Brigham Young University
BYU ScholarsArchive

International Congress on Environmental Modelling and Software

2nd International Congress on Environmental Modelling and Software - Osnabrück, Germany - June 2004

Jul 1st, 12:00 AM

Energy Consumption, Employment and the Kyoto Protocol in New Zealand: Searching for Causality

Les Oxley

Frank G. Scrimgeour

Koli Fatai

Follow this and additional works at: https://scholarsarchive.byu.edu/iemssconference

Oxley, Les; Scrimgeour, Frank G.; and Fatai, Koli, "Energy Consumption, Employment and the Kyoto Protocol in New Zealand: Searching for Causality" (2004). *International Congress on Environmental Modelling and Software*. 90.
https://scholarsarchive.byu.edu/iemssconference/2004/all/90

This Event is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in International Congress on Environmental Modelling and Software by an authorized administrator of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.

Energy Consumption, Employment and the Kyoto Protocol in New Zealand: Searching for Causality

Les Oxley[a,b], F. Scrimgeour[c] and K. Fatai[c],

[a]Department of Economics, University of Canterbury
[b]Adjunct Professor, Department of Economics, University of Western Australia
[c]Department of Economics, University of Waikato

Abstract: This paper considers the causal relationship between employment, energy consumption and economic growth using a range of different approaches. The study finds long-run neutrality in energy consumption, except for electricity and oil consumption where there is evidence of uni-directional linkages from electricity consumption to employment and from oil consumption to employment. We also found that there is uni-directional link from real GDP growth to employment. These conclusions are robust across the different methodologies and have implications of environmental and energy issues including the Kyoto Protocol.

Keywords: Employment, Energy, Kyoto Protocol

1. Introduction

The literature on the causal relationship between employment and other macroeconomic variables has increased dramatically recently given the advances in available methodologies. One area that is still interesting to study because of controversies it creates is the causal relationship between employment and energy residential consumption (disaggregated into coal, oil, electricity and gas), employment and industrial energy consumption, employment and total final energy consumption, and employment and real GDP growth.

Although there have been several studies in the general area of causal links between energy consumption and employment, (Akarca and Long, 1979; Yu, Chow and Choi, 1988; Yu and Jin, 1992; Murray and Nan, 1992), there remain real controversies. Some commentators arguing for the neutrality hypothesis (Yu, Chow and Choi, 1988), while others argue for a unilateral or bilateral relationship (Murray and Nan, 1992; Stern, 2000).

This present study is important for New Zealand because of the recent policy framework prepared by the Ministry for the Environment and the Ministry of Economic Development on government strategies towards energy conservation and the Kyoto protocol (EECA, 2001). Reducing energy consumption may or may not affect the level of employment in New Zealand. It would be helpful, therefore, for policy makers, to scrutinise empirical studies to determine the causal relationships between energy consumption and employment in an industrialized country other than the United States and the few Asian countries where most of the recent studies have been focused. This study contributes to the international literature by using, among others, a relatively recent method (AutoRegressive Distributed Lag or ARDL), to infer causality.

The study is divided into seven sections. The second section briefly discusses the conflicting results of studies examining the causality between energy consumption and employment. The third and fourth sections describe and discuss the data and methodology used in this paper. The fifth section presents the empirical results followed by a brief discussion of the results in section six. The final section comprises a summary and brief conclusion to the study.

2 Other Literature: Brief Overview

While there have been several studies on the causal linkages between employment and energy consumption conducted on the US, where the results conflict. Akarca and Long (1979) found, using US data, that energy consumption unidirectionally causes employment. In a later study, Yu, Chow and Choi (1988) found evidence in support of the neutrality hypothesis that there is no causal relationship using Sim's (1972) technique, again using data for the US. Murray and Nan (1992), however, use Sim's approach and argue that there is evidence to support reverse causality from employment to energy consumption in the United States. Yu and Jin (1992), find no relationship between employment and energy consumption and an index of industrial production. Murray and Nan (1992), also found no relationship between employment and energy consumption for the US using both Granger (1969) and Sim's (1972) technique. Thus, for the US, studies remain largely inconclusive.

