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The electricity consumption and GDP nexus for the Fiji Islands

Paresh Kumar Narayan [a,*], Baljeet Singh [b]

[a] *Griffith Business School, Gold Coast Campus, Griffith University, Gold Coast, Queensland 9726, Australia*
[b] *School of Economics, The University of the South Pacific, Suva, Fiji Islands*

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Abstract

Fiji is a small open island economy dependent on energy for its growth and development; hence, the relationship between energy consumption and economic growth is crucial for Fiji's development. In this paper, we investigate the nexus between electricity consumption and economic growth for Fiji within a multivariate framework through including the labour force variable. We use the bounds testing approach to cointegration and find that electricity consumption, GDP and labour force are only cointegrated when GDP is the endogenous variable. We use the Granger causality *F*-test and find that in the long-run causality runs from electricity consumption and labour force to GDP, implying that Fiji is an energy dependent country and thus energy conservation policies will have an adverse effect on Fiji's economic growth.
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1. Introduction

The relationship between energy consumption and economic growth has been debated quite extensively in the literature, yet the direction of the causality relationship remains unresolved. The debate has focused on whether energy consumption causes economic growth or economic growth causes energy consumption, or whether a two-way relationship exists. From a policy viewpoint, the direction of causality between these variables has important implications (Narayan and Smyth,

* Corresponding author.
E-mail address: P.Narayan@griffith.edu.au (P. Kumar Narayan).

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Table 1
Growth of real GDP and electricity consumption, 1970–2002

Year	Real GDP growth rate	Electricity consumption growth rate	Electricity consumption growth to GDP growth ratio
1970–1980	4.8599	31.5222	6.4861
1981–1990	2.4534	9.2780	3.7817
1991–2000	2.4117	4.4773	1.8565
2001–2002	2.1837	5.4476	2.4946

Source: Fiji Electricity Annual Reports (various issues), Asian Development Bank Key Statistics and International Monetary Fund Database.

2005a; Asafu-Adjaye, 2000; Ghosh, 2002). For instance, a finding in favour of a positive unidirectional causality running from GDP to electricity consumption is a strong justification for energy conservation policies, such as electricity rationing, for this finding implies that a country is not dependent on energy for growth and development. However, if unidirectional causality runs from electricity consumption to GDP or labour force, then reducing electricity consumption could lead to a fall in income and/or employment. This is because a finding confirming evidence in favour of energy positively causing GDP implies that (1) the country in question is energy dependent, and (2) negative shocks to energy, such as shocks leading to higher energy prices or energy conservation policies, will negatively impact GDP.

Like other developing countries, Fiji requires large volumes of energy for producing goods and services, and as in most non-oil producing countries, its energy demand is met by large quantities of imports. Electricity is a crucial input in the production of goods and services in Fiji. It is a major input component for several sectors, including manufacturing, communication, education, commercial, entertainment, and construction. Table 1 shows the growth of electricity consumption and real GDP for Fiji. The average growth in electricity consumption over 10-year intervals has outpaced the growth in real GDP. Both electricity consumption and real GDP growth have generally shown a downward trend and similarly the electricity consumption growth to GDP growth ratio has also declined over the same period. For instance, over the periods 1970–1980, 1981–1990 and 1991–2000 electricity consumption growth to GDP growth ratio was 6.4, 3.7, and 1.8, respectively.

That the growth in electricity consumption has outperformed the growth in output is not surprising. In fact, following the military coups in 1987, Fiji's economic growth rate has been poor, averaging only around 2% per annum against expectations of a 5% growth rate. The main reason for this poor economic growth performance has been political instability. During the same time, Fiji's population has grown at an annual average of 1%, and around 50% of Fiji's population lived in urban areas in 2000 as opposed to 40% in 1990. Urbanization has increased the demand for electricity consumption.

Yu and Taplin (1997) noted that the Pacific Island countries' extensive dependency on energy for production has important policy implications for their development and growth. Since 1996, the government of Fiji has placed a major emphasis on energy in its development plan. The government through its renewable energy development programme (PEDP) is committed to promoting greater and more efficient utilization of promising local energy resources. Various programmes and projects are undertaken by the department of energy to improve energy supply in Fiji. This includes setting up of various solar programmes, rural electrification programmes, and wind energy conversion systems. More importantly, research has also been undertaken to

discover alternative sources of fuel. In recent parliamentary debates, the government of Fiji announced its plan to diversify the function of the Fiji sugar corporation (FSC) to include electricity generation and biofuel production. However, to fully understand the implications of such policies, it is imperative to understand the relationship between energy consumption and economic growth. The purpose of this paper is to investigate the causal relationship between a particular form of energy consumption, namely, electricity consumption, and economic growth for Fiji. This empirical exercise is important for Fiji because it will allow us to deduce whether or not Fiji is an energy dependent country. On the basis of this knowledge, we will be able to recommend whether energy conservation policies are a viable option for Fiji.

