Renewable Energy Consumption and Economic Growth: Evidence from Vietnam

Samuel Attuquaye Clottey
Division of Low-carbon Economy and Environmental Regulation,
Institute of Industrial Economics, Jiangsu University, China
Huaping Sun
Division of Low-carbon Economy and Environmental Regulation,
Institute of Industrial Economics, Jiangsu University, China
School of Environmental Science and Engineering,
Shanghai Jiao Tong University, China
Joshua Clifford Kofi Amissah
Rebeca Nasolwa Mkumbo
Division of Low-carbon Economy and Environmental Regulation,
Institute of Industrial Economics, Jiangsu University, China

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Abstract

This paper contributes to the existing voluminous research on energy and growth providing a dynamic and comprehensive effect of investing in clean energy and it consequences on economic growth employing the ADRL modus operandi to co-integration to estimate the reality of co-integrating among the series in the long run. The analytical tests were realized utilizing the maximum lags explicitly chosen by estimating the series at level and confirming the stability of the unrestricted VAR model. The result establishes co-integration among the variables in the long run finding an inverse relationship between alternative and nuclear energy consumption and economic growth. The other indicator of clean energy that is electricity power consumption indicates a positive significant relationship with economic growth. Further we conclude that there is a bidirectional causal relationship between these two indicators and economic growth in the long run. This endorses the prospective benefit of Vietnam to invest in clean energy.

Keywords: Clean energy, economic growth, alternative and nuclear energy, Electricity power consumption, foreign direct investment, carbon emission

Introduction

Vietnam has recorded a constant rise in economic growth over the past two decades realizing not less than 6 percent annual growth rate. This is expressed evidently in the reduction of their poverty rate. Simultaneously the demand for energy usage increased just about twice as fast as their real GDP growth during that same period World Development Indicator (WDI 2014). Specifically, the gross domestic product (GDP) per capita increased approximately twenty times, going up from USD 114 in 1990 to USD 2,109 during this growth period. (EA Energy Anlyses 2017). A forecast on energy demand shows that by 2035 the final energy demand will be approximately 2.5 times higher than in 2015 according to a report from the National energy Development plan for the period 2016-2025 pursuing the vision to 2035. During the early period of growth, the energy sector of Vietnam has reformed rapidly changing from an agricultural support economy built on the consumption of outmoded biomass fuels, to a modern diversified economy taking advantage of other clean energy sources. With an unprecedented constant increase in energy consumption and the recent fluctuation in the import and export of energy, Vietnam's energy sector has a stack of energy-related issues to elucidate; this includes concerns associated with globalization and climate change, inadequate domestic fossil resources and emissions projected to cause a shortage of water and other environmental effluence, this will largely affect their main source for electricity generation. In 2000, Renewable energy such as biomass and hydroelectricity jointly recorded 53 percent of the total primary energy supply. However, this share was 24 percent down from 53 percent at 2015 (Institute of Energy 2016.) .During this same period, the share of coal grew from 15 percent to 35 percent of total energy supply. This trend is estimated to continue for a very long period as the domestic supply of hydro and biomass is unable to meet the increasing energy demand. Moreover, the country's erratic power supply, particularly in rural regions is a major concern. In other to combat these challenges, jurisdictional measures have to be carried out, for instance, restructuring foreign investments to ensure reinforcement and ultimately stimulate the expansion of renewable-energy production volume. A report (EA Energy Anlyses 2017) shows that Vietnam's recent dependence on coal and fossil-fuel energy is a major cause of the rise in greenhouse gas (GHG) emitted by their region, recording the highest GHG emitted country within the ASEAN region. More precisely the total GHG emitted increased just about three times within a decade accompanied by a 48 percent rise in carbon intensity per GDP during that same period (EA Energy Anlyses 2017). Against this background and the 2018 sustainable development goal from the World Bank on affordable and clean energy, this paper investigates the impact of renewable energy consumption on economic growth and further examines the causal relationship between growth and the selected indicators of Renewable energy in Vietnam. (Lee 2013, Huang, Li et al. 2018) describes clean energy as non-carbohydrate energy, including nuclear energy, hydro energy, solar energy， Biomass, etc. that does not emit carbon dioxide during production. In his studies, (Lee 2013) discloses that there exist a positive relationship between foreign direct investment and clean energy usage. Hence the inflow of foreign direct investment in the form of efficient innovative technology or finances promotes economic growth and consequently, enhances environmental quality. In addition, clean energy in the form of nuclear and renewable-energy consumption has significantly heightened growth and development of the industrial sectors of most economies. Most developed economies are adopting these energy sources as supplements to other energy production approaches. Nevertheless, the easy accessibility and lower prices of unclean energy still make these developed economies engrossed with these energy sources. Clean energy investment has been identified as one of the most effective and efficient modus operandi to mitigate problems associated with climate change and pollution in the long run (Bilgili, Koçak et al. 2016) .Again investing and developing clean energy consumption has greater benefits and favorable environmental consequences to other unclean energy sources. For instance, (Pao, Li et al. 2014) in their study on growth, renewable energy and unclean energy in MIST (Mexico, Indonesia, South Korea, and Turkey) countries utilizing panel co-integrating approach, discovered a long term causality between clean energy usage and economic growth and a positive bidirectional short-run causal relationship between the series. In the short run, clean energy increases fossil fuel consumption and further generates a negative environmental response, by providing the source of power to keep the new energy source up and running .Zhang et al. (2014) looking at the possible nexus in renewable energy between China and United States of America hinted that such initiative may potentially expand both economies, minimize carbon emissions thereafter promoting environmental quality, inspiring green growth and energy security hence providing them with greater shared merits. The issue of clean energy investment has long been recommended by various environmentalist and energy economist to mitigate carbon emissions and to create a low-carbon economy at the local and global stage, also the recent rise in climate change requires countries to adopt and invest in this energy source, given that, to achieve low-carbon economy. It is rational to combine nuclear energy consumption and renewable-energy usage to a proportionate degree. The rest of the paper is organized as follows. The second section briefly reviews the relevant literature. The third section discusses the empirical framework and data. The fourth segment reports and discusses the observed results. The final section concludes the paper.