The bivariate model used in the Murray and Nan's study, using both Granger and Sim's approach, was of the behavioural form: $EMP=F(EMP_{t-i})$; $EMP=F(EMP_{t-i},EEC_{t-i})$; $EEC=F(EEC_{t-i})$; $EEC=F(EEC_{t-i}, EMP_{t-i})$, where EMP is US employment and EEC is US total final energy consumption. The Stern (2000) study, however, used a multivariate, VAR, model to estimate causal relationship between employment and real GDP in the US, arguing that a multivariate model would solve possible problems caused by omitted variables. Moreover, long-run dynamics can be estimated in a VAR setting. The model that Stern used was of the form:

$$f(x_{1t}) = f(x_{rt})' \Gamma + u_t \qquad (1)$$

$$f(x_{1t}) = [1, t, r \text{ past GDP}, k \text{ past capital input}, s \text{ past labour input}, m \text{ past energy input}]$$

t = time trend to capture impacts of exogenous technical change; r = r past lags of GDP; k = k past lags of capital input; s = s past lags of labour input; m = m past lags of energy input; Γ = matrix of regression coefficients; u_t = random error vector. The r, k, s and m past lags were chosen using the Hannan-Quinn Information Criterion (HQC).

While there have been a number of studies of the causal link between energy consumption and employment in the US, surprisingly only a few studies have been conducted for other countries. Cheng (1998) used a multivariate model to study the energy consumption-employment nexus in Japan. He used Hsiao's (1981) version of the Granger causality test.

3. Data

The data for employment (1960-1999) were taken from the OECD database of main indicators in Statistic New Zealand's PC-Infos. The real GDP and energy data were both taken from the International Energy Agency's (IEA) energy and economic indicator database. The energy data were disaggregated into coal, gas, electricity and oil for 1960-1999. The energy data are measured in millions of tons oil equivalent (Mtoe). All data were transformed into natural logarithms.

4. Methodology

4.1 Causality Tests

One of the methods used includes the standard Granger version of a causality test. Because of the relatively small sample size used, the standard Granger version of causality test has an advantage, as a simulation study by Guilkey and Salemi (1982) showed favourable results for the Granger causality method even in small samples. In addition, we used two other methods: the AutoRegressive Distributed Lag (ARDL) regression model of Pesaran *et.al.* (1996), and the Toda and Yamamoto (1995) method. The advantage of the ARDL method is that it does not require information on the variables' order of integration.

4.1.1. Engle and Granger (1987) type test

Engle and Granger (1987) proved that if two variables, individually, are integrated of order one, I(1) and cointegrate, then a causal relationship exists between the two variables. The "Granger Representation Theorem" is useful for modeling series that are I(1) as a VAR model provided the series are cointegrated. However, if the null of no cointegration is accepted, the series must be transformed to induce stationarity.

Following the original Granger

$$\mathrm{X_t} = \alpha + \sum_{i=1}^{k} \zeta_i \mathrm{X_{t-i}} + \sum_{j=1}^{l} \varphi_j \mathrm{Y_{t-j}} + \varepsilon_t \qquad (2)$$

$$\mathrm{Y_t} = \psi + \sum_{i=1}^{r} \chi_i \mathrm{Y_{t-i}} + \sum_{j=1}^{s} \gamma_j \mathrm{X_{t-j}} + \nu_t \qquad (3)$$

approach, there are three alternative routes, depending on the order of integration of the variables, by which causality can be tested. The first two approaches are valid when the variable are I(1) and cointegrated. The third is valid where the variables are not cointegrated and must be I(0) either directly or via transformation. Via approach 1., presented in the bivariate case by equations (2) and (3) above, if the variables are I(1) and cointegrated, the disturbance term will be I(0) and with the assumption of zero mean, the disturbance will drift up and down near the zero line. This implies that the variables are superconsistent.

