



ENERGY CONSUMPTION AND ECONOMIC GROWTH FOR SMALL ISLAND DEVELOPING STATES: A PANEL ARDL APPROACH



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ABSTRACT

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Global warming has been internationally debated and significant importance has been laid on the link between energy conservation policies and economic growth. Studies on the energy consumption-growth nexus has been widely discussed but such studies has not reached a consensus. In addition to that this topic has not been widely investigated for the case of small island developing states (SIDS). The present study aim at investigating the link between energy consumption and Economic growth for a panel of SIDS over the period 1990-2016. The panel autoregressive distributed lag (PARDL) has been considered for this purpose. The study finds that in both the long run and short run, there is a direct link between energy consumption and economic growth. Moreover, CO₂ emissions, foreign investment and trade openness are seen to be determinants of economic growth in the long run. From this investigation, it can be concluded that energy conservation policies would not benefit the economies in terms of economic growth. However, to attain sustainable development, low carbon alternatives should in used. For instance, the economies could adopt renewable energy policies.

Contribution/Originality: This study contributes to the existing literature of energy consumption-growth nexus for small island developing states. It uses new estimation methodology namely the Panel Autoregressive distributed lag model. The paper's primary contribution is finding that in both the long run and short run, there is a direct link between energy consumption and economic growth.

1. INTRODUCTION

Financial economists have been putting a lot of emphasis on the link between energy consumption, energy prices and economic growth. However, mainstream economists rather lay importance on land, labour and capital as the main factors influencing economic growth. The concept of energy use and economic growth is not thoroughly investigated for small island developing states.

SIDS countries are considered as ecologically vulnerable. These countries are small and do have certain economic disadvantages mainly in the form of limited natural resources and overdependence on a small number of goods and services for exports, high import dependence, limited local markets, and restricted ability to attain economies of scale. Also, SIDS are highly dependent on energy and hence most of their export earnings are used to

finance energy expenditure.¹ Referring to CO₂ emission, its average value in SIDS is 4.7 mega tons (Mt). There are 6 small island developing states which are categorized as high-income and upper-middle-income small islands which produces more than 5 Mt CO₂. Trinidad and Tobago produces nearly 50 Mt of CO₂ and thus represent the island which is the most polluting in the SIDS group. Together, the SIDS account for below 1 percent of global GHG emissions. However, these islands are highly affected by global climate change (SIDS Factsheet, 2013)².

Analysing the literature, it is noted that there are mixed evidences on the link between energy consumption and economic development. For instance, *Apergis and Payne (2012)* investigated the case of 80 countries over the period 1990-2007, reported a two way causality between the renewable energy and economic growth and similar results are obtained for the non-renewable energy and economic growth. However, the study by *Chiou-Wei et al. (2008)* revealed no link between these variables. On the other hand concentrating on firms' productivity, *Aldieri and Vinci (2017)* investigation reveal that there is a statistically negative influence of spatially distributed environmental spillovers on firms' productivity while *Aldieri et al. (2018)* concluded that environmental spillovers have an inverse influence by endorsing the prevalence of the displacement effect. Studies on the impact of energy use on economic growth focus more on industrialized countries and emerging economies and less on SIDS. More so, a unified framework incorporating both energy use and carbon emission is rarely found in existing studies. In terms of techniques, no studies have been found on this topic which uses the panel autoregressive lag model.

Hence, this study aims at examining the possible linkages between energy consumption and economic growths for selected small island developing states. The causal link between CO₂ emissions and economic growth is as well discussed. The methodological approach used is the Panel autoregressive distributed lag (ARDL) to cointegration as proposed by *Pesaran et al. (1999)*.

