phi_3\text{-}1) = \beta_3 = 0$ against the alternative hypothesis of trend stationary i.e., H_A : $(\phi_3\text{-}1) = \beta_3 \neq 0$ by using the Φ_3-statistic with critical values from Dickey and Fuller (1981, Table VI, p.1063). If the calculated Φ_3-value is less than the critical value, the null is accepted and Y_t is non-stationary with insignificant trend; conversely, if the null is rejected, Y_t is stationary with a significant trend and is a trend stationary series.

3.3. Testing for Cointegration

If the series were integrated of the same order, Johansen's procedure [Johansen (1988)] can be used to test the presence of a cointegrating vector between agricultural energy consumption, agricultural GDP and energy prices. The procedure was based on maximum likelihood estimation of the error correction model;

$$\Delta Z_t = \delta + \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots\ldots + \Gamma_{p-1} \Delta Z_{t-p+1} + \Pi Z_{t-p} + \mu_t \quad \ldots \quad \ldots \quad (5)$$

Where; $Z_t = [C_t, Y_t, P_t]$, C_t is total energy consumption in the agriculture sector and all the other variables are the same as specified previously. $\Delta z_t = z_t - z_{t-1}$, and Π and Γ_i are $(n \times n)$

matrices of parameters with $\Gamma_i = -(1 - A_1 - A_2 \dots - A_i)$, $(i = 1, \dots, k-1)$, and $\Pi = 1 - \Pi_1 - \Pi_2 \dots - \Pi_k$. The term Πz_{t-p} provides information about the long-term equilibrium relationship between the variables in Z_t. Information about the number of cointegrating relationships among the variables in Z_t is given by the rank of the Π-matrix. Johansen (1988) uses the reduced rank regression procedure to estimate Π-matrix and the trace test statistic is used to test the null hypothesis of at most r cointegrating vectors against the alternative that it is greater than *r*.

Harris (1995) notes that there are three realistic models (denoted as Models 2-4) implicit in (5). Model 2 is where there are no linear trends in the levels of the endogenous I(1) variables and the first-differenced series have a zero mean; here the intercept is restricted to the cointegration space. Model 3 is where there are linear trends in the levels of the endogenous I(1) variables and there is an intercept in the short-run model only. Model 4 is where any long-run linear growth is not accounted for by the model and a linear trend is present in the cointegration vectors.[2] We test between these models following the Pantula principle [Harris (1995)], testing the joint hypothesis of both rank and the deterministic components [Johansen (1992)].

3.4. Granger Causality Test

If cointegration is established, then Engle and Granger (1987) error correction specification can be used to test for Granger causality. For example, if the series oil consumption (OC_t) and real GDP (Y_t) are I (1) and cointegrated, then the ECM model is represented by the following equations;

$$\Delta OC = \alpha_0 + \sum_{i=1}^{n} \beta_i \Delta OC_{t-1} + \sum_{i=1}^{n} \beta_j \Delta Y_{t-1} + \delta ECT_{t-1} + \mu_t \quad \dots \quad \dots \quad \dots \quad (6)$$

$$\Delta Y = \varphi_0 + \sum_{i=1}^{n} \sigma_i \Delta Y_{t-1} + \sum_{i=1}^{n} \sigma_j \Delta OC_{t-1} + \lambda ECT_{t-1} + \varepsilon_t \quad \dots \quad ... \quad \dots \quad (7)$$

where Δ is difference operator, μ_t and ε_t are the white noise error terms, ECT_{t-1} is the error correction term derived from the long-run co integrating relationship, while n is the optimal lag length orders of the variables which are determined by using the general-to-specific modelling procedure [Hendry and Ericsson (1991)]. The null hypotheses are: Y_t will granger—cause OC_t if $\mu_t \neq 0$. Similarly, OC_t will granger cause Y_t if $\varepsilon_t \neq 0$. To implement the Granger-causality test, F-statistics are calculated under the null hypothesis that in above equations all the coefficients of μ_t and $\varepsilon_t = 0$.