This study uses the bounds testing approach to cointegration and the Granger causality test to examine the relationship between electricity consumption and economic growth. Following Narayan and Smyth (2005a), we use a multivariate cointegration and vector-error correction strategy. A common approach in some studies is to include a capital or energy price or labour input variable in addition to the energy and output variable. Recent studies have included the employment variable (Chang et al., 2001; Fatai et al., in press; Narayan and Smyth, 2005a) or energy prices (Masih and Masih, 1997) or capital and labour inputs (Stern, 1993). Consistent with the availability of time series data for Fiji, we include the labour force variable. From a policy point of view, this study is novel in that it is the first study that models Fiji's electricity demand within a time series framework.

The remainder of the paper is organized as follows. In Section 2, we provide an overview of the energy sector in Fiji. In Section 3, we provide a brief overview of the literature on the nexus between electricity consumption and GDP. In Section 4, we explain the econometric methodologies. In Section 5, we discuss the results, and in the final section we provide some concluding remarks.

2. An overview of energy sector

Like most developing countries, Fiji's energy resources are limited. In other words, Fiji lacks any major conventional energy source such as crude oil, natural gas and coal. Fiji, thus, relies heavily on imported crude product for her industrial energy needs, transportation and electricity generation. The three main sources of energy in Fiji are petroleum product, electricity and coal. About 70% of energy consumption is sourced from imported light and heavy petroleum products, approximately 16% are sourced from electricity, 5% from coal, and primary biomass makes up the rest of the energy consumption. For the period 1979–2000, the average annual growth rates of hard coal, light petroleum product, heavy petroleum product and electricity consumption were −0.2%, 0.5%, 1.2%, 2.24%, respectively. This suggests that electricity consumption has experienced the greatest percentage rise with coal showing a negative average growth over the same period.

Prior to 1983, Fiji relied heavily on diesel generators to produce electricity. This meant that large volumes of imported fuels were used for electricity generation. To reduce dependency on imported fuel and to substitute cheaper renewable energy for costly fuel, the Fiji development plan 8 (DP8) emphasized the need to investigate and utilize promising local renewable energy (Nakavulevu et al., 1999).

In 1983, a major hydroelectricity station was successfully completed which supplied about 90% of the electricity to Viti Levu, the largest island in Fiji. However, some communities in Viti Levu are still dependent on diesel generators. The establishment of the hydropower station contributed positively to greater electricity consumption in Fiji. For the period 1983–2002, per capita kilowatt electricity consumption increased by an annual average of 3.3%.

While hydroelectricity remains the major source of electricity in Fiji, the rest of the electricity needs is being met by the diesel generators, solar energy systems, wind conversion systems and thermal generators. Solar energy is regarded as one of the potential sources of energy for Fiji, not only because sunshine is available in abundance, but also because it is environmentally friendly and can be provided cheaply. Since 1993, with assistance from government and foreign aid donors, several 23PV projects were successfully implemented. Solar energy system can easily be used for providing residential electricity, refrigeration, and maintaining rural water system.

Currently, wind technology is operated on a very small scale in Fiji. However, future plans are to set up a major wind conversion system in the western part of Fiji. Wind energy conversion system can also become a major source of energy for Fiji, as it is environmentally friendly and can be obtained at low cost.

Diesel generators continue to provide a significant amount of electricity in urban as well as rural areas. It is one of the most expensive means of generating electricity. The cost of operating and maintaining diesel generators further increased with recent hikes in fuel prices. Plans are under way to gradually substitute other means of electricity generation for diesel generators. It is not only costly to the Fiji electricity authority and individual operators, but it also has a negative impact on the balance of trade and foreign reserves.

Since 1996, numerous research and assessments have been undertaken by the Department of Energy to identify and exploit potential renewable energy sources. Greater utilization of the renewable energy is likely to further reduce dependency on imported fuel. This, apart from enhancing the security of Fiji's energy supply, would also ensure that Fiji would be less prone to hikes in fuel prices.

