Bui, Xuan Hoi

Article

An investigation of the causal relationship between energy consumption and economic growth : a case study of Vietnam

Reference: Bui, Xuan Hoi (2020). An investigation of the causal relationship between energy consumption and economic growth : a case study of Vietnam. In: International Journal of Energy Economics and Policy 10 (5), S. 415 - 421.
https://www.econjournals.com/index.php/ijeep/article/download/9583/5302.
doi:10.32479/ijeep.9583.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(5), 415-421.

An Investigation of the Causal Relationship between Energy Consumption and Economic Growth: A Case Study of Vietnam

Xuan Hoi Bui

Department of Industrial Economics, Hanoi University of Science and Technology, Vietnam. *Email: hoi.buixuan@hust.edu.vn

Received: 14 March 2020 **Accepted:** 27 June 2020 **DOI:** https://doi.org/10.32479/ijeep.9583

ABSTRACT

This article investigates the causal links between economic growth and energy consumption in Vietnam by using Vietnam's updated data in the period of 1984-2016. The error correction mechanism (ECM) is employed to detect the causal relationship in the presence of co-integration between two variables. Applying Granger's causality test within an error-correction modeling technique, we find long-run bidirectional Granger causality between energy consumption and economic activities. The source of causation in the long-run is found by the significance of the error correction terms in both directions. In the short-run, the unidirectional Granger causality running from energy consumption to economic growth is also observed. The findings provide implications for energy development strategy to ensure the sustainable economic growth in the long term for Vietnam - a rapid developing country in ASEAN region.

Keywords: Energy, Economic Growth, Granger's Causality Test, Error Correction Mechanism, Vietnam
JEL Classifications: O13, O53, Q43

1. INTRODUCTION

The relation between energy consumption (hereafter is so called EC) and economic growth (hereafter is written in short as EG) is always an interesting subject attracting hot debates among economists as well as policy makers. From the previous century, Kraft and Kraft (1978) using the data of United States in the period of 1947-1974, found the unidirectional causality from GNP to energy consumption. Still this country, Akarca and Long (1980) re-examined this relationship but their results found no causality between energy and GNP using data for period 1950-1970 and 1950-1968. For the same period, all three papers of Yu and Hwang (1984), using the data of period 1947-1979; Yu and Choi (1985), testing with data for the period 1950-1970; and Erol and Yu (1987a,b) employing data of 1947-1979, were not able to find the causal relationship between two these variables either.

In 1993, by using a multivariate technique to investigate the causality in relationship between GDP and EC with data of the period between 1947 and 1990, Stern (1993) found no evidence that energy consumption causes GDP, but yet identified that a measure of final EC adjusted for changing fuel composition causes GDP with Granger's causality technique. The empirical results of an investigation on the co-integration and causality between two variables of Cheng (1996) by employing Hsiao's version of the Granger causality method with annual data on GNP, EC and capital of the period 1947-1990 for the United States, indicated no causality between EC and EG. These results strongly reaffirm the findings of several studies before.

The literature on this issue with practices at the other countries was also available. A note on the causal relationship between energy and GDP in Taiwan of Yang (2000), by using Taiwan's updated data in the period of 1954-1997, found bidirectional causality between total EC and GDP and the different directions of causes exist between GDP and various kinds of energy consumption, including coal, oil, natural gas and electricity. This study of Yang re-examines the research of Cheng and Lai

(1997) whose result found unidirectional causality running from GDP to EC in Taiwan for the period of 1955-1993 by using the Hsiao's version of Granger technique. Among developing countries, the article of Asafu-Adjaye (2000) also estimated the causality between these two variables for 4 countries: Thailand, the Philippines, India and Indonesia. This author used the co-integration and error-correction modeling techniques and came to the main results indicating that in the short-run bidirectional Granger causality runs from EC to EG for Thailand and the Philippines while unidirectional causality from energy to income found for India and Indonesia.

Similarly, Ebohon (1996) researched a case study of Tanzania and Nigeria – the other developing countries. His empirical result showed a simultaneous causal relationship between energy and EG for both countries. Based on that, an interesting conclusion drawn from this result was that: "unless energy supply constraints are eased, EG and development will remain elusive to these two African countries. Most recently, Khan et al. (2018) continued to follow this research direction in transition economics with an investigation of causal relation between electricity consumption, EG and trade openness in Kazakhstan. The causality analysis shows that electricity consumption Granger causes EG and trade openness in this country.

