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# Impact of Globalization on Coal Consumption in Vietnam: An Empirical Analysis

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## Abstract

The study investigates the impact of globalization on coal consumption in Vietnam. This study employs an autoregressed distributed lag approach on time series data for the period of 1990 to 2017. The study tests the stationary, cointegration of time series data and utilizes autoregressed distributed lag modeling technique to determine the short-run and long-run relationship among coal consumption, globalization, income, population, and CO<sub>2</sub> emissions. The results show that globalization increases coal consumption in Vietnam in the long run. The results also show that rapid economic growth promotes more coal consumption in the short run as well as in the long run. Moreover, higher population reduces coal consumption, and CO<sub>2</sub> emissions decrease coal consumption both in the short run and the long run. The findings of the study suggest that globalization increases coal consumption in Vietnam in the long run. This result suggests that the increase in globalization level in Vietnam increases coal consumption. An interesting finding is that higher population reduces coal consumption, and population is an important factor towards the lessening in coal consumption. The findings confirm that environmental pollution decreases coal consumption in the short run and the long run. This implies that coal consumption may be green consumption in Vietnam.

**Keywords:** Coal Consumption, Globalization, CO<sub>2</sub> Emissions, ARDL Bound Test, Vietnam.

**JEL Classification Code:** F01, Q5, O18.

## 1. Introduction

Vietnam has followed the globalization trend since the early 1990s. Globalization has helped developing countries like Vietnam increase international trade and accelerate financial flows. It raised economic growth and industrial development substantially, leading to a drastic shift in production activities to the country (Nguyen & Tran, 2018; Nguyen, 2019). Vietnam has achieved remarkable economic development in the period 1990-2019. The country achieved a nearly forty-fold increase in gross domestic product

(GDP) between 1990 and 2019, and a twenty seven-fold increase in GDP per capita, and it now has middle-income country status with a population of over 95 million people. Vietnam's impressive achievements on economic growth have surpassed the progress made in many other countries at similar income levels. The increasing population, rapid urbanization, and rapidly growing economic activities in industrial and service sectors was accompanied by rapid increases in the production and consumption of energy such as oil and coal.

In Vietnam, coal is black gold for industrialization. It is an important support for the rapid development of the Vietnamese economy and occupies a main position in the energy structure in Vietnam in a quite long period of time. The nation's coal consumption increased from 4,579,000 short tons in 1990 to 60,257,780 short tons in 2017 due to impressive progress in economic growth, structural changes, industrial development and growing urbanization in the country (Nguyen, 2019). Like many developing countries, Vietnam has large amounts of coal reserves, but at the same time its economic growth is closely related to coal

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consumption. The large use of coal by a few developing countries like Vietnam sustains their pursuit of economic growth.

While there may be debate on what, exactly, has driven the country's rapid energy consumption, especially coal consumption, one thing is clear: it has been accompanied by rapid increases in economic growth. In addition to the development of modern industry and services, there are many other factors causing the changes in coal consumption. Although coal is an important energy source, relatively few nexus studies about coal consumption have been published. There is apparently a need to fill this research gap.

To explore which factors affect coal consumption, this paper empirically examines the direct impact of globalization on coal consumption in Vietnam spanning the period 1990–2017. To the best of our knowledge, there has thus far been little attempt to investigate the relationship between globalization and coal consumption. Unlike previous empirical studies, which had employed various proxies for globalization such as FDI, trade, etc., this study uses the composite KOF globalization index that encompasses different dimensions of globalization and prevents excessive oversimplification of complexities involved in understanding the ongoing process of globalization. The current study intends to contribute to the existing literature of globalization and energy consumption by answering the following research question: Does globalization affect coal consumption? The findings of the study should hopefully provide effective energy policy directions to policy makers, and in addition serve as reference material to researchers interested in the current topic.

The rest of the paper is structured as follow. Section 2 summarizes the related literature; Section 3 briefly presents data and estimation strategy; Section 4 discusses empirical results; finally, some conclusions are presented in Section 5.

