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THE IMPACT OF ELECTRICITY SUPPLY ON ECONOMIC GROWTH IN SRI LANKA

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The impact of electricity supply on economic growth in Sri Lanka

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Abstract

This paper applies to Sri Lanka a simple econometric model developed by Yang (2000) who found a bi-directional causal relationship between gross domestic product (GDP) and electricity consumption in Taiwan for the period 1954 – 1997. We find that current as well as past changes in electricity supply have a significant impact on the change in real GDP in Sri Lanka. An extra economic output of 88000 to 137000 Rupees is predicted for every 1MWh increase in electricity supply.

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Introduction

Today, many developing countries are facing power shortage problems. An adequate and regular power supply may be one of the most crucial factors which supports economic growth in developing countries. According to a study on the relationship between electricity use and economic development conducted by Ferguson et al (2000), there is a strong correlation between electricity use and economic development[2].

The Pearson correlation coefficient between growth in annual electricity use and average annual economic growth for Sri Lanka during the period 1971 – 1995 is 0.993 (Ferguson et al, 2000)[3]. Figure 1 shows this strong correlation between average annual growth rates of Gross Domestic Product (GDP) and electricity demand in Sri Lanka between 1984 and 1997 (CEB 1999). Energy demand in Sri Lanka is mainly met by hydropower so that electricity supply decreases severely when the country is hit by serious droughts. This has led to a dramatic decline in its economic growth. In particular, serious droughts in 1996 meant that Sri Lanka experienced a severe power crisis which adversely affected the economy in 1996.

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[2] Similar studies are, for example, Ramcharran (1990); Huang (1993); Mashi and Mashi (1996); Asafu-Adjaye (2000).

[3] Their analysis uses electricity consumption in kWh as the energy use variable and GDP (Gross Domestic Product) at PPP (purchasing power parities) in 1995 US dollars.

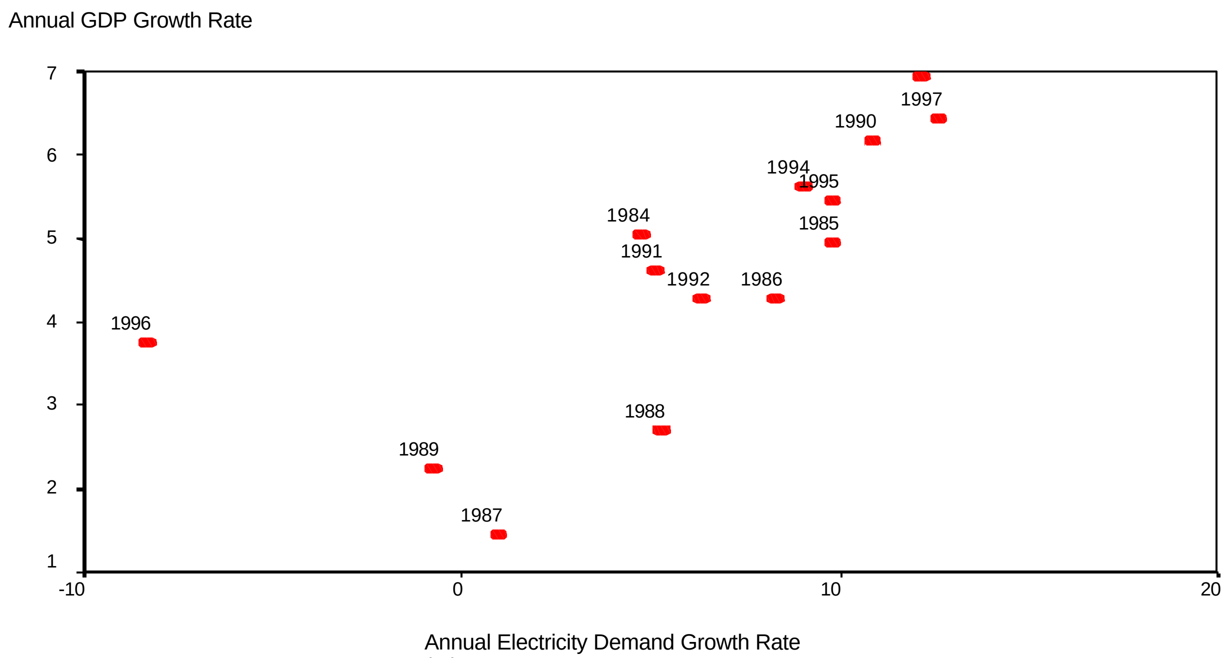

Figure 1 **GDP and Electricity demand growth rates in Sri Lanka**

Source: CBSL (1998); Statistical Digests of relevant years (Information Management Branch CEB)