If the original variables are I(1) causality can also be tested using the variables

$$\Delta X_t = \alpha + \sum_{i=1}^{k} \zeta_i \Delta X_{t-i} + \sum_{j=1}^{l} \varphi_j \Delta Y_{t-j} + \xi ERR_{t-1} + \varepsilon_t \quad (4)$$

$$\Delta Y_t = \psi + \sum_{i=1}^{r} \chi_i \Delta Y_{t-i} + \sum_{j=1}^{s} \gamma_j \Delta X_{t-j} + \phi ERR_{t-1} + \nu_t \quad (5)$$

transformed to I(0) adding an error correction term to capture the short-run dynamics: where ERR_{t-1} represents the one period lagged error term from the regression of the variables that cointegrate. The third approach is where the variables are I(1), but not cointegrated. In this case, the data need to be transformed to induce stationarity. However, because they are not cointegrated, no error correction mechanism binds the non-cointegrated variables and hence no one period lagged error term is needed in (4) and (5). Non-causality is inferred on the basis of joint tests of the null H_o: $\varphi_1 = \varphi_2 = \varphi_3 = \ldots = \varphi_n$ or H_o: $\gamma_1 = \gamma_2 = \gamma_3 = \ldots = \gamma_n$; and/or $\xi = 0$; $\phi=0$, depending on the model under test.

4.1.2. Toda and Yamamoto (1995) test

In addition to the Engle and Granger approach, the Toda and Yamamoto (1995) method is also used to consider robustness across approaches. The Toda and Yamamoto approach involves using levels of the variables as in (6) and (7) even if the variables may be individually non-stationary.

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + u_t \quad (6)$$

$$Y_t = a + \sum_{i=1}^{q} b_i Y_{t-i} + \sum_{j=1}^{r} c_j X_{t-j} + v_t. \quad (7)$$

The initial lag lengths m, n, q and r are chosen using the AIC criterion. The initial lag lengths are then augmented with an extra lag depending on the likely order of integration of the series X_t and Y_t. If X_t and Y_t are assumed I(1), then one extra lag is added to (6) and (7). Wald/LM tests are then used to test causal direction excluding the extra lag added to capture maximum order of integration.

4.1.3. ARDL approach

The main advantage of this approach for cointegration testing and estimation is that it can be applied whether the regressors are I(0) or I(1). It therefore avoids the pre-test problems associated with standard cointegration analysis. The first stage of the process involves establishing the existence of a long-run relationship between the variables and is tested by considering the joint significance of the coefficients of the lagged levels variables Y_{-1} and X_{-1} in an equation like (8) below:

$$\Delta X_t = \alpha + \sum_{i=1}^{k} \zeta_i \Delta X_{t-i} + \sum_{j=1}^{l} \varphi_j \Delta Y_{t-j} + \beta Y_{t-1} + \gamma X_{t-1} + \varepsilon_t \quad (8)$$

using tables presented in Pesaran *et al*. (1996) to test for the existence of a long-run relationship between X and Y. If the null hypothesis of no long-run relationship is rejected, the ARDL model can be established and either a long-run or ECM version of the model constructed. Causality can be inferred when a long-run relationship exists between at least two variables and that the lags of the two variables, as in (8), are jointly not equal to zero when one of them is the dependent variable. The lags of the variables, however, are jointly equal to zero when the other variable is the dependent variable.

5. Empirical Results

The first stage involves tests of the order of integration of the variables. This is essential for some of the tests considered. The augmented Dickey-Fuller test (1981) is used and the results presented as Table 1. With the exception of gas, which was found to be I(2) all the other variables of interest were I(1).

Given all, except gas consumption, are I(1), we then test for bivariate cointegration as the second stage using the Johansen (1991) ML method.

Table 1. Unit Root Tests (intercept and linear trend).