In Vietnam, Tran (2015) in her pioneering research, also using VECM Granger test and for investigating the relationship between electricity consumption and economic activities of six ASEAN countries data for period 1996-2014, found the causality running unidirectionally from electricity consumption and economic growth. In 2017, Le (2017) applying causality of Toda Yamamoto and using the 1986-2014 period's data, found the causal relationship bidirectionally between electricity consumption and economic growth for Vietnam.

There have been abundant studies aiming at examining the causal links between energy and economic growth in advanced and developing or emerging market economies (Glasure and Lee, 1997; Oh and Lee, 2004; Faisal and Nirmalya, 2013; Ho and Siu, 2007; Yildirim et al., 2014; Al-mulali et al., 2015; Augustine and Damilola, 2015; Tang et al., 2016; Chandio et al., 2019). However, the review of theses literatures reveals mixed and inconclusive evidence concerning the relationship between EC and EG of different countries. Therefore, the pertinent issues merit further examination. In fact, the direction of causality between these two variables has significant different policy implications. In case of existence of unidirectional Granger causality from EG to EC, it may be implied that energy conservation policies should have no effects on EG. If there exists unidirectional causality running from EC to EG, it can be understood that reducing energy consumption may lead to a fall in GDP. On the other hand, the discovering of no causal relationship in either direction between EC and EG, would signify that energy policies do not affect economic growth, for example.

Hence, the main purpose of this article is to examine the causality between total EC and EG or gross domestic product of Vietnam – a rapid developing nation, by using updated data in the period 1984-2016. In the following section, the methodology and models that we use in the causality test are briefly developed. After that, we will prepare the data of Vietnam for the test and their preliminary analysis is presented. In the following sections, we will analyze the empirical results obtained from effective Granger causality test within ECM framework, make a conclusion and propose some policy implications.

2. METHODOLOGY AND DATA

As discussed above, based on the results of studies conducted in many countries, we hypothesize that there will also be a causal relationship between EC and EG in Vietnam. Therefore, investigating this relationship with effective testing methods to find out the nature and confirm whether there is a real causal relationship is what we would like to study in this paper. Understanding the causal direction between these two variables is crucial to effective energy sector management, especially in the developing countries like Vietnam.

This section discusses the econometric procedures undertaken to test the direction of causality between two variables: EC and EG. Traditionally, Granger's causality test is one of the most commonly used and highly effective methods of studying time series to show the impact and direction of impact among variables. Basically, causality is a complex issue that has been studied for a long time. The causality test developed by Granger (1969) is a convenient and very general approach for detecting the presence of a causal relationship between two variables. The causal relationship that Granger studied is predicting the value of a variable through past values of other variables or of itself. A time series of variable X is said to Granger cause another time series of variable Y if the prediction error of current Y declines by using the past value of variable X in addition to past values of variable Y. The task of choosing the lead/lag length is arduous especially when the numbers of observations are relatively small. Given this fact, using the standard Granger's causality method requires that the series of selected variables should be stationary. It has been shown that using non-stationary data for causality test may yield spurious regression. Thus, the Augmented Dicky-Fuller (ADF) test Dickey and Fuller (1979 and 1981) is used in investigating the stationary property of two variables. If two variables are stationary, the model can be specified accordingly as follows:

$$\Delta X_t = \alpha_{11} + \sum_{i=1}^{m} \beta_{1i}\Delta X_{t-i} + u_{11t} \quad (1)$$

$$\Delta X_t = \alpha_{12} + \sum_{i=1}^{m} \beta_{1i}\Delta X_{t-i} + \sum_{j=1}^{n} \delta_{1j}\Delta Y_{t-j} + u_{12t} \quad (2)$$

and by analogy

$$\Delta Yt = \alpha_{21} + \sum_{i=1}^{p} \beta_{2i}\Delta Y_{t-i} + u_{21t} \quad (3)$$

$$\Delta Yt = \alpha_{22} + \sum_{i=1}^{p} \beta_{2i} \Delta Y_{t-i} + \sum_{j=1}^{q} \delta_{2j} \Delta X_{t-j} + u_{22t} \quad (4)$$