Reducing the incidence of power shortages is one of the main incentives for the development of new generating capacity in many developing countries. In a previous paper we have found that the expected increase in economic output due to increased electricity supply (designated as EO, for 'Economic Output') was the parameter whose uncertainty had the largest effect on the Net Present Value of a large dam project in Sri Lanka (Morimoto and Hope, 2001). Hence the aim of this study is to examine the impact of electricity supply on economic growth in Sri Lanka. The model used in this research was developed by Yang (2000) who found a bi-directional causal relationship between gross domestic product (GDP) and electricity consumption in Taiwan for the period 1954 – 1997. The results will be useful both for macroeconomic planners, and for decision makers involved in electricity supply projects, such as new dams.

The next section describes the methodology of this study, followed by the presentation of the results. The final section applies the analysis to obtain a better estimate of the parameter EO.

Methodology

Yang (2000) employed the Granger-causality test and found that electricity shortages could restrain economic growth in Taiwan. He used first differenced real GDP as a dependent variable, with lagged first differenced electricity consumption and lagged first differenced real GDP as independent variables in the model described in Equation (1).

$$DGDP_t = a + \sum_{i=1}^{3} b_i \, DGDP_{t-i} + \sum_{i=1}^{2} c_i \, DELECT_{t-i} + u_t \qquad (1)$$

where ΔGDP_t = first differenced real GDP in Taiwan at time t, $\Delta ELECT_{t-i}$ = first difference of electricity consumption in Taiwan at time t-i and u_t = error term at time t.

Yang did not present the estimated coefficients of the equation in his paper. However, he estimated another model without $\Delta ELECT_{t-i}$ and obtained Akaike's final prediction errors (error values which are used to select appropriate independent variables and lag specifications) for both models with and without $\Delta ELECT_{t-i}$. He found that the Akaike's final prediction error for the equation with $\Delta ELECT_{t-i}$ was smaller than the one without $\Delta ELECT_{t-i}$, which supports the hypothesis that electricity consumption *Granger-caused* GDP in Taiwan.

Since Sri Lanka does not import or export electricity, the amounts of electricity production and consumption are the same[4]. Thus, in this paper, annual electricity production will be used instead of electricity consumption. The current electricity consumption was not included in Yang's model as his model was purely to investigate the directions of the causality[5]. However, according to Yang, the current electricity consumption is included in the estimation of a production function in research publications on Taiwanese economic growth. In the case of Sri Lanka, the change in electricity production at time t, ΔELECTt, should also be included, as GDP growth at time t seems highly dependent on electricity supply at time t (see Figure 1). Hence, the following slightly modified equation is used in this study.

$$DGDP_t = a + \sum_{i=1}^{3} b_i DGDP_{t-i} + \sum_{i=0}^{2} c_i DELECT_{t-i} + v_t \qquad (2)$$

Where ΔGDP_t = first differenced real GDP in Sri Lanka at time t, $\Delta ELECT_{t-i}$ = first difference of electricity production in Sri Lanka at time t-i, and v_t = error term at time t.

Equation (2) implies that change in real GDP at time t is a function of past changes (with yearly lags up to t-3) in real GDP and of current as well as past changes in electricity supply (with yearly lags up to t-2).

[4] See UN Energy Statistics Year book.

[5] A time series is said to *Granger-cause* another time series Y if the prediction error of current Y declines by using past values of X in addition to past values of Y.

Results

Annual data for the period 1960-1998 for real GDP (Billion Rs) and for electricity production (Million kWh) in Sri Lanka are used (See Figures 2 & 3)[6].