## 2. Literature Review

### 2.1. International Trade and Energy Consumption

The first type of literature investigates the link between energy consumption and trade. There are few empirical studies about the relationship between energy consumption and trade. These studies indicated different results for different countries. Kwakwa (2017) explains that trade has a positive effect on the electricity consumption. Tarek (2019) found that increasing and decreasing trade openness have also positive effects on the energy consumption in the long run and short run, except an insignificant effect of decreasing trade openness in the long run.

Most of the studies point to a causal relation between energy consumption and trade in short run as well as in the long run. Some studies revealed a long run or short run Granger causality running from international trade to energy consumption (Narayan & Smyth, 2009; Sadosky, 2011a; Sohag et al., 2015; Muhammad et al. 2016). Some studies demonstrated evidence of unidirectional causality relationship running from energy consumption to trade (Lean & Smyth, 2010a; Sadosky, 2011b). Some studies indicated the bi-directional relationship between trade and energy consumption (Nasreen & Anwar, 2014; Kyophilavong et al., 2015; Amri, 2017). Other studies stated that no causal relation was found between exports and electricity generation (Lean & Smyth, 2010b).

In general, the effect of trade on energy consumption is dependent on the economic conditions of countries (Shahbaz et al., 2014). By international trade, developing countries can import advanced technologies from developed countries, which helped reduce energy intensity and produce more output. It is also possible for changes in energy consumption to affect trade in various ways (Saifullah et.al., 2017). One way is that energy is a key input of production because it is necessary for machinery and equipment in the process of production. Second, in order to trade manufactured goods or raw materials, energy is required for fuel transportation. If there is no adequate energy supply, trade openness will be influenced adversely. So, energy has an important role in expansion of trade, and for this purpose, adequate consumption of energy is necessary (Islam et.al., 2017).

### 2.2. Foreign Direct Investment and Energy Consumption

The second type of literature comprehensively investigates the relationship between foreign direct investment and energy consumption. The relationship is mentioned by a few studies. The available studies on the FDI-energy consumption nexus reveal quite diverse, divergent and mixed findings, a clear indication that the matter is not yet conclusive, and, therefore, a lot of empirical investigations still need to be done to settle the issue.

On the theoretical front, Tang (2009) argued that FDI inflows increase industrialization, manufacturing levels and transport sector activities, all of which are major users of energy. Antweiler et al. (2001) noted that FDI influences energy consumption through the scale, technique and composition effect. The scale effect is when FDI affects energy consumption through its positive impact on economic growth whilst the technique effect is when FDI introduces new techniques and technologies used for the production processes which require more energy consumption (Nguyen, 2020). An example of the scale effect is when FDI changes

the structure of the economy from being a labor-intensive to a capital-intensive economy, which by its nature uses a lot of energy. Through expansion of industrialization, transportation and urbanization, FDI tends to induce energy consumption (Sadorsky, 2010; Bekhet & Othman, 2011; Doytch & Narayan, 2016).

Empirical studies, which investigate the direct influence of FDI on energy consumption are still very scant. Some studies found that energy consumption was positively affected by FDI (Khan et al. 2014; Abidin et al. 2015; Mohamed & Mamat, 2016) or energy usage was found to have accelerated by FDI inflows in developing countries (Mielnik & Goldemberg, 2002). On the contrary, some studies showed that FDI had a negative influence on energy consumption (Bento, 2011; Elliot et al. 2013; Shahbaz & Hamdi, 2014; Sbiba et al. 2014; Zhu et al. 2016).

Most of the empirical studies focus on the causality relationship between FDI and energy consumption. The first group of studies found a unidirectional causal relationship running from FDI towards energy consumption in middle-income countries (Sadorsky, 2010; Bekhet & Othman, 2011; Omri & Kahouli, 2014; Doytch & Narayan, 2016). The second group of studies noted a unidirectional causal relationship from energy consumption to FDI (Omri & Kahouli, 2014; Abdouli & Hammami, 2017). The third group showed that FDI and energy consumption have impacted each other (Abidin et al. 2015; Gokmenoglu & Taspinar, 2015). The last group suggests that the causal relationship between FDI and energy consumption was found to be nonexistent (Lee, 2013; Belmokaddem et al. 2014; Ibrahiem, 2015).