3. An overview of the related literature

The causality relationship between electricity consumption and economic growth has important policy implications, as explained earlier. Hence, several studies have attempted to establish the relationship between electricity consumption and economic growth. A general observation from these studies is that the results have been mixed: that is, while some studies find causality running from economic growth to electricity consumption, others find causality running from electricity consumption to economic growth. The purpose of this section is to provide a brief overview of the findings of studies that model the nexus between electricity consumption and economic growth.

In a recent study, Narayan and Smyth (2005a) examined the relationship between electricity consumption, employment and real income for Australia using multivariate Granger causality tests for the period 1966 to 1999. They found a unidirectional causality running from GDP to electricity consumption, and from GDP to employment. They found that in the long run, electricity consumption Granger caused GDP and GDP Granger caused electricity consumption, and in the short run only electricity consumption Granger caused GDP. Similarly, Jumbe (2004) examined the relationship between electricity consumption and economic growth for Malawi for the period 1970–1999. His finding showed a two-way causal relationship between electricity consumption and economic growth. Lam and Shiu (2004) examined the causal relationship between electricity consumption and economic growth for China. They also found evidence of unidirectional Granger causality running from electricity consumption to economic growth. Glasure and Lee (1997) examined the relationship between GDP and electricity consumption for Korea and Singapore for the period 1961–1990. They found evidence of unidirectional causality running from electricity consumption to GDP for Singapore; but no evidence of causality was found in the case of Korea. In a recent study for Turkey for the period 1950–2000, Altinay and Karagol (2005) found evidence of unidirectional Granger causality running from electricity consumption to income. On the other hand,

Ghosh (2002) examined the causality relationship between electricity consumption and economic growth for India for the period 1950–1997. He found evidence of unidirectional Granger causality running from economic growth to electricity consumption.

Huang (1993) examined the electricity–economic growth nexus for China for the period 1950–1980. He did not test for any causal relationships, but examined the correlation among the variables, and found the income elasticity of electricity consumption to be greater than unity. A similar study was conducted by Holtedahl and Joutz (2004) for Taiwan for the period 1955–1996. They found the income elasticity of electricity demand to be unity in the long run, while the relative price of electricity (to petroleum products) elasticity was inelastic. On another study on Taiwan, where tests for causation were conducted, Yang (2000) found bi-directional causality between GDP and electricity consumption.

Morimoto and Hope (2004) examined the relationship between electricity consumption and economic growth for Sri Lanka for the period 1960–1998. Using ordinary least squares regression models, they found that current and past changes in electricity supply had a positive impact on changes in GDP. Hondroyiannis (2004) examined the demand for residential electricity for Greece for the period 1960–1998. He found the income elasticity to be greater than unity, while the price response was inelastic in the long run.

Moreover, Wolde-Rufael (2006) examined the causal relationship between energy consumption and economic growth for 17 African countries for the period 1971–2001. He found evidence of causality for 12 countries and no causality for the remaining 5 countries. In the case of Cameroon, Ghana, Nigeria, Senegal, Zimbabwe he found evidence of positive unidirectional causality running from economic growth to electricity consumption. In the case of Benin, the Democratic Republic of Congo and Tunisia, there was unidirectional causality running from electricity consumption to economic growth, while in case of Egypt, Gabon and Morocco, there was bidirectional causality between the two variables. In a similarly motivated study, Yoo (in press) examined the causal relationship between electricity consumption and economic growth in the ASEAN countries for the period 1971–2002. In the case of Malaysia and Singapore, he found bidirectional causality between electricity consumption and economic growth. For Indonesia and Thailand, he found unidirectional causality running from electricity consumption to economic growth.

4. Methodology

4.1. Cointegration

To search for possible long run relationships amongst the variables, namely GDP, electricity consumption and labour force, we employ the bounds testing approach to cointegration suggested by Pesaran et al. (2001). This involves estimating the following unrestricted error correction model (UECM):

$$\Delta \ln Y_t = a_{oY} + \sum_{i=1}^{n} b_{iY}\Delta \ln Y_{t-i} + \sum_{i=1}^{n} c_{iY}\Delta \ln E_{t-i} + \sum_{i=1}^{n} d_{iY}\Delta \ln L_{t-i} + \sigma_{1Y}\ln Y_{t-1} + \sigma_{2Y}\ln E_{t-1} + \sigma_{3Y}\ln L_{t-1} + \varepsilon_{1t} \quad (1)$$