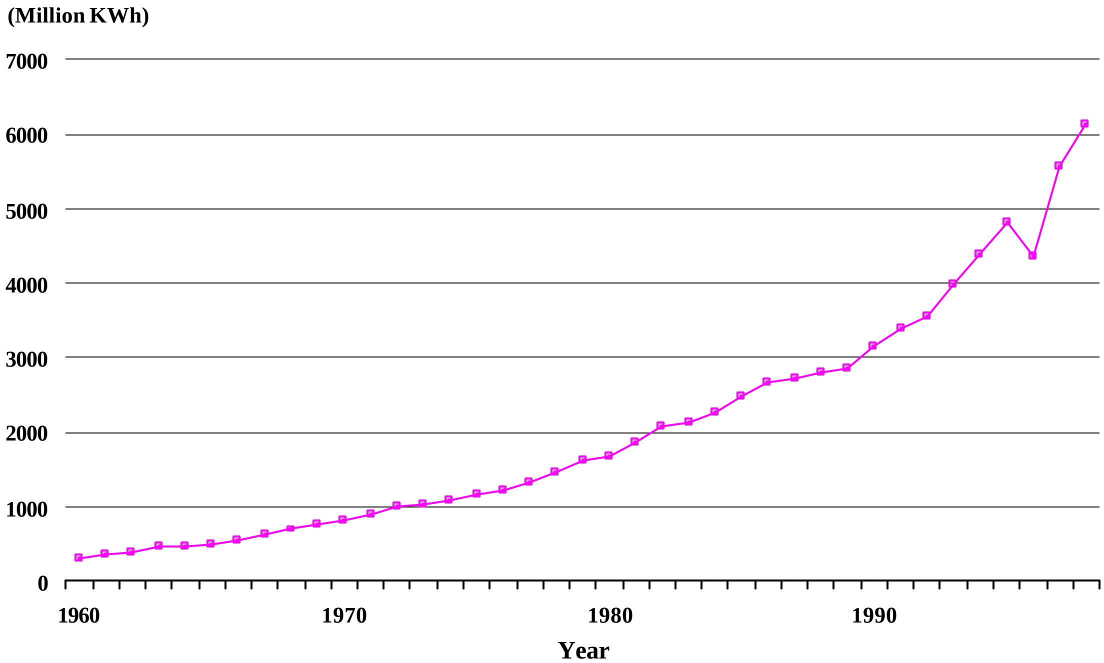

Figure 2 **Electricity production in Sri Lanka (Million kWh)**

Source: UN Energy Statistics Year Book (various years); UN Monthly Bulletin of Statistics (various years)

[6] The nominal GDP are transformed into real GDP in 1998 prices using GDP deflators, which is the same transformation method as Yang's.