To conclude the literature review, forgoing studies on the factors affecting energy consumption has yielded inconsistent results depending on various factors such as estimation methodology, stage of development of the economy, data use, and sample size. It is evident that more studies should be conducted to determine the factors that affect energy consumption. From a critical perspective, the use of trade or foreign direct investment as an indicator of globalization may lead to mixed and inconclusive empirical findings. The emergence of mixed and inconclusive findings will also misguide policy makers in the process of designing policies. In addition, although the relationship between globalization and energy consumption has been mentioned by previous studies, no study has been done on the direct effect of globalization on energy consumption, especially coal consumption. This present study is trying to fill this gap by investigating the impact of globalization on coal consumption in Vietnam, which could be interesting due to the fact that the country is strongly integrated in a global context of concern about the negative effects on health and the environment due to production and energies that come from fossil fuels.

### 3. Research Methods

#### 3.1. Model Specification

To investigate the effect of globalization on coal consumption in Vietnam, the empirical model is specified in the form:

$$LCOALC_t = \beta_0 + \beta_1 LKOF_t + \beta_2 LGDP_t + \beta_3 LPOP_t + \beta_4 LCO_2_t + u_t \quad (1)$$

Where LCOALC stands for natural logarithm of coal consumption; LKOF is natural logarithm of overall globalization index; LGDP refers to natural logarithm of gross domestic product; LPOP denotes natural logarithm of population; LCO<sub>2</sub> represents natural logarithm of carbon dioxide emissions; *t* illustrates year; *u<sub>t</sub>* designates the error term; and  $\beta_0$  is constant;  $\beta_i$  (*i* = 1,4) are parameters.

As spurious regression arises in case of nonstationary data, it is significant that all variables are subjected to a unit root test to determine the stationary properties (i.e., unchanged mean and covariance) of time series. The Augmented Dickey-Fuller (ADF) unit root test is a common tool employed on all variables to check the stationary and the order of integration. The testing procedure for ADF test is applied to the model:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^p \delta_i Y_{t-i} + \varepsilon_t \quad (2)$$

In this model of equation,  $\Delta$  is the difference operator,  $\alpha$  is a constant,  $\beta$  is the coefficient of time trend, *p* is autoregressive order of lag,  $\varepsilon_t$  is white noise. The null hypothesis of ADF test is that a unit root is present in a time series (i.e.  $\gamma = 0$  or the time series is non-stationary) whereas the alternative hypothesis assumes stationary (i.e.  $\gamma < 0$ ). A series is said to be integrated of order *t*, denoted by I(*t*), if one can obtain a stationary series by differencing the series *t* times. The notations I(0) and I(1) refer to the stationary series at level form or first difference level.

Cointegration involves a certain stationary linear combination of variables which are individually non-stationary but integrated to an order, I(*d*). Cointegration is an econometric concept that mimics the existence of a long-run equilibrium among underlying economic time series that converges over time. Thus, cointegration establishes a stronger statistical and economic basis for empirical error correction model, which brings together short and long-run information in modeling variables. Testing for cointegration is a necessary step to establish if a model empirically exhibits meaningful long run relationships. Engle and Granger (1987) were the first to formalize the idea of cointegration,

providing tests and estimation procedure to evaluate the existence of long-run relationship between set of variables within a dynamic specification framework. Cointegration test examines how time series, which though may be individually non-stationary and drift extensively away from equilibrium can be paired such that the workings of equilibrium forces will ensure they do not drift too far apart. There are several tests of cointegration, other than Engle and Granger procedure, among them is Autoregressive Distributed Lag cointegration technique or bound cointegration testing technique. Unlike the Engle-Granger and Johansen Juselius cointegration procedures, which require the respective time series be integrated of order one, the ARDL approach to cointegration does not require the variables to be integrated of the same order.