Where Δ is the difference operator, Xt and Yt are the two studied variables, m, n, p, q are number of lags, α and β are coefficients to be estimated and u_{it} are serially uncorrelated random error terms. Equations (2) and (4) are in unrestricted forms, while equations (1) and (3) are in restricted forms. Equations (1) and (2) a made into a pair to detect whether the coefficient of the past lags of variable Y can be zero as a whole and by the same way, equations (3) and (4) are made into another pair to detect whether the coefficient of past lag of variable X can be zero as a whole. Based on the estimated coefficients for the equations (2) and (4) we have 4 different hypotheses about the relations between two variables can be formulated:

- Unidirectional Granger's causality from Y to X. In this case, Y increases the prediction of the X but not vice versa. Thus $\sum_{j=1}^{n} \delta_{1j} \neq 0$ and $\sum_{j=1}^{q} \delta_{2j} = 0$
- Unidirectional Granger's causality from X to Y. In this case, X increases the prediction of the X but not vice versa. Thus $\sum_{j=1}^{n} \delta_{1j} = 0$ and $\sum_{j=1}^{q} \delta_{2j} \neq 0$.
- Bidirectional causality. In this case $\sum_{j=1}^{n} \delta_{1j} \neq 0$ and $\sum_{j=1}^{q} \delta_{2j} \neq 0$, so X increases the prediction of Y and vice versa.
- Independence between two variables X and Y. In this case, there is not Granger's causality in any direction, thus $\sum_{j=1}^{n} \delta_{1j} = 0$ and $\sum_{j=1}^{q} \delta_{2j} = 0$.

Hence by obtaining one of these results, it seems to be possible to detect the Granger's causality relationship between two variables EC and EG. Moreover, according to Engle and Granger (1987), in case at least one co-integrating relationships between two variables was found, and then a causal relationship exists in at least one direction. The dynamic Granger causality can be captured from Error Correction Model (ECM) - a more comprehensive test of causality - derived from the long-run co-integrating relationship. Assuming X et Y are found to be co-integrated, then in an effort to capture the short-run and long-run sources of causality between variables, the ECM of equations (5) and (6) can be estimated:

$$\Delta X_t = \alpha_{12} + \pi ETC_{t-1} + \sum_{i=1}^{m} \beta_{1i} \Delta X_{t-i} + \sum_{j=1}^{n} \delta_{1j} \Delta Y_{t-j} + u_{12t} \quad (5)$$

$$\Delta Yt = \alpha_{22} + \phi ETC_{t-1} + \sum_{i=1}^{p} \beta_{2i} \Delta Y_{t-i} + \sum_{j=1}^{q} \delta_{2j} \Delta X_{t-j} + u_{22t} \quad (6)$$

Where ETC_{t-1} denotes the error correction term, which is derived from the long-run co-integration relationship an measures the magnitude of the past disequilibrium. π, ϕ are the adjustment coefficients showing how much disequilibrium is corrected. The deviation from long-run equilibrium is gradually corrected through a series of short-run adjustments.

Therefore, in order to further investigate the relationship between energy and economic activities to get the most accurate assessments, it is necessary to verify the co-integration property of two variables by using Johansen co-integration test [Johansen (1988), Johansen and Juselius (1990)]. If EC and EG are not co-integrated, the standard Granger's causality technique is applicable, as shown in equations (1)-(4). Conversely, if variables are co-integrated confirming the existence of Granger causality but not pointing out its direction, then the ECM is used in testing process to detect the direction of long-run causality in co-integrated vectors (equations 5-6)[1]. To justify the long-run causality between two variables equation 5, we test the following null hypothesis π =0. If we reject the null, then Y Granger causes X in the long-run and vice versa. A similar test can be applied on ϕ in equation 6 to check if X Granger causes Y in the long-run or not. Short-run causality running from Y to X is detected if the null hypothesis $\delta_{1j} = 0$ can be rejected, otherwise the conclusion is that Y does not Granger cause X in short-run. Similarly, to verify the short-run causality from X to Y in equation 6, we must test the null hypothesis $\delta_{2j}=0$ or not.