Brief Literature Review

There are quite a number of works available hashing out the connections and impact of clean energy consumption and economic growth using variant econometric models and methods. For instance, (Sbia, Shahbaz et al. 2014) utilized time-series data from UAE for their analysis verifying the nexus between economic growth and clean energy, foreign direct investment, trade openness and carbon emissions. They established that clean energy, and economic growth has positive consequence on energy consumption. Other studies on renewable-energy usage (Apergis and Payne 2010, Apergis and Payne 2011, Apergis and Payne 2013) and nuclear energy consumption (Apergis and Payne 2010, Lee and Chiu 2011, Nazlioglu, Lebe et al. 2011) respectively and economic growth employing panel data set is also available. Nevertheless, their diverse empirical reports showing dissimilar results make the topic very interesting and worth further investigation. (Nazlioglu, Lebe et al. 2011) found a unidirectional relationship between nuclear energy consumption and economic growth for Hungary, an inverse causality for the UK and Spain, and no causality for eleven other OECD countries. These outcomes propose that nuclear power may be a comparatively insignificant element of overall production in most OECD economies. According to (Ozturk 2010), the main reason for this conflict is as a result of country difference, features, time period, econometric approach or methodology, and types of energy consumption. Studies by (Dogan 2017, Shakouri and Khoshnevis Yazdi 2017, Dutta, Bouri et al. 2018) also discloses a unidirectional causal relationship from economic growth to renewable-energy consumption in the short-run and bidirectional causal response hypothesis in the long-run. (Shakouri and Khoshnevis Yazdi 2017) also discovered a unidirectional causality running from renewable energy usage to economic growth. Still on the renewable-energy usage and economic growth nexus, (Jaforullah and King 2015, Bilgili, Koçak et al. 2016) and (Salim, Hassan et al. 2014) support the rationality that developing renewable energy could significantly diminish carbon emissions. Conversely, (Menyah and Wolde-Rufael 2010, Wolde-Rufael and Menyah 2010) establishes that there is no connection between renewable-energy consumption and economic growth. (Pfeiffer and Mulder 2013) also investigated the diffusion of non-hydro clean energy technology for generating electricity in 180 developing countries using two-stage estimation techniques. They report that diffusion increases with the enforcement of economic and regulatory instruments.To conclude, a study conducted by (Perobelli and Oliveira 2013) in 27 Brazilian states formulated a proxy for energy development potentials using factor analysis, identifies three energy development potentials, which include; demand for energy, supply of clean energy and supply of unclean energy. Studies by (Shahbaz, Loganathan et al. 2015) found that renewable-energy consumption enhances economic growth in Pakistan establishing that labor and capital also aids economic development.