2. ECONOMETRIC MODELING

The study aims at investigating the relationship between energy consumption and economic growth in selected Small Island Developing States³ over the period 1990 to 2016⁴. Following the standard literature such as *Levine and Zervos (1998)* and *Barro (1991)* the following econometric model is being used;

$$Y = f(ENER, CO_2, HC, OPEN, FDI)$$

The natural logarithm of the variables have been used in order to reduce the problem of heteroskedascity. This technique also make interpretation of the results easier and more meaningful. This result in the following:

$$\ln Y_{i,t} = \beta_0 + \beta_1 \ln ENER_{i,t} + \beta_2 \ln CO_{2i,t} + \beta_3 \ln FDI_{i,t} + \beta_4 \ln HC_{i,t} + \beta_5 \ln OPEN_{i,t} + \varepsilon_{i,t}$$

Where *i* represent country, *t* represents time; ε is the random error term.

The parameter estimates are $\beta_1 \dots \beta_5$ and the random disturbance term is ε_{it} . Data has been obtained from the World Development database. *Table 1* shows the variables used in the study, with definition and sources.

¹ <http://www.sids2014.org/index.php?menu=1579>

² <http://unohrlls.org/custom-content/uploads/2013/09/Small-Island-Developing-States-Factsheet-2013-.pdf>

³ Refer to *Table 3* in Appendix

⁴ Based on data availability for SIDS

Table-1. Variables definition and sources.

Variables	Definition	Related Literature	Sources
Y	GDP per capita	Han and Lee (2013); Tiwari (2011)	WDI
ENER	Primary Energy consumption	Gozgor <i>et al.</i> (2018)	WDI
CO2	CO2 emission per capita	Han and Lee (2013), Tiwari (2011)	WDI
HC	Human Capital	Boopen and Vinesh (2011)	UNESCO
OPEN	Trade openness	Akin (2014)	WDI
FDI	Foreign Investment	Sukar <i>et al.</i> (2011)	WDI

Source: Author's Computation.

As discussed above, the Panel autoregressive distributed lag (PARDL) approach to cointegration has been used. This methodology is selected mainly based on various of its attributes. To start with, the ARDL models gives better estimates of the long run coefficients as well as unbiased estimates and valid t-statistics even when some of the regressors are endogenous (Pesaran *et al.*, 2001; Harris and Sollis, 2003).

Thus, this paper aim at examining the link between energy consumption and economic growth in both the short-run and long-run. Hence, the MG (Mean Group) and PMG (Pooled Mean Group) estimations are used for investigation purposes. Finally, Hausman Test is being done to decide whether the MG or PMG estimators will be used.

2.1. Mean Group (MG) Estimator⁵

Pesaran and Smith (1995) first discussed about the mean group estimator. They argued on the estimation of separate regressions for individual country in the sample and to calculate the coefficients as unweight means of the estimated coefficients for each countries. By so doing, there is no imposition of any sort of restrictions. Thus all the coefficients are allowed to vary and be heterogeneous in the long-run and short-run. For the individual countries, the long run estimates are obtained from the MG framework for individual countries.

The ARDL is as following:

$$Y_{it} = \alpha_i + \gamma_1 Y_{i,t-1} + u_{it}$$

for country i , where $i= 1,2,\dots, N$.

The long-run parameter θ_i for the country i is:

$$\theta_i = \frac{\beta_i}{1 - \gamma_i}$$

While for the whole panel the MG estimators will be given by:

$$\hat{\theta} = \frac{1}{N} \sum_{i=1}^N \theta_i \quad \hat{\alpha} = \frac{1}{N} \sum_{i=1}^N \alpha_i$$

2.2. Pooled Mean Group (PMG) Model

Also we have the pooled mean group (PMG) estimators. Here, the short-run coefficients, the intercepts, the speed of adjustment to the long-run equilibrium as well as the error variances are allowed to be heterogeneous by country. However, the long-run slope values are limited to be homogeneous across countries.