For investigating the causal relationship between EC and EG, the data used is the updated annual time series covering the period from 1984 to 2016 for Vietnam, in which:

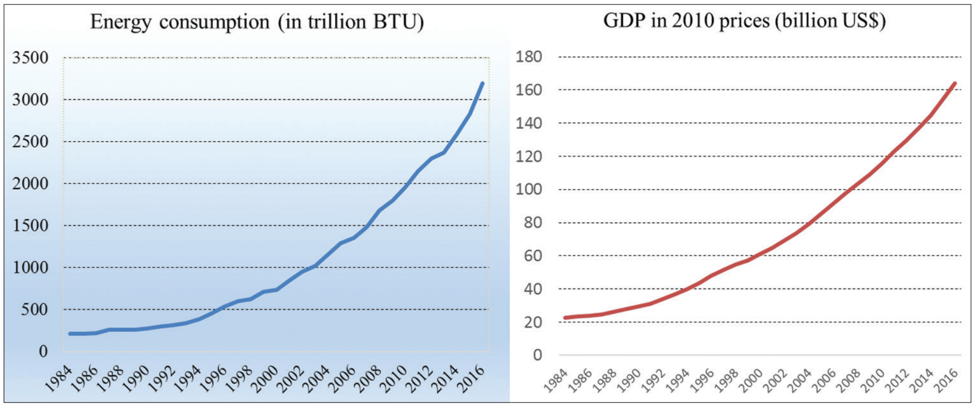
- Variable describing the EG: we use the real gross domestic product series in 2010 prices in milliards US$ (hereafter is so called GDP). In using GDP deflators, these time series are transformed from the nominal gross domestic product series in Vietnamese currency and collected in database system of World Development Indicators (WDI) from World Bank.
- Variable describing the total EC: we use the total primary energy consumption of Vietnam. These series are expressed in terms of milliard BTU and collected from the U.S. Energy Information Administration - EIA.

By the observation of the Figure 1 and the analysis of data, we can see that the country recorded high annual growth rates in energy consumption and economics in period after "Doi Moi Policy"[2]. In other words, it is the same nature of time series properties of two variables involved. Owing to this, keeping the original form of series following the same tendency will cause certain difficulties for testing procedure because the time series, which tend to increase exponentially usually are non-stationary in level form. Thus, failure to account for such properties of time series could result in misleading relationships among the variables. In order to solve this problem, all variables will be expressed in natural logarithmic form. Thus, instead of using the two series economic growth and

1 Toda and Philips (1993) proposed that if a linear combination of non-stationary variables is also non-stationary the the standard Granger causality test is applicable while if linear combination of non-stationary variable is stationary, then the causality can be determined in error correction model.

2 "Doi Moi"-in Vietnamese and "Renovation" in English is the name given to the economic reforms initiated in Vietnam in 1986 with the goal of creating a "socialist-oriented market economy". The term DOI MOI itself is a general term with wide use in the Vietnamese language. However, the Doi Moi Policy refers specifically to these reforms.

Figure 1: Energy consumption and GDP in 2010 price of Vietnam, period from 1986 to 2016



Source: IEA for Energy data and WB for economic data

energy consumption and investigating their relationship, we study here after the causal relationship between the two series LnGDP and LnEC: LnGDP =f(LnEC) and by analogy LnEC = f(LnGDP).

Based on that, the investigation of the causal relationships between variables economics and energy for Vietnam will be performed in different steps as follows:

Step 1: Stationary testing of variables

- In the first step, we carry out stationary testing process for LnGDP and LnEC time series to ensure the stationary of each variable. As mentioned, the regression analysis needs a prerequisite that time series of variables tested must be stationary because using non-stationary data in causality test may yield spurious causality results.

Step 2: Johansen's co-integration test

- As stated previously, by using Johansen method based on the Trace and Eigenvalue statistics, we perform the tests to verify the co-integration property of the series of LNGDP and LNEC (if any). Before performing the causality test, this step is important to should adopt the standard Granger's causality test or the error-correction modeling for investigating the causal relationships between energy and economic activities.