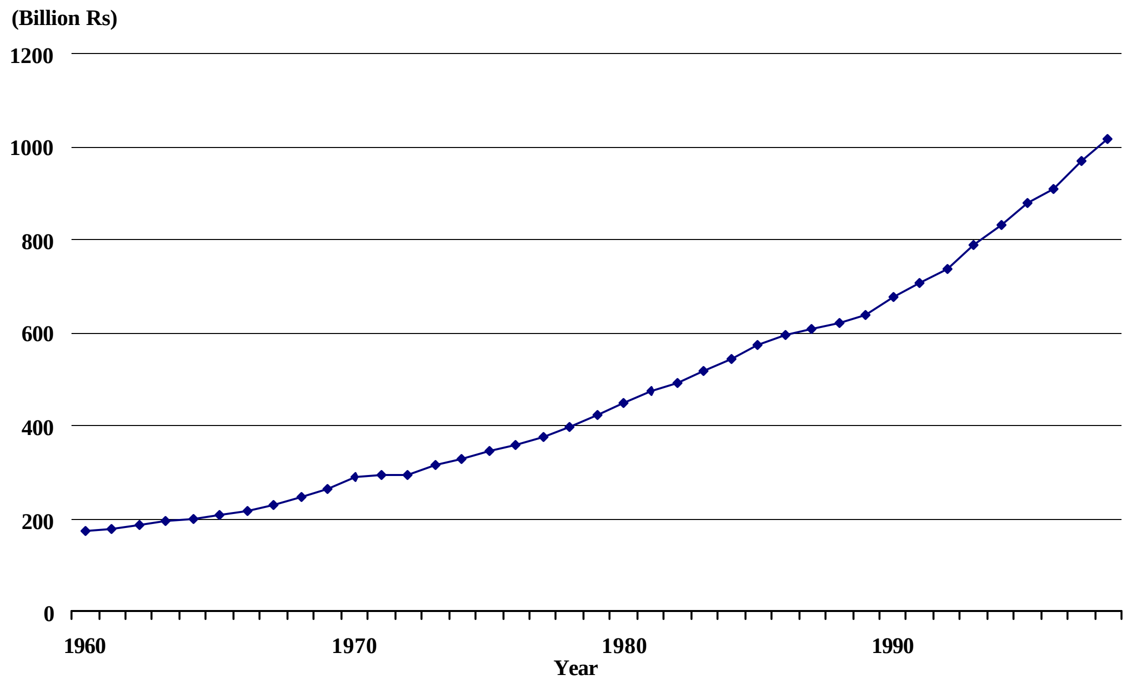

Figure 3 **Real GDP in Sri Lanka (Million Rs)**

Source: IMF IFS Year Book (various years); Pesaran *et al* (1998)

Before estimating the model, the stationarity of dependent and independent variables are examined in order to meet the condition of using Yang's Granger causality model. Although both GDP and electricity production are non stationary, their first differenced values are stationary according to the result from the Augmented Dickey-Fuller (ADF) test for stationarity and unit roots[7]. Moreover, the cointegration test for the series of GDP

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[7] The ADF test statistics show the values of 1.95 and 0.85 for the variables GDP and ELECT respectively, which are insignificant at the 5% level. However, the ADF test shows the values of –4.68 and –5.97 for a first difference of GDP and ELECT respectively, which are both significant at the 5% level. See basic econometrics textbooks such as Greene (2000) for more details about the ADF tests.

and electricity production is also satisfied, therefore the standard Granger causality test can be applied[8].

Equation (2) is estimated by a standard ordinary least square (OLS) regression analysis with 35 observations and the result is presented in Table I column 1. The value for the model fit (adjusted R^2=70%) is reasonable for this type of growth model[9]. All the coefficients of ΔGDP_{t-i} are insignificant at the 5% level individually (t-tests) and simultaneously (F-test)[10]. Therefore they are dropped from the model, which is then re-estimated[11]. The results are presented in Table I column 2. All the coefficients of $\Delta ELECT_{t-i}$ in the model (2) are significant at the 5% level. The result implies that current as well as past changes in electricity supply have a significant impact on the change in real GDP. According to the specification in Column 2 in Table I, one unit change in $\Delta ELECT_t$, $\Delta ELECT_{t-1}$, and $\Delta ELECT_{t-2}$ separately leads to changes in ΔGDP_t of 38.2, 30.0 and 44.1 units respectively. In other words, 1MWh increase in electricity supplies at time t, t-1, and t-2 results in economic growth at time t of 38200Rs, 30000Rs, and 44100Rs respectively. The coefficient of $\Delta ELECT_{t-2}$ is larger than the coefficients of

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[8] The unit root tests for residuals shows the value of –2.5, which is insignificant at the 5% level.

[9] Its diagnostic test shows that there are no serial correlation or heteroscedasticity problems.

[10] F-test for the null hypothesis of all the coefficients of ΔGDP_{t-i} being insignificant simultaneously shows the values of 0.72 with p-value 0.56.

[11] This bi-variate relationship between growth of GDP and electricity production may be over-estimated, as the usual production function also includes capital and labor. Hence, in future work, capital and labor parameters could also be included to improve the model.

$\Delta ELECT_t$ and $\Delta ELECT_{t-1}$, which is surprising, as it is generally expected that the impact decays as time passes. However, the above result could be due to time lags in the system, so that increased electricity supply takes some time to have its full effect on GDP growth.