Variable	Levels	First Differenc	Critical Values	Lags[a]
lcoal	-2.2	-4.56	-3.54	1
lgas	-2.79	-3.13	-3.54	2
lelec	-1.64	-4.25	-3.54	1
loil	-2.54	-5.64	-3.54	1
ltfc	-3.24	-3.66	-3.54	2
lind	-2.98	-4.77	-3.54	1
lemp	-2.34	-3.59	-3.54	0
lgdp	-2.9	-4.01	-3.54	1

[a] Number of lags in the VAR.

The cointegration test results are presented as Table 2.

For coal (*local),* industrial energy consumption (*lind.*), and total final energy consumption (*ltfc*), the null hypothesis of no bivariate cointegration was not rejected. Thus, although the variables were found to be I(1), they do not cointegrate with employment.

Table 2. Testing for bivariate cointegration between energy disaggregated variables, real GDP and employment, 1960-1999.

Variable	Max. Eigen.	Trace	H_0	H_1	VAR
lcoal	10.5	19.6	r = 0	r = 1	1
	9.1	9.1	r <= 2	r = 2	
lelec	29.6**	32.4**	r = 0	r = 1	2
	2.9	2.86	r <= 2	r = 2	
loil	26.1**	33.1**	r = 0	r = 1	1
	6.9	6.9	r <= 2	r = 2	
ltfc[a]	13.7	20.3	r = 0	r = 1	1
	6.6	6.6	r <= 2	r = 2	
lind[b]	14.4	21.3	r = 0	r = 1	1
	6.9	6.9	r <= 2	r = 2	
lgdp	17.59*	25.8**	r = 0	r = 1	1
	8.25	8.25	r <= 2	r = 2	

Note: Max. eigen denotes maximum eigenvalue statistic; Trace is trace statistic, VAR denotes order of the VAR. ** denotes significance at the 5% level. * denotes significant at the 10% level. [a] *ltfc* is the total final energy consumption level . [b] *lind* denotes industrial energy consumption. All the variables were transformed by taking their logarithms. CV (eigen) and CV (trace) are critical values for the eigenvalues and trace of the stochastic matrix at the 95% significance level.

However, there is a significant cointegrating relationship between electricity *(lelec)* consumption and employment, real GDP *(lgdp)* and employment, and oil *(loil)* consumption and employment.

Because all the variables, except electricity, oil and real GDP are I(1), but not cointegrated, in the next stage we transform the variables to induce stationarity and test for Granger causality.

Table 3. Test of bivariate causality, differenced data, not cointegrated, 1960-1999

Dep.	$\Delta lemp$	$\Delta lcoal$	$\Delta lind$	$\Delta lemp$	$\Delta lemp$	$\Delta ltfc$
Ind.	$\Delta lcoal$	$\Delta lemp$	$\Delta lemp$	$\Delta lind$	$\Delta ltfc$	$\Delta lemp$
k,l		1,2		1,1		1,2
r,s	1,2		3,1		2,2	
LM test	11.05	5.61	4.23	4.76	6.22	7.20
Prob.	(0.05)	(0.35)	(0.38)	(0.09)	(0.29)	(0.21)
LR*	13.28	6.12	4.50	5.10	6.85	8.06
Prob.	(0.021)	(0.30)	(0.34)	(0.08)	(0.23)	(0.15)
F-stat	2.31	0.95	0.93	2.29	1.08	1.30
Prob.	(0.07)	(0.46)	(0.46)	(0.12)	(0.39)	(0.30)
Conc.	$\Delta lcoal \nRightarrow \Delta lemp$	$\Delta lemp \nRightarrow \Delta lcoal$	$\Delta lind \nRightarrow \Delta lemp$	$\Delta lemp \nRightarrow \Delta lind$	$\Delta ltfc \nRightarrow \Delta lemp$	$\Delta ltfc \nRightarrow \Delta lemp$

Note: k, l, r and s are the lags (see section 6). Δ denotes a first difference, $\nRightarrow$ denotes 'not-causal', $\Rightarrow$ denotes 'causal'. Dep. = dependent variable.Ind. = independent variable. LM is Langrange Multiplier test. Prob. = probability. *Likelihood ratio test. F-stat is standard F-statistics.