Step 3: Granger's causality test

- In case of LnGDP and LnEC are not co-integrated, we use the standard Granger's causality test for investigating the causal relationship between LnGDP and LnEC. This method allows to show whether this causal relationship exits and how its direction is.
- Conversely, if the results of Johansen test show that these two variables are co-integrated, ECM model as a more comprehensive test of causality is used to investigate the causal relationships between LnGDP and LnEC.

We will develop this testing process with the support of EVIEWS software and analysis of empirical results about the causality between two variables for Vietnam.

2.1. Analysis of Empirical Results

2.1.1. Results of stationary and co-integration tests

As mentioned above, we first perform stationary properties test of time series energy and economic growth by using the ADF and PP unit root tests with the calculation from the econometric analysis software EVIEWS. The results strongly indicate that the LnGDP and LnEC variables in level are non stationary but are stationary in first-differences at all 3 significance levels: 1%, 5% and 10%.

For the stationary test results, we have the threshold of the rejection of null hypothesis of non-stationary for each variable. As detailed in Table 1, the ADF values are larger than the critical values at all significance levels of 1%, 5% and 10% for both variables in level. They have a unit root. That means the null hypothesis cannot be rejected in level, thus the variables are non-stationary. On the other side, after the first difference, the ADF values in first-differences are smaller than the critical value at all significance levels of 1%, 5% and 10%. Therefore, rejecting the null hypothesis of non-stationary which means that both LnGDP and LnEC are stationary in first-difference and we can conclude the economic activities and energy use are on the whole integrated of order one I (1) at all three significance levels: 1%, 5% and 10%. Thus, the Granger's causality models will be estimated with first-differenced data. The following examinations of the relationship between LnGDP and LnEC, we will use the significance level of 5% for our estimation below because this is a usual level in economic statistics and is widely accepted as a general level of significance for econometric estimation.

As mentioned above, given that energy consumption and economic activities are non-stationary and linear combination of series of two variables is stationary, it is necessary to test for the co-integration property of time series of energy consumption and economic activities before performing the causality test. Therefore, the next step is to investigate the presence of a long-run co-integration relationship by using Johansen maximum likelihood test based on the trace and eigenvalue statistics.

In analyzing the time series for investigation of the co-integrated relationship between variables, it is important to determine the appropriate lag lengths because the analysis results of Johansen co-integration test are very sensitive to the lag/lead specification. Various lag lengths were tried and lag structures usually were chosen by different criterions: Akaike's final prediction error criterion: AIC (Akaike Information Criterion), SC (Schwart Bayesian) and HQ (Hannan - Quinn Information Criterion). Based on optimizing AIC, SC and HQ criterions, using a range of lags are reported in Table 2. This result is obtained after performing many tests using different lengths of lag and the optimal lags k*=2 are chosen in this study.

After choosing an optimal lag, we have performed Johansen's test for investigating the co-integration relationship between two variables LNGDP and LNEC. The Johansen tests are called the maximum eigenvalue test and the trace test and the results of co-integration tested with Vietnamese date are reported in Table 3.

As showed Table 3, the statistics of Trace test reject the null hypothesis of non-cointegration as well as most co-integrated one. These statistic results allow us to confirm that there are two co-integrating relationships between LNGDP and LNEC time series at the significance level of 5%. Therefore, the analysis confirms the existence of long-run relationship between energy consumption and economic activities.

2.1.2. Results of Granger's causality test within an ECM framework

Having found evidence of the existence of co-integrations between two variables energy consumption and economic growth, this implies Granger causality among the variables in at least one direction. However, it does not indicate the direction of temporal causality. In the next step, we process to the estimation of ECM to draw inference about the direction of causality and to shed more light on the nature of causality between variables as well as in identifying the differences between the long-run and short-run Granger causality. Table 4 reports the findings of ECM model performed with the optimal lag length k*=2 and at the significance level of 5%.