$$\Delta \ln E_t = a_{oE} + \sum_{i=1}^{n} b_{iE}\Delta \ln E_{t-i} + \sum_{i=1}^{n} c_{iE}\Delta \ln Y_{t-i} + \sum_{i=1}^{n} d_{iE}\Delta \ln L_{t-i} + \varpi_{1E}\ln E_{t-1} + \varpi_{2E}\ln Y_{t-1} + \varpi_{3E}\ln L_{t-1} + \varepsilon_{1t} \quad (2)$$

$$\Delta \ln L_t = a_{oL} + \sum_{i=1}^{n} b_{iL}\Delta \ln L_{t-i} + \sum_{i=1}^{n} c_{iL}\Delta \ln Y_{t-i} + \sum_{i=1}^{n} d_{iL}\Delta \ln E_{t-i} + \theta_{1L}\ln L_{t-1} + \theta_{2L}\ln Y_{t-1} + \theta_{3L}\ln E_{t-1} + \varepsilon_{1t} \quad (3)$$

Here Δ is the first difference operator, ln Y is the natural log of real GDP, ln$E$ is the natural log of real electricity consumption, and ln L is the natural log of labour force. The F test is used to determine whether a long-run relationship exists between the variables through testing the significance of the lagged levels of the variables. When a long-run relationship exists between the variables, the F test indicates which variable should be normalised.

The null hypothesis of no cointegration amongst the variables in Eq. (1) is (H_0: $\sigma_{1Y}=\sigma_{2Y}=\sigma_{3Y}=0$) against the alternative hypothesis (H_1: $\sigma_{1Y}\neq\sigma_{2Y}\neq\sigma_{3Y}\neq 0$). This is denoted as $F_E(Y|E,L)$. In Eq. (2), where energy consumption is the dependent variable, the null hypothesis for no cointegration is (H_0: $\varpi_{1E}=\varpi_{2E}=\varpi_{3E}=0$) against the alternative ($H_1=\varpi_{1E}\neq\varpi_{2E}\neq\varpi_{3E}\neq 0$). This is denoted as $F_E(E|Y,L)$. In Eq. (3), where labour force is the dependent variable, the null hypothesis for no cointegration is (H_0: $\theta_{1L}=\theta_{2L}=\theta_{3L}=0$) against the alternative (H_0: $\theta_{1L}\neq\theta_{2L}\neq\theta_{3L}\neq 0$). This is denoted as $F_L(L|Y,E)$.

The F test has a non-standard distribution which depends upon (i) whether variables included in the ARDL model are $I(0)$ or $I(1)$, (ii) the number of regressors, (iii) whether the ARDL model contains an intercept and/or a trend, and (iv) the sample size. Two sets of critical values (CVs) are reported in Narayan (2005) for sample sizes ranging from 30 observations to 80 observations. Given the relatively small sample size in the present study (32 observations), we extract appropriate CVs from Narayan (2005).

4.2. Granger causality

If we do not find any evidence for cointegration among the variables then the specification of the Granger causality test will be a vector autoregression (VAR) in first difference form. However, if we find evidence for cointegration then we need to augment the Granger-type causality test model with a one period lagged error correction term. This is an important step because Engel and Granger (1987) caution that if the series are integrated of order one, in the presence of cointegration VAR estimation in first differences will be misleading.

$$\Delta \ln Y_t = \upsilon + \sum_{i=1}^{p} \vartheta_i \Delta \ln Y_{t-i} + \sum_{i=1}^{p} \kappa_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} \phi_i \Delta \ln L_{t-i} + \pi_1 \mathrm{ECT}_{t-1} + \varepsilon_{1t} \quad (4)$$

$$\Delta \ln E_t = \upsilon + \sum_{i=1}^{p} \kappa_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} \vartheta_i \Delta \ln L_{t-i} + \sum_{i=1}^{p} \phi_i \Delta \ln Y_{t-1} + \pi_2 \mathrm{ECT}_{t-1} + \varepsilon_{2t} \quad (5)$$

$$\Delta \ln L_t = \upsilon + \sum_{i=1}^{p} \phi_i \Delta \ln L_{t-i} + \sum_{i=1}^{p} \vartheta_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} \kappa_i \Delta \ln Y_{t-i} + \pi_3 \mathrm{ECT}_{t-1} + \varepsilon_{3t} \quad (6)$$