Table I. OLS estimates of first differenced real GDP (ΔGDP_t) in Sri Lanka for the period 1960-1998

Explanatory variables	(1) Original model	(2) ΔGDP_{t-i} all eliminated	(3) $\Delta ELECT_{t-3}$ added to (2)
Intercept	7072 (2.4)*	7710 (3.4)*	7138 (3.2)*
ΔGDP_{t-1}	0.15 (0.8)		
ΔGDP_{t-2}	-0.22 (-1.0)		
ΔGDP_{t-3}	0.12 (0.8)		
$\Delta ELECT_t$	37.2 (4.6)*	38.2 (7.2)*	34.2 (5.8)*
$\Delta ELECT_{t-1}$	25.5 (1.8)**	30.0 (4.9)*	24.2 (3.4)*
$\Delta ELECT_{t-2}$	46.4 (2.4)*	44.1 (4.5)*	37.7 (3.6)*
$\Delta ELECT_{t-3}$			22.0 (1.5)
Adjusted R^2	0.70	0.71	0.72

Note: The sample size is 35. The figures in parenthesis are t-values. * significant at the 5 % level; ** significant at the 10 % level; ΔGDP_{t-i} = first differenced real GDP in Sri Lanka at time t-i, $DELECT_{t-i}$ = first difference of electricity production in Sri Lanka at time t-i.

Implications for the parameter EO

Based on the above regression result, a value for the parameter EO (expected increase in economic output) used in the CBA model in Morimoto and Hope (2001) can be estimated. The standard error (SE) for the coefficients of $\Delta ELECT_t$, $\Delta ELECT_{t-1}$, and $\Delta ELECT_{t-2}$ are 5.3, 6.1, and 9.7 respectively. Therefore, the standard error for their sum should be $[5.3^2+6.1^2+9.7^2]^{1/2}=12.6$ with the assumption of these coefficients following independent normal distributions[12]. Hence, the 95% confidence interval for the joint impact of $\Delta ELECT_t$, $\Delta ELECT_{t-1}$, and $\Delta ELECT_{t-2}$ (which is what the parameter EO represents) is [38.2+30.0+44.1]+/-1.96(12.6) = 88-137. Then, the 95% confidence interval for the parameter EO may be expressed as the range 88000 to 137000Rs/MWh[13]. This range of values is much higher than the Ceylon Electricity Board estimation of 26000Rs/MWh, used as the modal value in the CBA model in Morimoto and Hope (2001)[14].

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[12] However, if the distributions of each coefficient are correlated, SE(sum of the three coefficients)$=[SE(c_0)^2+SE(c_1)^2+SE(c_2)^2+2\{cov(c_0, c_1)+cov(c_0, c_2)+cov(c_1, c_2)\}]^{1/2}=[5.3^2+6.1^2+9.7^2+2(0.25-3.8+25.1)]^{1/2}=14.2$. This calculation is carried out by the statistical package Microfit.

[13] The value for the standard error for the coefficients of $\Delta ELECT_t$, $\Delta ELECT_{t-1}$, and $\Delta ELECT_{t-2}$ are 5.3, 6.1, and 9.7 respectively. Thus the 95% confidence interval (CI) values are calculated as follows; CI($\Delta ELECT_t$) = 38.2+/-1.96*(5.3), CI($\Delta ELECT_{t-1}$) = 30.0+/-1.96*(6.1), CI($\Delta ELECT_{t-2}$) = 44.1+/-1.96*(9.7), Hence, the 95% confidence interval values for the coefficients $\Delta ELECT_t$, $\Delta ELECT_{t-1}$, and $\Delta ELECT_{t-2}$ are [27.8-48.6], [18.0-42.0], and [25.1-63.1] respectively.