Thus, the estimation of ECM yields significant coefficients on the error correction term in both equations; we can hence conclude that there is a bidirectional relationship between energy consumption and economic growth of Vietnam in long-run. As shown in Table 4 (panel A), the values of t-statistics = [102.726] and = [102.092] are greater than the values of t-statistic table. Energy in economic growth equation and economic activities in energy consumption equation are statistically significant at the 5% level. Increases in energy consumption are affected by rising GDP and vice versa. Given the variables are expressed in natural logarithms, the coefficients can be interpreted as elasticity. The result suggests that a 1% increase of energy consumption increases real GDP by 0.717%. Thus, energy consumption is an important contributing factor to real GDP. In the other direction, a 1% increase of real GDP increases energy consumption by 1.393%. Therefore, the energy intensity is enormous in Vietnam.

In addition to providing an indication of the direction of causality, the ECM enables us to distinguish between short-run and long-run Granger causality as mentioned above. In Panel B of Table 4, the short-run dynamics results from ECM estimation are

Table 1: Stationary properties of time series LnGDP and LnEC test results

	Level		First difference	
	T-Statistic	Prob.*	T-Statistic	Prob.*
Null Hypothesis: D(LNGDP) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 5 (Automatic-based on SIC, maxlag=8)				
Augmented Dickey-Fuller test statistic	−2.847499	0.1923	−4.503345	0.0072
Test critical values:				
1%	−4.284580		−4.356068	
5%	−3.562882		−3.595026	
10%	−3.215267		−3.233456	
*MacKinnon (1996) one-sided p-values.				
Null Hypothesis: D(LNEC) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on SIC, maxlag=8)				
Augmented Dickey-Fuller test statistic	−2.794072	0.2095	−4.935509	0.0021
Test critical values:				
1%	−4.273277		−4.284580	
5%	−3.557759		−3.562882	
10%	−3.212361		−3.215267	
*MacKinnon (1996) one-sided p-values.				

Source: EVIEW 11 with Vietnamese data

Table 2: Results of final prediction error and choice of optimal lags

Lag Order	LogL	LR	FPE	AIC	SC	HQ
0	35.11516	NA	0.000295	−2.452975	−2.356987	−2.424433
1	146.0288	197.1799	1.07e-07	−10.37251	−10.08454	−10.28688
2	152.7354	10.92921*	8.85e-08*	−10.57299*	−10.09305*	−10.43028*
3	155.8895	4.672799	9.57e-08	−10.51034	−9.838421	−10.31054
4	158.4240	3.379293	1.10e-07	−10.40178	−9.537887	−10.14490
5	163.2511	5.721050	1.08e-07	−10.46305	−9.407181	−10.14908
6	165.2947	2.119209	1.35e-07	−10.31812	−9.070281	−9.947074

Source: EVIEW 11 with Vietnamese data

Table 3: Results of Johansen test for co-integration between variables

Sample (adjusted): 1987 2016
Included observations: 30 after adjustments
Trend assumption: Linear deterministic trend (restricted)
Series: LNGDP LNEC
Lags interval (in first differences): 1 to 2
Unrestricted co-integration rank test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical value	Prob.**
None*	0.453215	32.61338	25.87211	0.0062
At most 1*	0.383324	14.50236	12.51798	0.0230

Trace test indicates 2 co-integrating eqn(s) at the 0.05 level
*denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: EVIEW 11 with Vietnamese data

Table 4: ECM estimated results for Vietnam

Vector Error Correction Estimates
Sample (adjusted): 1987 2016
Included observations: 30 after adjustments
Standard errors in ( ) & t-statistics in [ ], *significant at 5%

Panel A: Long-run estimation with EC_t and GDP_t as dependent variables			
Cointegrating Eq	CointEq1	Cointegrating Eq	CointEq1
LNGDP(−1)	1.000000	LNEC(−1)	1.000000
LNEC(−1)	−0.717491	LNGDP(−1)	−1.393745
	(0.00698)		(0.01365)
	[−102.726]		[−102.092]
C	0.664367	C	−0.925958