Table 3 presents results showing statistical independence between gas, coal, industrial energy consumption, total final energy consumption and employment, oil consumption, electricity consumption, real GDP and employment supporting the neutrality hypothesis.

Table 4: Causality test using levels of the I(1) variables, 1960-1999.

Dep.	*lemp*	*lelec*	*loil*	*lemp*	*lemp*	*lgdp*
Ind.	*lelec*	*lemp*	*lemp*	*loil*	*lgdp*	*lemp*
k, l	1,1		1,2	2,2	2,2	
r,s		2,2				2,2
LM test	3.75	8.72	14.32	5.82	8.49	0.48
Prob.	(0.59	(0.03	(0.01)	(0.32)	(0.01)	(0.78)
LR*	3.96	9.97	18.27	6.36	9.68	0.49
Prob.	(0.55	(0.01	(0.00)	(0.27)	(0.00)	(0.79)
F-stat	0.61	2.98	3.43	1.00	4.78	0.23
Prob.	(0.70	(0.04	(0.01)	(0.44)	(0.01)	(0.81)
Conc.	*lemp* $\nRightarrow$ *lelec*	***lelec*** $\Rightarrow$ ***lemp***	***loil*** $\Rightarrow$ ***lemp***	*lemp* $\nRightarrow$ *loil*	***lgdp*** $\Rightarrow$ ***lemp***	*lemp* $\nRightarrow$ *lgdp*

Because electricity, oil consumption and real GDP cointegrate with employment, the causality test can be constructed either in levels or first differences (with an additional one period lag error correction term). Table 4 presents the results when the variables are in levels, while Table 5 presents the results using an error correction model. The results in Table 4 and Table 5 show that there is uni-directional link from electricity, oil consumption and real GDP to employment.

Table 5: Causality test using an ECM term in a first-differenced model.

Dep.	$\Delta lelec$	$\Delta lemp$	$\Delta loil$	$\Delta lemp$	$\Delta lemp$	$\Delta lgdp$
Ind.	$\Delta lemp$	$\Delta lelec$	$\Delta lemp$	$\Delta loil$	$\Delta lgdp$	$\Delta lemp$
k, l	1,1		2,2		1,1	
r, s		3,2		2,1		1,1
ECM	-0.20	-0.02	0.50	0.52	-1.62	0.24
LM test	5.22	0.32	10.15	6.18	9.37	0.09
Prob.	(0.02)	(0.85)	(0.01)	(0.19)	(0.00)	(0.95)
LR*	5.62	0.33	11.82	6.77	10.75	0.09
Prob.	(0.02)	(0.85)	(0.00)	(0.15)	(0.00)	(0.95)
F-stat	5.42	0.14	4.01	1.51	5.56	0.04
Prob.	(0.03)	(0.87)	(0.01)	(0.23)	(0.00)	(0.96)
Conc.	$\boldsymbol{\Delta lelec \Rightarrow \Delta lemp}$	$\Delta lemp. \nRightarrow \Delta lelec$	$\boldsymbol{\Delta loil \Rightarrow \Delta lemp}$	$\Delta lemp \nRightarrow \Delta loil$	$\boldsymbol{\Delta lgdp \Rightarrow \Delta lemp}$	$\Delta lemp \nRightarrow \Delta lgdp$

To consider the robustness of these results across methodologies, we also use the Toda and Yamamoto (1995) approach. The results are presented as Table 6. The causality results there are qualitatively the same.

Table 6. Test of bivariate causality, Toda and Yamamoto approach, 1960-1999

Dep	*lcoal*	*lemp*	*loil*	*lemp*	*lgdp*	*lemp*
Ind.	*lemp*	*lcoal*	*lemp*	*lgdp*	*lemp*	*loil*
m,n	1,1		1,1	1,2		1,1

q,r		2,1			2,2	
LM test	0.81	1.43	3.04	12.83	0.54	1.42
Prob.	(0.37)	(0.23	(0.008)[a]	(0.000)[a]	(0.46)	(0.49)
Conc.	*lcoal* $\nRightarrow$ *lemp*	*lemp* $\nRightarrow$ *lcoal*	***loil*** $\Rightarrow$ ***lemp***	***lgdp*** $\Rightarrow$ ***lemp***	*lemp* $\nRightarrow$ *lgdp*	*lemp* $\nRightarrow$ *loil*

Table 6. cont.