In addition to the variables defined above, ECT_{t-1} is the lagged error-correction term derived from the long-run cointegrating relationship and ε_{1t}, ε_{2t} and ε_{3t} are serially independent random errors with mean zero and finite covariance matrix. In each case, the dependent variable is regressed against past values of itself and past values of other variables. The optimal lag length p in Eqs. (4)–(6) are selected using the Schwarz Bayesian Criterion. Letting $M_1=(\kappa_1=\ldots=\kappa_p)$, $M_2=(\vartheta 1=\ldots=\vartheta_p)$ and $M_3=(\phi_1=\ldots=\phi_p)$. The causality test is carried out by generating χ^2

statistics to establish whether the null hypotheses can be accepted or rejected. For Eq. (4) this amounts to H_0: $M_1=0$ and $M_3=0$; for Eq. (5) it is H_0: $M_2=0$ and $M_3=0$; and for Eq. (6) it is H_0: $M_1=0$ and $M_2=0$.

5. Empirical results

5.1. Data and unit root test

The three variables used in this study, namely, real GDP, electricity consumption and labour force contain annual observations for the period 1971–2002. All data were obtained from the *Asian Development Bank Key Statistics*, The Fiji Electricity Authority annual reports, the Department of Energy Statistics and the *Current Economic Statistics* published by the Fiji Bureau of Statistics. Our first aim is to investigate the unit root properties of the data series. It is true that knowledge on the integrational properties is not required for the application of the bounds test; however, it is a crucial step in ensuring that we obtain an unbiased estimation from the Granger causality tests. To obtain the integrational properties of the data series, we apply the ADF test, which tests the null hypothesis of nonstationarity. We find that the ADF test statistics for log levels of real GDP, electricity consumption and labour force exceed the 5% level critical value. The computed ADF test statistics for the natural logarithm of real GDP, electricity consumption and labour force are −1.88, −2.49 and −2.48, respectively, while the 5% level critical value is −2.96. However, when we subject the first difference of these variables to the ADF test, we find test statistics smaller than the 5% level critical value. The computed ADF test statistics for the first difference of the log of the real GDP, electricity consumption and labour force are −7.34, −5.87 and −6.98, respectively, leading us to conclude that $[Y_t, E_t, L_t]$ are integrated of order one or $I(1)$.

5.2. Cointegration

Our next aim is to investigate whether or not real GDP, electricity consumption and labour force share common long-run relationship(s). To achieve this, as explained earlier, we test for the presence of long-run relationships in Eqs. (1)–(3). Before we proceed to calculating the F-test statistic, an important step is to establish the optimal lag length to be used in the cointegration analysis. Using the Schwarz Bayesian Criterion, we find that 2 lags are the optimal for this exercise. We find that there is a long-run relationship amongst the variables when Y is the dependent variable because its F-statistic, which turns out to be 10.10, is higher than the upper bound critical value of 9.41 at the 1% level of significance. This implies that the null hypothesis of no cointegration among the variables in Eq. (1) cannot be accepted, while for Eqs. (2) and (3), the null hypothesis is accepted.

Table 2
Long-run elasticities

	Constant	ln E_t	ln L_t
OLS	−3.742[a] (−5.836)	0.100[a] (7.875)	0.822[a] (11.185)
FMOLS	−4.8998[a] (−8.4217)	0.085626[a] (7.9908)	0.94854[a] (14.6021)
ARDL	−4.7232[a] (−5.4069)	0.0714[a] (3.7140)	0.96020[a] (9.43521)

[a] Denotes statistical significance at the 1% level.

Table 3
Results of Granger causality test

F-tests $\chi^2(2)$				
Dependent variable	$\Delta \ln Y_t$	$\Delta \ln E_t$	$\Delta \ln L_t$	ECT_{t-1} [t-statistics]
$\Delta \ln Y_t$	–	0.02161 (+) [0.88415]	2.8194 (+) [0.10387]	−0.64041*** [0.0000]
$\Delta \ln E_t$	0.7861 (+) [0.38259]	–	0.61092 (+) [0.44077]	–
$\Delta \ln L_t$	5.4569** (+) [0.02661]	0.63220 (+) [0.43301]	–	–

*** (*) denote statistical significance at the 1% and 10% levels, respectively. The probability values are in square brackets while the estimated signs are in parenthesis.