The Electricity Sector

Between 2011-2015, the demand for electricity usage increased averagely at 10.6 percent per annum, lower than the 13.4 percent average growth rate of the period 2006-2010 (Institute of Energy 2016.). Electricity remains the highest production capacity in the final energy consumption mix, estimated to increase by 8 percent yearly on average until 2035, corresponding to a need for additional 93 giga watts of power generation capacity during the period. Nearly half of the new capacity is supposed to be powered by coal, while almost 25 percent will be supported by renewable energy (EA Energy Anlyses 2017). Our study adds to the existing literature using data set from Vietnam to investigate the impacts of the adaptation and usage of clean energy on economic growth.

Data and Methodology

This section describes the background and data utilized in investigating the empirical analysis of the clean-energy consumption and economic growth relationship. Annual time-series data on real GDP per capita, population, foreign direct investment, carbon emission and other two explanatory variables used to model clean energy consumption was sorted from the World Bank database, WDI (2018). These two distinct indicators include; alternative and nuclear energy and electric power consumption. The population series was employed to transform our data into per-capita units. Our data sampling considered 33 years that is from 1985 to 2017. In order to model the correlation between economic growth and clean energy consumption, a simple structural form model is built below:

$$Y_t = f(AnE_t, EpC_t, FDI_t, CO_{2t}) \tag{1}$$

Table 1. Variable description

VARIABLES/SERIES	DESCRIPTION	UNITS OF MEASUREMENTS	SOURCE OF DATA
$\mathbf{Y_t}$	Real Gross Domestic product	Real GDP per Capita	WDI
$\mathbf{AnE_t}$	Alternative and Nuclear Energy	Percentage of total energy usage	WDI
$\mathbf{EpC_t}$	Electric power consumption	kWh per capita	WDI
FDI	Foreign Direct Investment Inflow	BOP Current USD	WDI
CO2	Carbon Emission	Metric tons per Capita	WDI