Panel B: Short-run dynamics-ECM estimation with DEC_t and $DGDP_t$ as dependant variables		
Error Correction:	D(LNGDP)	D(LNEC)
CointEq1	0.162886	0.871441
	(0.07900)	(0.31003)
	[2.06186]*	[2.81079]*
D(LNGDP(−1))	0.493431	−0.282364
	(0.20380)	(0.79981)
	[2.42116]*	[−0.35304]
D(LNGDP(−2))	−0.434994	−0.290818
	(0.19317)	(0.75809)
	[−2.25189]*	[−0.38362]
D(LNEC(−1))	0.103508	0.217391
	(0.04943)	(0.19398)
	[2.09414]*	[1.12069]
D(LNEC(−2))	0.068985	−0.087169
	(0.04540)	(0.17819)
	[1.51934]	[−0.48919]
C	0.045291	0.113557
	(0.01185)	(0.04651)
	[3.82158]	[2.44154]

Source: EVIEW 11 with Vietnamese data

illustrated. In the short-run, the estimated coefficient of lagged energy consumption is statistically significant. Therefore, a change in energy consumption does affect the economic growth in the short-run. These results imply that, in the short-run there is unidirectional Granger causality running from energy consumption to economic growth while economic growth has neutral effect on energy consumption. The estimated coefficient of ETC is significantly positive and takes the value of less than one. This indicates that any deviation from long-run equilibrium will be corrected. While the coefficient of the lagged error correction term in the GDP equation is relatively small (0.162, or 16.2%), this is relatively high (0.871, or 87.1%) and significant at the 5% level in the EC equation. This significance implies that the change in energy consumption does rapidly respond to any deviation in the long-run equilibrium (or short-run disequilibrium) for the t-1 period. In other words, the effect of an instantaneous shock to energy consumption will be completely adjusted in the long-run. It should be noted that the preferred ECMs are chosen because they pass four main diagnostic tests. The results for Vietnam show that there are long-run bidirectional causalities but unidirectional causality running from economic activities to energy consumption.

3. CONCLUSION AND POLICY IMPLICATIONS

The energy consumption-economic growth relationship for most countries has been abundantly examined, however, for Vietnam there exists only one study that examines the electricity-GDP relationship. This paper has investigated the existence and direction of causal linkages between energy consumption and economic growth for Vietnam – a rapid developing country in ASEAN region. ADF and Maximum likelihood procedures were used to verify the time series properties of variables with a sample of annual data covering the period 1984-2016 and ECM were estimated and used to test for the nature of Granger causality of variables. Based on the test results, we can conclude that, in the short-run, unidirectional Granger causality runs from energy consumption to economic growth. In the long-run, there is bidirectional Granger causality between two variables of Vietnam.

This study's findings of long-run feedback between energy consumption and economic activities have a number of implications for Vietnamese policy analysts and policymakers. Whereby, a high level of economic growth leads to high level of energy demand and vice versa for this country. The results of the ECM model quantitatively are confirmed by the growth rates of GDP and energy consumption after the "Doi moi" policy in Vietnam. From the policy perspective, the confirmation of the feedback hypothesis warns against the use of policy instruments geared towards restricting energy consumption, as it might lead to adverse effects on economic growth. Emphasis should be mainly placed on the supply side options and national energy efficiency improvements program than on such energy limiting policies. Especially, some currently used demand side management activities by various utilities around the world could be also useful for Vietnam in this context.

Moreover, for an energy analyst, a case may exist for focusing on the components and structure of GDP in order to minimize the adverse effect of energy constraints on its sustainability. This identified relationship guides also energy forecasters to develop the appropriate long-term national energy plan to ensure rapid economic development of country. And finally, on the basis of these results, the important policy implication that can be drawn is that given similar economic characteristics and development stage adjusting the national energy structure is a feasible strategy for newly industrialized countries. This can be implemented with equal emphasis on the energy-related environmental pollution and economic development to ensure the sustainable economic growth in the long run for Vietnam.

REFERENCES

Akarca, A.T., Long, T.V. (1980), On the relationship between energy and GNP: A re-examination. Journal of Energy Development, 5, 326-331.

Al-Mulali, U., Saboori, B., Ozturk, I. (2015), Investigating the environmental Kuznets curve hypothesis in Vietnam. Energy Policy, 76, 123-131.

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.

Augustine, C.O., Damilola, F.A. (2015), Energy consumption, energy prices and economic growth: Causal relationships based on error correction model. International Journal of Energy Economics and Policy, 5(2), 408-414.