Pesaran and Shin (1999) proposed Autoregressive Distributed Lag (ARDL) approach to cointegration or bound procedure for a long-run relationship, irrespective of whether the underlying variables are  $I(0)$ ,  $I(1)$  or a combination of both. Bounds test approach can be applied in two steps. The existence of a long-run relationship between the variables in the model is searched in the first step, and the short-term and long-term coefficients of the model are estimated in the second step. In the first step, the existence of the long-run relation between the variables under investigation is tested by computing the Bound F-statistic (bound test for cointegration) in order to establish a long-run relationship among the variables. The ARDL unrestricted error correction model approach to cointegration testing is of the form:

$$\begin{aligned} \Delta LCOALC_t = & \alpha + \sum_{i=1}^p \alpha_{0,i} \Delta LCOALC_{t-i} + \sum_{j=0}^{q_1} \alpha_{1,j} \Delta LKOF_{t-j} \\ & + \sum_{j=0}^{q_2} \alpha_{2,j} \Delta LGDP_{t-j} + \sum_{j=0}^{q_3} \alpha_{3,j} \Delta LPOP_{t-j} \\ & + \sum_{j=0}^{q_4} \alpha_{4,j} \Delta CO_{2,t-j} + \beta_0 LCOALC_{t-1} \\ & + \beta_1 LKOF_{t-1} + \beta_2 LGDP_{t-1} + \beta_3 LPOP_{t-1} \\ & + \beta_4 LCO_{2,t-1} + u_t \end{aligned} \quad (3)$$

Where  $\Delta$  is the first difference operator,  $\alpha$  is the drift component and  $u_t$  are the random errors.

The null hypothesis of no cointegration ( $H_0$ ):  $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$  is tested against the alternative hypothesis of cointegration ( $H_1$ ):  $\beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$ . However, as discussed by Pesaran et al. (2001), the asymptotic distribution of the F-statistic is non-standard, regardless of whether the variables are  $I(0)$  or  $I(1)$ . Pesaran et al. (2001) provide lower and upper bound critical values, where the lower bound critical values assume all variables are  $I(0)$

while the upper bound critical values assume all variables are  $I(1)$ . If the calculated F-statistic is above the upper critical value, the null hypothesis of no cointegration can be rejected irrespective of the orders of integration of the variables. If the calculated F-statistic is below the lower critical value, the null hypothesis of no cointegration cannot be rejected. However, if the calculated F-statistic falls between the lower and upper critical values, the result is inconclusive.

After estimating ARDL model for identifying cointegration, it is essential to confirm the stability of ARDL model in terms of serial correlation, heteroskedasticity, model misspecification, normality. First, serial correlation can be verified by the Breusch-Godfrey Lagrange multiplier test of Breusch and Godfrey (1978). Second, heteroscedasticity is inspected by the Breusch and Pagan test (Breusch and Pagan, 1979). Third, model misspecification can be detected through the Ramsey's RESET test (Ramsey, 1969). Fourth, the normality is checked by the Jarque-Bera test (Gujarati and Porter, 2009). Finally, Cumulative Sum of Recursive Residuals (CUSUM) and cumulative sum of square of recursive residuals (CUSUMSQ) tests are utilized to ensure the stability of the coefficients. When the stability of the ARDL model is acknowledged, short-run and long-run estimations can be initiated.

If cointegration is established, the following conditional ARDL model to investigate the effects of the independents variables on the dependent variable is estimated for the purpose of determining the values of the coefficients of the independent variables in the long run.

$$\begin{aligned} LCOAL_t = & \gamma + \sum_{i=1}^p \gamma_{0,i} LCOAL_{t-i} + \sum_{j=0}^{q_1} \gamma_{1,j} LKOF_{t-j} \\ & + \sum_{j=0}^{q_2} \gamma_{2,j} LGDP_{t-j} + \sum_{j=0}^{q_3} \gamma_{3,j} LPOP_{t-j} \\ & + \sum_{j=0}^{q_4} \gamma_{4,j} LCO_{2,t-j} + \varepsilon_t \end{aligned} \quad (4)$$