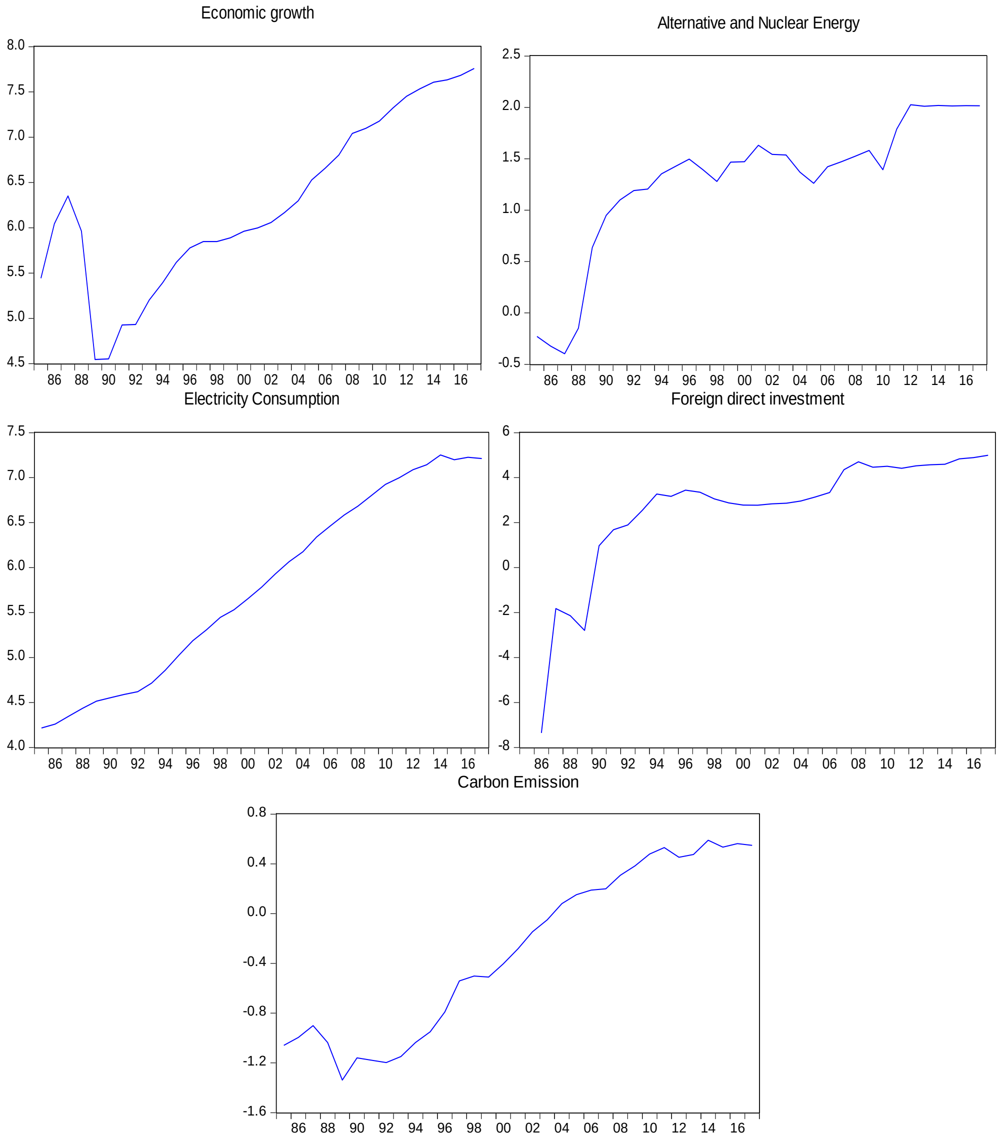


Fig. 1 Trend of the Series

For statistical analysis and inference, we transform our function into an econometric model introducing the random or stochastic error term, the elasticity coefficients of the independent series and an intercept. In advance, for efficient estimation and to minimize heteroscedasticity we further convert our econometric model into a natural log to get equation (2).

Table 2. Descriptive Statistics

Variables	$\ln Y_t$	$lnAnE_t$	$lnEpC_t$	$lnFDI_t$	$lnCO_{2t}$
Mean	6.276646	1.287904	5.792239	2.616769	-0.294976
Median	6.058745	1.425104	5.783618	3.153801	-0.283011
Maximum	7.759241	2.026698	7.251994	4.994377	0.589766
Minimum	4.546176	-0.396886	4.217010	-7.353395	-1.338297
Std. Dev.	0.939062	0.671643	1.061032	2.683446	0.675672
Skewness	-0.031765	-1.376639	-0.023674	-2.131196	-0.078629
Kurtosis	2.055674	4.172449	1.528410	7.602912	1.431741
Jarque-Bera	1.231708	12.31336	2.980752	52.47304	3.415731
Probability	0.540179	0.002119	0.225288	0.000000	0.181252
Sum	207.1293	42.50083	191.1439	83.73660	-9.734218
Sum Sq. Dev.	28.21878	14.43533	36.02522	223.2273	14.60905
Observation	33	33	33	32	33

$$\ln Y_t = \beta_o + \beta_1 lnAnE_t + \beta_2 lnEpC_t + \beta_3 lnFDI_t + \beta_4 lnCO_{2t} + \varepsilon_t \qquad (2)$$