Dep	*lind*	*lemp*	*ltfc*	*lemp*	*lelec*	*lemp*
Ind.	*lemp*	*lind*	*lemp*	*ltfc*	*lemp*	*lelec*
m,n		1,1		1,1		1,2
q,r	1,1		1,2		1,2	
LM test	0.67	0.079	1.55	1.61	0.51	2.92
Prob.	(0.41)	(0.99)	(0.46)	(0.20)	(0.77)	(0.08)**
Conc.	*lind* $\nRightarrow$ *lemp*	*lemp* $\nRightarrow$ *lind*	*ltfc* $\nRightarrow$ *lemp*	*lemp* $\nRightarrow$ *ltfc*	*lemp* $\nRightarrow$ *lelec*	***lelec*** $\Rightarrow$ ***lemp***

Note : m, n, q and r are the number of lags without the extra lag added to each variable. ** denote significant at the 10% level. * denotes significant at the 5% level.

The third method used is the ARDL of Pesaran *et.al.* (1996), which can be used to infer causality. The results are presented as Table 7. As for the previous tests, the results show that oil consumption causes employment and that there is no causality relationship between coal consumption and employment.

Table 7: Inferring directions of causality using ARDL method with ARDL(2,2).

Dep	*lemp*	*loil*	*lemp*	*lelec*	*lcoal*	*lemp*	*lemp*	*lgdp*
Ind.	*loil*	*lemp*	*lelec*	*lemp*	*lemp*	*lcoal*	*lgdp*	*lemp*
F-test	20.48	1.05	1.82	6.00	2.62	2.43	4.90	0.77
Lower	4.9	4.9	4.9	4.9	4.9	4.9	4.0	4.9
(Upper	(5.7)	(5.7)	(5.7)	(5.7)	(5.7)	(5.7)	(4.8)	(5.7)
Conc	***loil*** $\Rightarrow$ ***lemp***	*lemp* $\nRightarrow$ *loil*	*lelec* $\nRightarrow$ *lemp*	***lemp*** $\Rightarrow$ ***lelec***	*lemp* $\nRightarrow$ *lcoal*	*lcoal* $\nRightarrow$ *lemp*	***lgdp*** $\Rightarrow$ ***lemp***	*lemp* $\nRightarrow$ *lgdp*

Note: [a] Denotes lower and upper bound for the critical values in Pesaran (1996). Upper bounds critical values are in brackets. Critical values are at 95% significant level for all the ARDL tests except the critical values for the *lemp-lgdp* test where the critical value is at the 90% significant level.

This latter result on coal may be expected as the level of coal consumption in New Zealand is very low compared to countries like Australia. For electricity the results suggest that there is a long run relationship between electricity consumption and employment, and that employment causes electricity consumption. For the GDP-employment relationship, the results suggest no causality linkages between GDP and employment at the 95% level. However, at the 90% significant level we found that there is causality running from real GDP to employment. Note that when we test for bivariate cointegration between real GDP and employment, we only found bivariate cointegration at the 90% level when using the trace statistics of the stochastic matrix.

6. Discussion

Electricity and oil are the two major energy sources for production in New Zealand. They also have the largest share of fuel used by consumers, making up more than half of consumers total energy use (47% for oil and 27% for electricity). The results presented here show that electricity and oil consumption are both linked to employment uni-directionally. There is also a causal relationship between energy consumption and real GDP. The uni-directional causal relationship between employment and real GDP is consistent with the result for British Columbia (Debenedictis 1997). Debenedictis showed that real GDP in British Columbia and Canada, both uni-directionally Granger causes employment in British Columbia. The results in Debenedictis, however, are for regional economies in British Colombia. These results showed that more labour is demanded following a period of expansion, while less labour is demanded following a period of recession. The results presented here for the causal relation between oil, electricity consumption and employment show that, in a period of expansion, consumption of oil and electricity expand as demand for inputs increase.