The unrestricted specification for the ARDL system of equations for different consecutive time periods and for a number of countries for the dependent variable Y is:

⁵ & 4: Adapted from "Panel ARDL Using E-Views 9 ~ Meo School of Research"

$$Y_{it} = \sum_{j=1}^p \lambda_{ij} Y_{i,t-j} + \sum_{j=1}^q \gamma_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it}$$

Where $X_{i,t-j}$ the (k x 1) is vector of explanatory variables for group i and μ_i represents fixed effect.

It can be written as a VECM system:

$$\Delta y_{it} = \theta_i (y_{i,t-1} - \beta' X_{i,t-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \gamma'_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it}$$

Where β_i are the long-run parameters and θ_i are the equilibrium or error-correction parameters.

The PMG restriction is that the elements of β are common across countries:

$$\Delta y_{it} = \theta_i (y_{i,t-1} - \beta' X_{i,t-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \gamma'_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it}$$

All the dynamics and the ECM terms are free to vary in PMG.

2.3. Error Correction Term

The error correction term reflects the speed of adjustment which help to reestablish equilibrium in the dynamic model. This term gives an indication on how rapidly variables meet the equilibrium. The condition is that this coefficient should be negative and statically significant (Banerjee *et al.*, 1998).

2.4. The Hausman Test

The hausman test allows us to determine whether the MG or PMG estimates should be used. In the case where the parameters are homogenous, then it imply that the the most efficient estimates are the PMG rather than the MG. Hence, the efficient estimator under the null hypothesis, is the PMG estimates. In this investigation, the hausman test shows that the PMG should be adopted as p value is greater than 5%.

Hence only the PMG results are shown in the next section and the results are discussed. Also, it was found that the some variables are stationary at level and some variables are stationary at first difference and non at second difference. Hence, the PARDL framework can be used in this study.

3. ANALYSIS AND DISCUSSION

3.1. Long Run Estimates

Analysing the long run estimates of the regression, the results shows that the energy coefficient is positive (+0.1771) and significant. Hence, it implies that for every 1% increase in energy use, output increases by 0.1771%. It can therefore be argued that energy consumption induce economic growth in the selected small island developing states under this study. This finding is in line with the growth hypothesis which suggest that the consumption of energy consumption is very important and it influences economic growth. Also, it is a counterpart to the inputs of factors of production namely capital and labour. Hence, an increase in energy consumption causes an increase in real GDP. Therefore, it can be concluded that the economies considered in this study are 'energy dependent' and energy conservation policies may be applied with care as these can have adverse effects on real GDP. However, as highlighted by Costantini and Martini (2010) if the economies uses more efficient energy sources and less polluting preferences, then it can stimulate growth rather than creating an obstacle to it.

Table-2. PMG estimates (Dependent variable: LnY)

LONG RUN RESULTS	Variable	PMG	Significance
		LnENER	0.1771
	LnCO ₂	0.5553	0.0000
	LnHC	-0.1658	0.0463
	Ln OPEN	0.1358	0.0339
	Ln FDI	0.1385	0.000
SHORT RUN RESULTS	ECT	-0.1351	0.000
	D(LnENER)	0.0309	0.0334
	D(LnCO ₂)	-0.0055	0.8457
	D(LnHC)	0.0857	0.0712
	D(LnOPEN)	-0.0468	0.1810
	D(LnFDI)	-0.0075	0.0096
	Constant	1.1623	0.0000
	No. Countries	20	
	Hausman test	0.312	
	Prob> chi 2	P>5% - PMG Chosen	

Note: D is first difference operator; PMG means pooled mean group; ECT is error correction term. Dependent variable: Economic growth (LnY) Independent variable:

Further analysing the results, it can be observed that pollutant emissions increases growth in the long run, suggesting that an increase in CO₂ emissions leads to economic prosperity. Similar results were obtained for the case of [Lim et al. \(2014\)](#) for Philippines, where CO₂ emissions were seen to boost economic growth. For instance, [Munasinghe \(2008\)](#) is of the view that less developed countries end up being more polluted whereby CO₂ emissions are high and this is the result of their poor knowledge and lack of technology when increasing their economic development. [Munasinghe \(2008\)](#) claims that green growth will be achieved by implementing the 'sustainomics' theory together with international collaboration. The results obtained from the present study are in line with [Munasinghe \(2008\)](#) since SIDS are form part of the less developed countries, enlightening the direct link between CO₂ and GDP. The findings of [Munasinghe \(2008\)](#) also declares that if high income countries would help the low income countries through the transfer of clean technologies, funding and advices on sustainable development policies; then these least developed countries would take advantage from industrialisation and at the same time minimise environmental degradation. In contrast, [Holtz-Eakin and Selden \(1995\)](#) reported that in the long run, less CO₂ emissions will increase GDP per capita.

Moreover, it is further detected from the results that economic growth is dependent on foreign investment. For instance an increase in foreign investment boost economic growth by 0.14%. This result is similar to [Sukar et al. \(2011\)](#). For instance, as summarized by [Hermes and Lensink \(2003\)](#) FDI bring several positive externalities to the host country through various channels. The study quoted the competition channel whereby more competition leads to more productivity, boost efficiency and investment in human and physical capital. There is also the training channel whereby FDI train labour resulting in knowledge spillover. Technological spillovers also take place as FDI come with advanced technology. There is as well the linkages channel as well as the demonstration channel where domestic firms imitate the more advanced technologies used by foreign firms. Zooming on the results, it is observed that trade openness also cause economic growth. As argued by [Silajdzic and Mehic \(2018\)](#) trade openness can lead to a better resource allocation through mean of economies of scale and scope and also through more competition. Moreover, it enables knowledge diffusion and technology transfer which results in productivity patterns that boost technological progress and result in more efficiency. In addition to the ARDL results, there is also short run estimates which are reported. Given that the variables are cointegrated provides evidence that the ECM representation can be used in order to investigate the short run dynamics. Estimation results are presented in [Table 2](#) above. It is observed that even in the short run the energy variable is positive and significant. Hence, energy consumption do increase economic growth in both the short run and long run. Moreover, human capital is as well seen to be a determinant of economic growth in the short run.

4. CONCLUSION AND POLICY IMPLICATIONS

Using rigorous econometric panel analysis, this paper attempted to investigate the growth–environment nexus over the period 1990–2016 for selected small island developing states. Preliminary tests showed that some data are stationary at level and others are stationary at first difference and non at second difference. Consequently, the causal relationships among the variables were investigated within a PARDL framework. Also, the hausman test shows that the best estimates to use should be the pool mean group ones. The main empirical findings revealed that in the long run, there is a direct link between energy consumption and economic growth. Moreover, CO₂ emissions, foreign investment and trade openness are seen to be determinants of economic growth in the long run.

These findings are very significant for designing proper environmental policies. From this investigation, it can be concluded that energy conservation policies would not benefit the economies in terms of economic growth. However, to attain sustainable development, low carbon alternatives should in used. For instance, the economies could adopt renewable energy policies. For this change to happen, collective long-term commitment of all stakeholders are required. For instance, the government along with private sectors, international agencies as well as the population should be involved to help this transmission and ensure that economic growth is not affected. An effective regulatory framework is strongly recommended. Further research should focus more on the causal links between CO₂ emission and the other determinants in the study. Moreso, a static analysis can also be done to compare with the present dynamic analysis. Likewise, the research can be extended to a longer time frame.

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Appendix: Description of SIDS countries under study

Table-3. Sample of Countries.

Caribbean SIDS	Pacific SIDS	AIMS SIDS
Antigua and Barbuda		
Aruba		
Bahamas	Kiribati	Cape Verde Comoros
Barbados		
Belize	Papua New Guinea	Mauritius Maldives
Dominica		
Dominican Republic		
Grenada		
Guyana		
Jamaica		
St. Lucia		
St. Vincent and the Grenadines		
Trinidad and Tobago		

Source: Author's Computation.

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