Where $\ln Y_t$ denotes the natural log of real Income at time t, $\ln AnE_t$ represents the natural log of alternative and nuclear energy at time t, $\ln EpC_t$ embodies the natural log of electric power consumption at time t, $\ln FDI_t$ shows the natural log of real foreign direct investment and $\ln CO_{2t}$ displays the natural log of carbon emission metric tons per capita. β_0 is the constant or drift parameter, $\beta_1, \beta_2, \beta_3$ *and* β_4 denotes the elasticity coefficients of the independent variables on the dependent variable, while ε_t represents the random or stochastic error term that is anticipated to be normally distributed with zero mean and constant variance. Our study implements the autoregressive distributed lag (ARDL) or bound test modus operandi following (Pao, Li et al. 2014, Sbia, Shahbaz et al. 2014) to co-integration presented by (Pesaran, Shin et al. 2001) to test for the long-run equilibrium relationship between real GDP and the explanatory variables in our model. Ultimately, we want to investigate the relationship between real GDP and the proxies of clean energy indicators. Co-integration is an econometric model that emulates the presence of a long-run equilibrium between underlying time series that come together over time. It, therefore, creates a robust statistical and economic foundation for empirical error correction model, hence bringing together both short and long-run statistics in representing the variables. Co-integration test is essential if a model empirically shows significant long run connections. Failure to establish co-integration between the baseline series, it then turns out to be very vital to work with the variables in differences instead. When using the ADRL co-integration technique, we are able to estimate the error correction model employing a simple linear transformation grouping short-run adjustment from shocks with the long-run devoid of compromising long-run statistics; ADRL is used even though the series are stationary at *I(*0*)*, *I(*1*)* or mixture of both. Lastly, it exhibits good characteristics for small or finite sample size unlike other co-integration methods making it superior to them. We, therefore, build the unrestricted error correction model of ARDL co-integration method as below:

$$\Delta \mathrm{lnY_t} = \alpha_0 + \sum_{j=1}^{m} \alpha_{1j} \Delta lnY_{t-j} + \sum_{j=0}^{m} \alpha_{2j} \Delta lnAnE_{t-j} + \sum_{j=0}^{m} \alpha_{3j} \Delta lnEpC_{t-j} + \sum_{j=0}^{m} \alpha_{4j} \Delta lnFDI_{t-j} + \sum_{j=0}^{m} \alpha_{4j} \Delta lnCO2_{t-j} + \theta_1 lnY_{t-1} + \theta_2 lnAnE_{t-1} + \theta_3 lnEpC_{t-1} + \theta_4 lnFDI_{t-1} + \theta_5 lnCO2_{t-1} + \mu_t \quad (3)$$

In order to establish the long run equilibrium relationship among the series we continue by testing the joint null hypothesis of the variables. The null hypothesis to be tested is $\mathrm{H_0} = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ whilst the alternative hypothesis is given as $\mathrm{H_1} \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq 0$. The null hypothesis indicates the non-existence of co-integration while the alternative hypothesis shows the presence of co-integration among the variables. We will investigate the reality of co-integration between the dependent and independent variables utilizing the F-test statistics of the ARDL technique to co-integration employing the ordinary least square criterion. When the F-statistic is greater than the value of upper bound of the (Pesaran, Shin et al. 2001) critical bound table then we can conclude that the series are co-integrated .Else the variables are not co-integrated. That is when the expected F- test statistic is smaller than the lower bounds value of the (Pesaran, Shin et al. 2001) critical bound table and the result is indecisive when the F-test statistic lies between the higher and the lower bound values. We begin by constructing the long-run model of the ARDL method to co-integration in equation (4) which is then followed by the error correction model in equation (5) respectively. The two equations are estimated below:

$$\mathrm{lnY_t} = \gamma_0 + \sum_{j=1}^{m} \gamma_{1j} lnY_{t-j} + \sum_{j=0}^{m} \gamma_{2j} lnAnE_{t-j} + \sum_{j=0}^{m} \gamma_{3j} lnEpC_{t-j} + \sum_{j=0}^{m} \gamma_{4j} lnFDI_{t-j} + \sum_{j=0}^{m} \gamma_{5j} lnCO2_{t-j} + \mu_t \quad (4)$$

$$\Delta \mathrm{lnY_t} = \delta_0 + \sum_{j=1}^{m} \delta_{1j} \Delta lnY_{t-j} + \sum_{j=0}^{m} \delta_{2j} \Delta lnAnE_{t-j} + \sum_{j=0}^{m} \delta_{3j} \Delta lnEpC_{t-j} + \sum_{j=0}^{m} \delta_{4j} lnFDI_{t-j} + \sum_{j=0}^{m} \delta_{4j} lnCO2_{t-j} + \mu_t \quad (5)$$

Ultimately to avoid inefficient and biased estimation we commenced our empirical analysis by performing a unit root test on the dependent and independent series.

Results and Empirical Evidence

We employed two alternative unit root test approach the Phillip-Perron (PP) and the Augmented Dickey- Fuller (ADF) test to investigate the reality of stationarity among our dependent and independent variables. The results clearly indicate that our variables were stationary at $I(0)$ and $I(1)$, even though stationarity check is not very significant for Autoregressive distributed lag (ADRL) or bound testing technique to co-integration. The outcome of the unit root test is presented in Table 3 and 4 respectively. Thereafter, we advance to investigate the co-integration relationship between our series. Following (Pesaran, Shin et al. 2001) approach to co-integration utilizing the ADRL method, we investigate the existence of co-integration between our series by estimating the F statistics using the OLS variable addition test in the third equation. Since the F statistic is greater than the upper bound value, there is the presence of co-integration within our variable at 1 percent significance level confirming a strong relationship between our explained variable and explanatory variables. Hence we reject the null hypothesis of no long-run relationship concluding that our variables are co-integrated. The result for this test is found in Table 5. We continue to estimate the long-run model in equation (4). The long-run results show a negative significant relationship between alternative and nuclear energy consumption and economic growth. Explaining that a percentage increase in alternative and nuclear energy usage will delay economic growth by 0.7351 percent holding the other explanatory variables constant. The estimated results may advocate that utmost resources are being channeled to this sector to an extent that it slows down growth and development. Suggesting that investing and developing alternative and nuclear energy consumption will obstruct economic growth. Another reason can be attributed to the fact that this source of energy is not fully developed hence the government needs to direct more resources to expand this energy source. The result of the long-run model was estimated and presented in table 6.

Table 3.

Phillips-Perron				
Series	**Level**		**First Difference**	
	Intercept	**Intercept and Trend**	**Intercept**	**Intercept and Trend**
$\mathbf{lnY_{it}}$	-0.2236[0.9254]	-1.7109[0.7230]	-4.2551[0.0022]***	-4.3603[0.0084]**
$\mathbf{lnAnE_{it}}$	-2.5223[0.1198]	-1.7552[0.7025]	-4.0207[0.0041]***	-4.2066[0.0120]**
$\mathbf{lnEcP_{it}}$	-0.7110[0.8299]	-1.2624[0.8792]	-2.3875[0.1533]	-2.5023[0.3249]
$\mathbf{lnFDI_{it}}$	-5.7192[0.0000]***	-5.8363[0.0002]***	-9.1765[0.0000]***	-9.4071[0.0000]***
$\mathbf{lnCo2_{it}}$	-0.2915[0.9155]	-1.9257[0.6180]	-4.5225[0.0011]***	-4.4465[0.0068]***

***, **,* indicates significance at 1%, 5% and 10% respectively

Table 4.