5.3. Long-run elasticities

Having found a long-run relationship between real GDP, electricity consumption and labour force when GDP is the dependent variable, in this section, we estimate the long-run elasticities. In other words, we investigate the impact of electricity consumption and labour force on GDP for Fiji. To achieve this aim, we use three different estimators, namely, the ordinary least squares (OLS), the fully modified OLS[1], and the autoregressive distributed lag model (ARDL).[2] The use of more than one estimator allows us to gauge the robustness of the results. The results are reported in Table 2. We find fairly robust results on the impact of electricity consumption and labour force on GDP. For instance, all estimators reveal that electricity consumption has a positive impact on GDP for Fiji; this result is statistically significant at the 5% level according to all the three estimators. Although the magnitude of the impact seems to be fairly small, ranging from 0.07 to 0.1, implying that a 1% increase in electricity consumption leads to between 0.07% and 0.1% increase in GDP. On the relationship between labour force and GDP, the result is statistically significant at the 1% level across all the three estimators. The results imply that a 1% increase in labour force leads to a 0.8–1.0% increase in GDP.

5.4. Granger causality

The existence of a cointegrating relationship among GDP, electricity consumption and labour force suggests that there must be Granger causality in at least one direction, but it does not indicate the direction of temporal causality between the variables. We examine both short-run and long-run Granger causality in this section. The short-run causal effects can be obtained by the F-test of the lagged explanatory variables, while the t-statistics on the coefficient of the lagged error-correction term in Eq. (4) indicates the significance of the long-run causal effect.

Beginning with the short-run effects, both labour force and electricity consumption are insignificant at the 5% level in the income equation (Table 3)). This implies that both labour force and electricity consumption do not Granger cause GDP in the short run. In the electricity consumption equation, both GDP and labour force are statistically insignificant, implying GDP

[1] The fully modified OLS technique was developed by Phillips and Hansen (1990). It has two advantages, as highlighted by Narayan and Narayan (2005). First, it corrects for endogeneity and serial correlation effects. Second, it asymptotically eliminates the sample bias. There are two conditions considered essential for the appropriateness of the FMOLS. First, there is only one integrating vector. Second the explanatory variables are not cointegrated among themselves.

[2] The ARDL model is estimated through including several lags of the dependent and independent variables. To obtain the optimal lag length, a lag selection criterion, such as the Schwarz Bayesian Criterion, can be employed. For some empirical applications and details on this methodology, see Narayan and Narayan (2004), and Narayan and Smyth (2004, 2005a,b, 2006).

and labour force do not Granger cause electricity consumption in the short run. In the labour force equation, while GDP is statistically significant, electricity is insignificant at the 5% level. This implies that while there is neutrality between electricity consumption and labour force, there is unidirectional causality running from GDP to labour force.

Turning to the long-run results, the coefficient on the lagged error correction term is significant with the correct sign in the GDP equation at the 1% level, which confirms the results from the bounds test for cointegration. The coefficient on the lagged error correction term measures the speed of adjustment to obtain equilibrium in the event of shock(s) to the system. The result suggests that changes in GDP are a function of disequilibrium in the cointegrating relationship. That the lagged error correction term is negative and significant implies that the series is non-explosive and that long-run equilibrium is attainable. Because the ECT_{t-1} measures the speed at which the endogenous variable adjusts to changes in the explanatory variables before converging to its equilibrium level, the coefficient of −0.64 suggests that convergence to equilibrium after a shock to real GDP in Fiji takes slightly over one and half years. Thus, in the long run both electricity consumption and labour force Granger cause GDP, meaning that causality runs interactively through the error correction term from electricity consumption and labour force to GDP.

6. Conclusion and policy implication

The goal of this paper was to model the relationship between economic growth and electricity consumption for Fiji. We achieved this goal by undertaking a multivariate modeling strategy through including labour force in the analysis. Our main findings were as follows. First, we found that there was one cointegration relationship among the variables when GDP was the endogenous variable. Second, to cover for the robustness of our findings, by using three long-run estimators, namely, the OLS, the FMOLS, and the ARDL estimators, we found that both electricity consumption and labour force had a positive and statistically significant impact on Fiji's GDP. Third, we investigated the direction of causation among the variables using the Granger causality testing procedure and found unidirectional causality running from electricity consumption to GDP in the long run and a bidirectional causality running from GDP to labour force in the short run.