Chandio, A.A., Rauf, A., Jiang, Y., Ozturk, I., Ahmad, F. (2019), Cointegration and causality analysis of dynamic linkage between industrial energy consumption and economic growth in Pakistan. Sustainability, 11(17), 4546.

Cheng, B.S. (1996), An investigation of cointegration and causality between energy consumption and economic growth. Energy Development, 21(1), 73-83.

Cheng, B.S., Lai, T.W. (1997), An investiation of co-integration and causality between energy consumption and economic activity in Taiwan. Energy Economics, 19, 435-444.

Dickey, D., Fuller, W. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74, 427-431.

Dickey, D., Fuller, W. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometric Society, 49(4), 1057-1072.

Ebohon, O.J. (1996), Energy, Economic growth and causality in developing countries a case study of Tanzania and Nigeria. Energy Policy, 24(5), 447-453.

Engle, R.E., Granger, C.W.J. (1987), Co-integration and error correction: Representation, estimation and testing. Econometrica, 55, 251-276.

Erol, U., Yu, E.S.H. (1987a), Time series analysis of causal relationships between US energy and employment. Ressources Energy, 9, 75-89.

Erol, U., Yu, E.S.H. (1987b), On the causal relationship between energy and income for industrialized countries. The Journal of Energy and Development, 13, 113-122.

Faisal, A., Nirmalya, C. (2013), Electricity consumption-economic growth nexus: An aggregated and disaggregated causality analysis in India and Pakistan. Journal of Policy Modeling, 35(4), 538-553.

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

Granger, C.W.J. (1969), Investigating causal relations by econometric models and cross-spectral methods. Econometrica, 37, 424-438.

Ho, C.Y., Siu, K.W. (2007), A dynamic equilibrium of electricity consumption and GDP in Hong Kong: An empirical investigation. Energy Policy, 35(4), 2507-2513.

Johansen, S. (1988), Statistical analysis of cointegrating vectors. Journal of Economic Dynamics and Control, 12, 231-254.

Johansen, S., Juselius, K. (1990), Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics, 52, 169-210.

Khan, S., Jam, F.A., Shahbaz, M., Mamun, M.A. (2018), Electricity consumption, economic growth and trade openness in Kazakhstan: Evidence from cointegration and causality. OPEC Energy Review, 42(3), 224-243.

Kraft, J., Kraft, A. (1978), On the relationship between energy and GNP. Journal of Energy and Development, 3, 401-403.

Le, T.K.L. (2017), Tiêu Thụ Điện Năng, Đầu Tư Trực Tiếp Nước Ngoài Và Tăng Trưởng Kinh Tế Việt Nam. Đại Học Kinh Tế Thành Phố Hồ Chí Minh, Master Thesis in Economic Science, Ho Chi Minh City University of Economics.

Oh, W., Lee, K. (2004), Causal relationship between energy consumption and GDP revisited: The case of Korea, 1970-1999. Energy Economics, 26(1), 51-59.

Stern, D.I. (1993), Energy and economic growth in the USA: A multivariate approach. Energy Economics, 15(2), 137-150.

Tang, C.F., Tan, B.W., Ozturk, I. (2016), Energy consumption and economic growth in Vietnam. Renewable and Sustainable Energy Reviews, 54, 1506-1514.

Tran, T.M. (2015), Mối Quan Hệ Nhân Quả Giữa Sản Lượng Điện Tiêu Thụ Và Tăng Trưởng Kinh Tế Ở Các Nước ASEAN. Đại Học Kinh Tế Thành Phố Hồ Chí Minh, Master Thesis in Economic Science, Ho Chi Minh City University of Economics.

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

Yildirim, E., Aslan, A., Ozturk, I. (2014), Energy consumption and GDP in ASEAN countries: Bootstrap-corrected panel and time series causality tests. The Singapore Economic Review, 59(2), 1450010.

Yu, E.S.H., Choi, J.Y. (1985), The causal relationship between energy and GNP: An international comparison. Journal of Energy and Development, 10, 249-272.

Yu, E.S.H., Hwang, B.K. (1984), The relationship between energy and GNP: Further results. Energy Economics, 6, 186-190.