Augmented Dickey- Fuller				
Series	**Level**		**First Difference**	
	Intercept	**Intercept and Trend**	**Intercept**	**Intercept and Trend**
$\ln Y_{it}$	-0.6578[0.8429]	-4.4552[0.0001]***	-4.2742[0.0021]***	-4.3974[0.0077]***
$\ln AnE_{it}$	-2.2075[0.2076]	-1.8754[0.6437]	-4.0016[0.0043]***	-4.26891[0.0104]**
$\ln EcP_{it}$	-5.4322[0.0002]***	1.0732[0.9998]	-0.9765[0.7486]	-0.2669[0.9871]
$\ln FDI_{it}$	-5.6038[0.0001]***	-6.6769[0.0000]***	-9.2662[0.0000]***	-9.3623[0.0000]***
$\ln Co2_{it}$	-0.2431[0.9227]	-1.8201[0.6713]	-4.5532[0.0010]***	-3.7049[0.0375]**

***, **,* indicates significance at 1%, 5% and 10% respectively

Table 5.

ARDL Bound Test Results			
$Y_t = f(AnE_t\ EpC_t, FDI_t, CO2_t)$	**Significance Level**	**Critical Value Bound**	
F-statistic		**Lower Bound**	**Upper Bound**
(23.6052)* **	10%	4.04	4.78
Lag length	5%	4.94	5.73
(4,4,4,2, 4)	1%	6.84	7.84

*** indicates significance at 1%

Likewise, the negative result could be attributed to the absence of a sound institutional framework associated with alternative and nuclear energy production in Vietnam hence providing support for (Wolde-Rufael and Menyah 2010, Wesseh and Zoumara 2012, Salim, Hassan et al. 2014, Wesseh and Lin 2015, Shakouri and Khoshnevis Yazdi 2017) in their work. Similarly if other factors inducing economic growth are held constant the coefficient of electricity power consumption is significant and positively related to economic growth in the long run. This result explains that a percentage increase in electricity power usage in Vietnam holding the other factors constant will lead to an increase in economic growth, hence government should pay attention to this source of energy during policy formulation and implementation. Besides we concluded that this source of energy is also not fully developed. Our results also indicate a bidirectional long run causal relationship between alternative and nuclear energy and electricity power consumption and economic growth. Further we conclude that alternative and nuclear energy source will promote economic growth in the fifth year.

Table 6. Long run estimates

Dependent Variable or Series = $\ln Y_t$		
Variables/Series	**Coefficients**	**(P-values)**
$\ln AnE_t$	-0.7351.	[0.0000]**
$\ln EpC_t$	1.1644	[0.000]***
$\ln FDI_t$	-0.0691	[0.0263]**
$\ln CO2_t$	1.4918	[0.0000]***

Constant	6.8888	[0.0021]***

Author's own computation

Table 7. Short run estimates

Dependent Variable or Series = $\ln Y_t$		
Variables/Series	**Coefficients**	**(P-values)**
$\Delta \ln AnE_t$	0.0976	[0.3891]
$\Delta lnAnE_{t+5}$	0.1864	[0.0147]**
$\Delta \ln EpC_t$	0.5443	[0.1188]
$\Delta \ln FDI_t$	0.0729	[0.0055]***
$\Delta \ln CO2_t$	-0.1633	[0.4901]
Constant	0.0528	[0.1160]
ECT-1	-0.1149	[0.0025]***

Author's own computation

Table 8. Coefficient Diagnostic Test

Test	**F-statistics**	**(P-values)**
Serial Correlation	1.5884	[0.2208]
Heteroscedasticity	2.1830	[0.7840]
Cusum/Cusum sq	Stable	Stable