4. DATA AND RESULTS

Annual time series data in logarithmic form for the period 1972-2005 relate to per capita oil (Kgs), electricity (KWh^{-1}), and gas (cft) consumption; per capita real agricultural GDP (million Rs.) is the nominal GDP; real prices of diesel, electricity and gas are used in estimation. GDP deflator (2001=100) is used to estimate the real values. Pakistan Economic

[2]Model 1 accounts for no intercepts and no deterministic trends in the cointegrating space, which is unrealistic; Model 5 is appropriate if the data exhibit quadratic trends in level form, which is difficult to justify when the variables are in log form since it implies an unlikely ever increasing or decreasing growth rate.

Survey, Pakistan Energy Yearbooks, Food and Agriculture Organisation (FAO) statistical database and International Monetary Fund (IMF) statistical database are the main sources of data.

Table 2 presents the results of the series (in logarithms) for unit root using ADF test both with and without linear trend. The τ_τ-test implies that we cannot reject the null of a unit root in all series except for per capita real GDP (*LY*) which appears to be a stationary series. The $\tau_{\tau\beta}$-test implies that we cannot reject the null of insignificant trend in all series except for per capita real GDP (LY) where we accept the alternative. The Φ_3-test tests the null of a unit root and no trend jointly and results imply non-rejection of the null in all series. We remove the deterministic trend and τ_μ-test is used to test the null of a unit root and we cannot reject the null in all series. In short, the only time series of per capita real GDP seems stationary in the trended model and its trend is also significant as the results indicate. However, relying on the more authenticated Φ_3-test showed that the per capita real GDP series is non-stationary with no trend. We finally conclude that all the series involved in the analysis are non-stationary.

Table 2 also indicates the first differenced results for both trended and non-trended models. The first differenced absolute values of test-statistics for all series are well above the 95 per cent critical values. Therefore, the null hypothesis of unit root is rejected for these series and they become stationary after first difference i.e., I (1).

Table 2

Augmented Dickey-Fuller (ADF) Unit Root Test Results

Variables	Trended Model			Non-trended Model
	τ_τ	$\tau_{\beta\tau}$	Φ_3	τ_μ
LOC	–1.17	–1.35	1.44	–0.76
LEC	–1.87	0.82	1.84	–2.03
LGC	–1.63	1.09	2.17	–2.36
LY	–4.15*	3.29*	5.42	–0.41
LOP	–1.58	1.40	1.91	–1.20
LEP	–1.20	1.96	2.53	–1.63
LGP	–2.01	1.78	1.70	–1.16
Critical Value	–3.57	2.85	7.24	–2.97
First -differenced ADF Unit Root Test Results				
Variables	Trended Model			Non-trended Model
DLOC	–4.67			–4.64
DLEC	–4.05			–3.79
DLGC	–5.18			–4.56
DLY	–6.90			–5.93
DLOP	–4.75			–4.78
DLEP	–4.55			–4.58
DLGP	–3.70			–3.77
Critical Value	–3.57			–2.97

Notes: 1. Critical values (95percent confidence level) are taken from Fuller (1976), pp. 373.
2. * Denotes significant.

After testing for unit root, the next step is to test for cointegration. Johansen's procedure is applied to test the cointegration between the variables in all the three models. The first step in Johansen's procedure is the selection of order of Vector Auto Regressive (VAR). We use the LR-statistic, adjusted for small samples [Sims (1980)], to test the null hypothesis that the order of the VAR is k against the alternative that it is four where k=0,1,…,4 and for all cases, k=1.[3] The second step in the Johansen procedure is to test the presence and number of cointegration vectors among the series in each model. Table 3 presents Johansen's cointegration results. We now use the Johansen procedure and trace statistics to test between Models 2-4 and to test for the presence and number of cointegrating vectors in all three models using the Pantula principle [Harris (1995)]. The results are presented in Table 3. For three models we conclude that there is one cointegrating vector (i.e., a unique long-run equilibrium relationship) and Model 2 (restricted intercepts and no trends) is the appropriate model.