7. Conclusions

This paper considers the issue of whether there are causal relationships between energy disaggregated into coal, oil, electricity and gas and employment. In addition, it also analyzes the causal relationship between industrial electricity consumption and total final energy consumption and employment as well as the relationship between real GDP and employment. The results presented in the paper show that both oil consumption and electricity consumption uni-directionally causes employment. Also, it argues that there is a uni-directional relationship between real GDP and employment.

The findings in our study demonstrate that real GDP affects employment directly, as real GDP Granger causes employment, and indirectly through energy consumption, in particular, the consumption of oil and electricity. The consumption of these fuels was found to Granger cause employment without feedback. A policy implication of the findings in this study therefore are that energy conservation will not restrain output growth, and finally a shock to the energy sector, especially if it affects the level of oil and electricity consumption, will affect employment growth but not the reverse. There are also other important factors that may need further study including the impact of energy price changes for example, a shock to oil and electricity prices, on employment. There are of course other factors that may affect employment or unemployment such as real wages, labour productivity etc. These factors may also include monetary policy and the duration of the economic cycles. The causal relationships of these other factors and employment is an interesting topic for further research.

8. Acknowledgements

We wish to thank the New Zealand Public Good Science Fund, grant number UOWX:0010, , for supporting the research.

9. REFERENCES

Akarca, A. and T.V. Long (1979) "Energy and employment: a time series analysis of the causal relationship," *Resources and Energy*, 12, 151-162.

Cheng, B.S. (1998), "Energy Consumption, employment and causality in Japan: a multivariate approach." *Indian Economic Review*, Vol. 33(1): 19-29.

Debenedictis LF. (1997). " A vector autoregressive model of the British Columbia regional economy," *Applied Economics*. 29(7): 877-888.

Dickey, D.A. and Fuller, W.A. (1981). "Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica*, (49): 1057-72..HHH

Energy Efficient and Conservation Authority (EECA) (2001). *National Energy Efficiency and Conservation*, Ministry for the Environment, Wellington, New Zealand.

Engle, R.F., and C.W.J.Granger (1987) "Cointegration and error-correction: representation, estimation, and testing." *Econometrica*, 55: 251-276.

Granger, C.W.J. (1969) "Investigating causal relation by econometric and cross-sectional method," *Econometrica*, 37, 424-438.

Guilkey, David K; Salemi, M. K. (1982). "Small Sample Properties of Three Tests for Granger-Causal Ordering in a Bivariate Stochastic System." *Review of Economics & Statistics*. Vol. 64 (4). p 668-80.

Hsiao, C. (1981), "Autoregressive modeling and money income causality detection". *Oxford Bulletin of Economics and Statistics*, 7: 85-106.

Johansen, S. (1991). "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica*, Vol. 59 (6):1551-80.

Murray, D.A. and G.D. Nan (1992) "The Energy and Employment Relationship: A Clarification". *The Journal of Energy and Development*, 16: 121-130.

Pesaran, M.H., Y.Shin, R.J. Smith, (1996). "Testing for the existence of a long-run relationship," DAE Working Paper No. 9622, Department of Applied Economics, University of Cambridge.

Sims, C.A. (1972). "Money, Income and Causality," *American Economic Review*, 62, 540-552.

Toda, Y.H. and T. Yamamoto (1995). "Statistical Inference in Vector Autoregressions with Possibly Integrated processes." *Journal of Econometrics*, 66, 225-50.

Yu, E.S.H., and J.C. Jin (1992), "Cointegration tests of energy consumption, income, and employment." *Resources and Energy*, 14, 259-66.

Yu, E.S.H., P.C.Y., Chow and J.Y. Choi (1988), "The Relationship between Energy and Employment: A Reexamination." *Energy Systems and Policy*, 9, 540-552.