[14] The UK Electricity Pool uses the even lower value of 23000Rs/MWh, as the value of lost load in UK. The value of outage cost to Chilean industry lies between 6080Rs/MWh (for 10% 1-month equiproportional restriction) and 17380Rs/MWh (for 30% 10-months equiproportional restriction). See

The range that Morimoto and Hope (2001) used for the parameter EO was a triangular distribution with minimum = 10000, most likely = 26000, and maximum = 118500Rs/MWh respectively. The regression results provide some support for this range since EO = 88000-137000Rs/MWh, estimated in this paper, overlaps this range. However, the estimates here allow the value to be much higher. The minimum value of 10000Rs/MWh, which is much lower than the minimum estimated value, now seems hard to justify. The maximum value of 118500Rs/MWh is not large enough to cover the full range of the estimated results. It is possible to expect such large economic growth due to increased power supply as predicted by the model, since Sri Lanka is currently facing power shortages, which may slow down the economic growth.

One final calculation is needed. The coefficient of $\Delta \text{ELECT}_{t-2}$ has the highest value according to the above result. Therefore it is necessary to check whether $\Delta \text{ELECT}_{t-3}$ also has a significant impact on GDP growth. Thus, $\Delta \text{ELECT}_{t-3}$ is added to the model in order to check its impact on ΔGDP. The result shown in Column 3 of Table I indicates that the coefficient of $\Delta \text{ELECT}_{t-2}$ is again larger than the coefficients of ΔELECT_{t} and $\Delta \text{ELECT}_{t-1}$; however, the coefficient of $\Delta \text{ELECT}_{t-3}$ is the smallest and insignificant. Furthermore, the 95% confidence interval value for the parameter EO predicted by the

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Serra and Fierro (1997) for more details. The exchange rates of £1 = 184Rs , and $1=79Rs are used (Central Bank of Sri Lanka 2000).

model with $\Delta \text{ELECT}_{t-3}$ is 78000 to 158000Rs /MWh, calculated using the same procedure as above; a very similar value to the one without $\Delta \text{ELECT}_{t-3}$ [15].

[15] $(34.2+24.2+37.7+22) +/- 1.96(5.9^2+7.2^2+10.5^2+15.0^2)^{1/2}$ = 78-158. The value for the standard error for the sum of the coefficients of ΔELECT_t, $\Delta \text{ELECT}_{t-1}$, $\Delta \text{ELECT}_{t-2}$, and $\Delta \text{ELECT}_{t-3}$ is 14.5 if these coefficients are correlated. This is calculated by $[5.9^2+7.2^2+10.5^2+15.0^2+2(11.2+8.5-41.6+41.6-59.5-65.9)]^{1/2}$

Conclusion

The impact of electricity supply on economic growth in Sri Lanka is closely examined in this study. The methodology is based on the research conducted by Yang (2000), using a simple econometrics model. The findings imply that current as well as past changes in electricity supply have a significant impact on a change in real GDP in Sri Lanka. The result can also be used to estimate a better range for the parameter EO (increase in economic output due to increased electricity supply in Sri Lanka) in the CBA model that we have developed (Morimoto and Hope (2001)). We calculate extra economic output of 88000 to 137000 Rs for every 1MWh increase in electricity supply in Sri Lanka.

The above bi-variate relationship between GDP and electricity production may be over-estimated, as the usual production function also includes capital and labor. Hence, in future work, capital and labor parameters could also be included to improve the model.

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References

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

CEB (1999) *Long Term Generation Expansion Plan 1999 - 2013*

CBSL (1998) *Annual Report Central Bank of Sri Lanka*

Ferguson, R, Wilkinson, W and Hill, R (2000) 'Electricity use and economic development' *Energy Policy* **28** 923-934

Greene,WH (2000), (4th ed.), *Econometric Analysis*, Prentice Hall international Inc

Huang, J-P (1990) 'Electricity consumption and economic growth: A case study of China' *Energy Policy* **21** 717-720

Mashi, AMM, and Mashi, 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

Morimoto, R and Hope, C (2001) 'An extended CBA model of hydro projects in Sri Lanka', *Judge Institute of Management Research Paper*

Pesaran, MH, Smith, RP, and Akiyama, T (1998) *Energy Demand in Asian Developing Countries* Oxford University Press, 226

Ramcharran, H (1990) 'Electricity consumption and economic growth in Jamaica' *Energy Economics* **12** 65-70

Serra, P, and Fierro, G (1997) 'Outage costs in Chilean industry' *Energy Economics* **19** 417-434

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