Our findings lead to the following policy implication. In the long run electricity consumption and labour force positively Granger cause economic growth, suggesting that Fiji is an energy dependent country. This implies that energy conservation policies, such as rationing electricity consumption, are likely to have an adverse effect on economic growth. The energy growth policies regarding electricity consumption should be adapted in such a way that the development of this sector stimulates economic growth. The department of energy should continue to investigate and exploit the possibilities of renewable energy for electricity generation as this will, apart from reducing Fiji's reliance on imported fuels, stimulate Fiji's economic growth through, among others, curbing current account deficits. On the demand side, consumers should be made aware of the importance of efficient use of electricity, particularly given our finding that electricity consumption positively contributes to economic growth in Fiji.

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References

Altinay, G., Karagol, E., 2005. Electricity consumption and economic growth: evidence from Turkey. Energy Economics 27, 849–856.

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.

Chang, T., Fang, W., Wen, L.F., 2001. Energy consumption, employment, output and temporal causality: evidence from Taiwan based cointegration and error correction modeling techniques. Applied Economics 33, 1045–1056.

Engel, R.F., Granger, C.W.J., 1987. Cointegration and error correction representation, estimation and testing. Econometrica 55, 251–276.

Fatai, K., Oxley, L., Scrimgeour, F., in press. Energy consumption and employment in New Zealand: searching for causality.

Ghosh, S., 2002. Electricity consumption and economic growth in India. Energy Policy 30, 125–129.

Glasure, Y.U., Lee, A.R., 1997. Cointegration, error-correction, and the relationship between GDP and electricity: the case of South Korea and Singapore. Resource and Energy Economics 20, 17–25.

Holtedahl, P., Joutz, F.L., 2004. Residential electricity demand in Taiwan. Energy Economics 26, 201–224.

Hondroyiannis, G., 2004. Estimating residential demand for electricity in Greece. Energy Economics 26, 319–334.

Huang, J.-P., 1993. Electricity consumption and economic growth: a case study of China. Energy Policy 21, 717–720.

Jumbe, C.B.L., 2004. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Economics 26, 61–68.

Lam, P., Shiu, A., 2004. Electricity consumption and economic growth in China. Energy Policy 32, 47–54.

Masih, A.M.M., Masih, R., 1997. On the temporal causal relationship between energy consumption, real income prices: some new evidence from Asian NICs based on amultivariate cointegration/vector error correction approach. Journal of Policy Modeling 19, 417–440.

Morimoto, R., Hope, C., 2004. The impact of electricity supply on economic growth in Sri Lanka. Energy Economics 26, 77–85.

Nakavulevu, P., Narayan, P., Seru, N.D., 1999. Fiji Department of Energy Renewable Energy Development Programme. The South Pacific Journal of Natural Sciences 17, 11–15.

Narayan, P.K., 2005. The saving and investment nexus for China: evidence from cointegration tests. Applied Economics 37, 1979–1990.

Narayan, P.K., Narayan, S., 2004. The *J*-curve: evidence from Fiji. International Review of Applied Economics 18, 369–380.

Narayan, P.K., Narayan, S., 2005. Estimating income and price elasticities of imports for Fiji in a cointegration framework. Economic Modelling 22, 423–438.

Narayan, P.K., Smyth, R., 2004. Trade liberalisation and economic growth in Fiji: an empirical assessment using the bounds testing approach. Journal of the Asia Pacific Economy 10, 96–115.

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

Narayan, P.K., Smyth, R., 2005b. Temporal causality and the dynamics of democracy, emigration and real income in Fiji. International Review of Applied Economics 19, 245–263.

Narayan, P.K., Smyth, R., 2006. What determines migration flows from low income to high income countries? An empirical investigation of Fiji–US migration 1972–2001. Contemporary Economic Policy 24, 332–342.

Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics 16, 289–326.

Phillips, P.C.B., Hansen, B.E., 1990. Statistical inference in instrumental variable regression with I(1) processes. Review of Economic Studies 57, 99–125.

Stern, D.I., 1993. Energy growth in the USA: a multivariate approach. Energy Economics 15, 137–150.

Wolde-Rufael, Y., 2006. Electricity consumption and economic growth: a time series experience for 17 African countries. Energy Policy 34, 1106–1114.

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

Yoo, S.H., in press. The causal relationship between electricity consumption and economic growth in the ASEAN countries, Energy Policy.

Yu, X., Taplin, R., 1997. A survey: international aid for renewable energy in the Pacific Islands since the 1970s. Energy Policy 25, 501–516.