Author's own computation

Model Stability test

Fig. 2. Graph of cumulative sum of recursive residuals

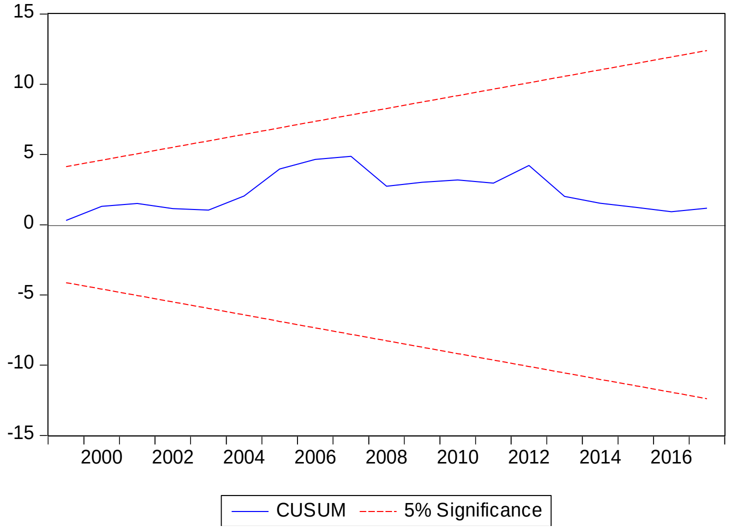
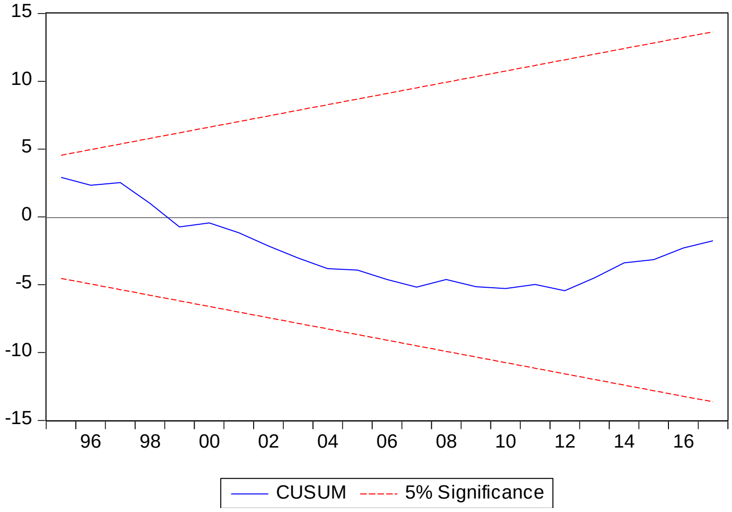


Fig. 3. Graph of cumulative sum of squares of recursive residuals



Conclusion and Policy Implications

This paper focuses on investigating the impacts of investing in clean energy on economic growth and consequently, examines the causal relationships between the dependent and independent variables in Vietnam following the ARDL modus operandi to co-integration by (Pesaran, Shin et al. 2001). Based on our results, we concluded that there is an occurrence of co-integration between the underlined variables at 1 percent significant level. The long-run estimate of the coefficient of the independent variables shows a negative significant relationship between alternative and nuclear energy consumption and economic growth. Prompting that this sources of clean energy will impede economic growth in the long run. This could be associated to the fact that this sources of clean energy is not fully developed or is under developed. More so another factor could be an unfavorable institutional framework towards this energy sector. Likewise, the coefficient of electricity power consumption recorded significant and positive relationship with economic growth. This result explains that the government of Vietnam should pay more attention to this source of clean energy generation in her strategic plans towards a sustainable and clean energy consumption goal. Through the concrete directions of the reviewed power development plan in collaboration with the renewable-energy development strategy, Vietnam will be able to grow their power sector achieving their 2030 set target. In advance the policy implication is that any modern efforts to improve energy usage through this source will increase economic growth. Regardless of the challenges associated with developing clean energy sources, when they are established and efficiently consumed will go a long way in providing energy security, green jobs and contribute to sustainable growth and development in Vietnam. Future empirical research can investigate the environmental impact of growth in the EKC model for Vietnam and consider the impacts of FDI and carbon emission on economic growth.

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