Table 3

Cointegration Test Based on Trace of Stochastic Matrix

Null	Alternative	Model 2	Model 3	Model 4
Oil Consumption Model				
r = 0	r = 1	32.77 (31.93)	20.51 (31.54)*	31.23 (42.34)
r < = 1	r = 2	12.59 (20.18)	2.36 (17.86)	12.97 (25.77)
r < = 2	r = 3	2.01 (9.16)	0.15 (8.07)	2.01 (12.39)
Electricity Consumption Model				
r = 0	r = 1	44.96 (34.87)	27.73 (31.54)*	41.95 (42.34)
r < = 1	r = 2	20.04 (20.18)	13.85 (17.86)	18.64 (25.77)
r < = 2	r = 3	7.68 (9.16)	1.27 (8.07)	4.86 (12.39)
Gas Consumption Model				
r = 0	r = 1	38.68 (34.87)	25.10 (31.54)*	39.50 (42.34)
r < = 1	r = 2	12.70 (20.18)	6.78 (17.86)	19.11 (25.77)
r < = 2	r = 3	4.46 (9.16)	0.47 (8.07)	6.27 (12.39)

Notes: 1. Critical values (95 percent confidence level) in parentheses [Pesaran, *et al.* (2000)].
2. * Indicates where the null is not rejected using the Pantula principle.

As we know if cointegration is established, then Engle and Granger (1987) error correction specification can be used to test for Granger causality. The results of causality between GDP and different components of energy are presented in the Table 4. In the first row of the table we see that per capita real GDP Granger cause oil consumption and significant at 5 percent level. However, oil consumption does not Granger cause per capita real GDP. This means that there is uni-directional causality running from per capita real GDP to oil consumption. Thus, it can safely be said that growth in agriculture sector will increase the demand for oil. A different scenario is observed in case of electricity consumption and GDP. Per capita real GDP does not Granger cause electricity consumption. However, electricity consumption Granger causes real per capita GDP.

[3]We also tried the Schwarz Bayesian Criterion (SBC) and Akaike information Criterion (AIC). Both SBC and AIC selects lag length one and two for oil model; and one and one for electricity and gas model respectively. To avoid over-parameterisation, we choose one as the lag length [Pesaran and Pesaran (1987)].

Table 4

Granger Causality Results

Causality	Lags	F-statistics	P-value	Result
LY → LOC	1	2.99	0.05	Uni-directional
LOC → LY	1	0.59	0.62	
LY → LEC	1	0.36	0.78	Uni-directional
LEC → LY	1	2.98	0.05	
LY → LGC	1	1.56	0.22	Neutral
LGC → LY	1	1.58	0.22	

Note: '→' Shows direction of causality.

This means that there is also uni-directional causality running from electricity consumption to per capita real GDP. In contrast with the above results, the non-significant values of F-statistics for Granger causality, both from GDP to gas and from gas to GDP, seems to suggest that there may not be any causal relationship between gas and agricultural GDP.

5. SUMMARY AND CONCLUSIONS

In this study, Johansen's co-integration approach and Granger causality is used to check the degree of integration and direction of causality among different economic time series for the period 1972-2005. It is found that all the series are first-differenced stationary and there exists a long run equilibrium relationship among concerned variables. Granger causality test result suggests that a uni-directional causality relationship exists for GDP and oil consumption; electricity and GDP, while neutrality hypothesis proved for gas and GDP.

As causality results implies that agricultural GDP and oil consumption has a causal relationship. The implication of this result is that any future growth in agriculture sector will increase the demand for oil. Further, electricity consumption and agricultural GDP show a causal relationship. Thus an important implication of this result is that if government improves the infrastructure and subsidises rural and agricultural electricity, it would significantly enhance agricultural share of GDP.

REFERENCES

Akarca, A. T. and T. V. Long (1979) Energy and Employment: A Time Series Analysis of the Causal Relationship. *Resources and Energy Economics* 2, 151–162.

Aqeel, A. and M. S. Butt (2001) The Relationship between Energy Consumption and Economic Growth in Pakistan. *Asia Pacific Development Journal* 8:2, 101–110.

Cheng, B. S. and T. W. Lai (1997) An Investigation of Co-integration and Causality between Energy Consumption and Economic Activity in Taiwan. *Energy Economics* 19:4, 435–444.

Dickey, D. A. and W. A. Fuller (1981) The Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica* 49, 1057–1072.

Engle, R. F. and C. W. J. Granger (1987) Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica* 55:2, 251–276.

Errol, U. and E. S. H. Yu (1987) On the Causal Relationship between Energy and Income for Industrialised Countries. *Journal of Energy and Development*. 13, 113–122.

Fuller, W. A. (1976) *Introduction to Statistical Time Series.* New York: John Wiley and Sons.

Granger, C. W. J. (1988) Some Recent Developments in a Concept of Causality. *Journal of Econometrics* 39, 199–211.

Greene, W. H. (2000) *Econometric Analysis*. New Jersey: Prentice-Hall, Inc.

Harris, R. (1995) *Using Cointegration Analysis in Econometric Modelling*. London: Prentice Hall, Harvester Wheatsheaf.

Hendry, D. F. and N. R. Ericsson (1991) Modeling the Demand for Narrow Money in the United Kingdom and the United States. *European Economic Review* 35:4, 833–886.

Holden, D. and R. Perman (1994) Unit Roots and Cointegration for the Economist. In B. B. Rao *Cointegration for the Applied Economists.* New York: St. Martin's Press.

Hwang, D. B. G. and B. Gum (1992) The Causality Relationship between Energy and GNP: The Case of Taiwan. *Journal of Energy and Development* 16, 219–226.

Johansen, S. (1988) Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamics and Control* 12, 231–2544.

Johansen, S. (1992) Determination of Cointegration Rank in the Presence of a Linear Trend. *Oxford Bulletin of Economics and Statistics* 54, 383–397.

Jumbe, C. B. L. (2004) Electricity Consumption and GDP: Empirical Evidence from Malawi. *Energy Economics* 26, 61–68.

Kraft, J. and A. Karaft (1978) On the Relationship between Energy and GNP. *Journal of Energy and Development* 3, 401–403.

Masih, A. M. and R. Masih (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* 30:10, 1287–1298.

Pakistan, Government of (2005) *Pakistan Economic Survey 2004-05.* Islamabad: Finance Division, Economic Adviser's Wing.

Pesaran, H. M. and B. Peraran (1987) *Working with Microfit 4.0: Interactive Econometric Analysis*. Oxford: Oxford University Press.

Pesaran, M. H., Y. Shin, and R .J. Smith (2000) Structural Analysis of Vector Error Correction Models with Exogenous I(1) Variables. *Journal of Econometrics* 97:2, 293–343.

Riaz, T. (1984) Energy Consumption and Economic Growth. *The Pakistan Development Review* 23:4, 431–53.

Said, S. E. and D. A. Dickey (1984) Testing for Unit Roots in Autoregressive-Moving Average Models of Unknown Order. *Biometrika* 71, 599–607.

Sims, C. A. (1980) Macroeconomics and Reality. *Econometrica* 48, 1–49.

Soytas, U. and R. Sari (2003) Energy Consumption and GDP: Causality Relationship in G-7 Countries and Emerging Markets. *Energy Economics* 25:1, 33–37.

Yang, H. Y. (2000) A Note on the Causal Relationship between Energy and GDP in Taiwan. *Energy Economics* 22:3, 309–317.

Yu, S. H. and J. Y. Choi (1985) The Causal Relationship between Energy and GNP: An International Comparison. *Journal of Energy and Development* 10:2, 249–72.