The short-run dynamic parameters are obtained by estimating an error correction model associated with the long-run estimates:

$$\begin{aligned} \Delta LCOAL_t = & \theta + \sum_{i=1}^p \theta_{0,i} \Delta LCOAL_{t-i} + \sum_{j=0}^{q_1} \theta_{1,j} \Delta LKOF_{t-j} \\ & + \sum_{j=0}^{q_2} \theta_{2,j} \Delta LGDP_{t-j} + \sum_{j=0}^{q_3} \theta_{3,j} \Delta LPOP_{t-j} \\ & + \sum_{j=0}^{q_4} \theta_{4,j} \Delta LCO_{2,t-j} + \mu ECT_{t-1} + \int_t \end{aligned} \quad (5)$$

Where residuals  $\varepsilon_t$  is independently and normally distributed with zero mean and constant variance,  $ECT_{t-1}$  is the error correction term,  $\mu$  is a parameter that indicates the speed of adjustment to the equilibrium level after a shock. It shows how quickly variables converge to equilibrium and it must have a statistically significant coefficient with a negative sign.

### 3.2. Data

In the current study, annual data is employed from 1990 to 2017 in order to achieve targeted research objectives, including coal consumption, globalization, gross domestic product, population, and CO<sub>2</sub> emissions series. The time range is limited by the availability of the data. Specific description of the variables is listed in Table 1.

All the raw data are converted into natural logarithm to effectively address the percentage change of coefficient estimates. The descriptive statistics of variables are shown in Table 2.

## 4. Empirical Results and Discussion

Vietnam experienced an increase in the level of globalization during 1990-2017. In 2017, Vietnam stands at

the 83rd position with an overall globalization index (KOF) of 64.55. In the three globalization components, Vietnam is ranked 95th in terms of economic globalization, 76th in political globalization, and 132nd in social globalization in the world. It is apparent that the country gave priority to the political aspect as compared to economic and social aspects.

During the rapidly globalized period 1990-2017, Vietnam witnessed a sharp rise in coal consumption from 4,579,000 short tons to 60,257,780 short tons and in gross domestic product from USD29.458 billion to USD175.284 billion. The population has increased from 67.989 million to 94.586 million over the period 1990-2017. In 2019, Vietnam became the 15th most populous countries in the world and the third in Southeast Asia. Vietnam, therefore, had to deal with the falling environmental quality as evidenced by the substantial increase in carbon dioxide emissions from 20,190 tons in 1990 to 271,470 tons in 2017 (see Figure 1). To understand the effect of globalization on the extent of coal consumption in Vietnam, we follow the steps as pointed out in the methodology section.

### 4.1. Unit Root Test Results

First, Augmented-Dickey Fuller unit root test is employed for the level of all variables of interest followed by the first

**Table 1:** Variable description and sources

Variable	Description	Measure	Data source
COALC	Coal consumption (anthracite, subanthracite, bituminous, subbituminous, lignite, brown coal, oil shale, and net imports of metallurgical coke)	Thousands of tons	The global economy database
KOF	Overall globalization index includes economic, political and social globalization	KOF index from 0 to 100	KOF index of globalization
GDP	Gross domestic product	2010 US dollars	World development indicators
POP	Population	People	World development indicators
	Carbon dioxide emissions (produced during consumption of solid, liquid, gas fuels and gas flaring)	Thousands of tons	World data atlas

**Table 2:** Descriptive statistics of variables

Variables	Mean $\pm$ SD	Max	Min
LCOALC	9.540633 $\pm$ 0.846903	11.00639	8.210384
LKOF	3.823671 $\pm$ 0.255857	4.167130	3.324676
LGDP	25.04376 $\pm$ 0.538004	25.88967	24.10625
LPOP	18.22162 $\pm$ 0.094001	18.36513	18.03485
LCO <sub>2</sub>	11.22749 $\pm$ 0.789581	12.39859	9.903957



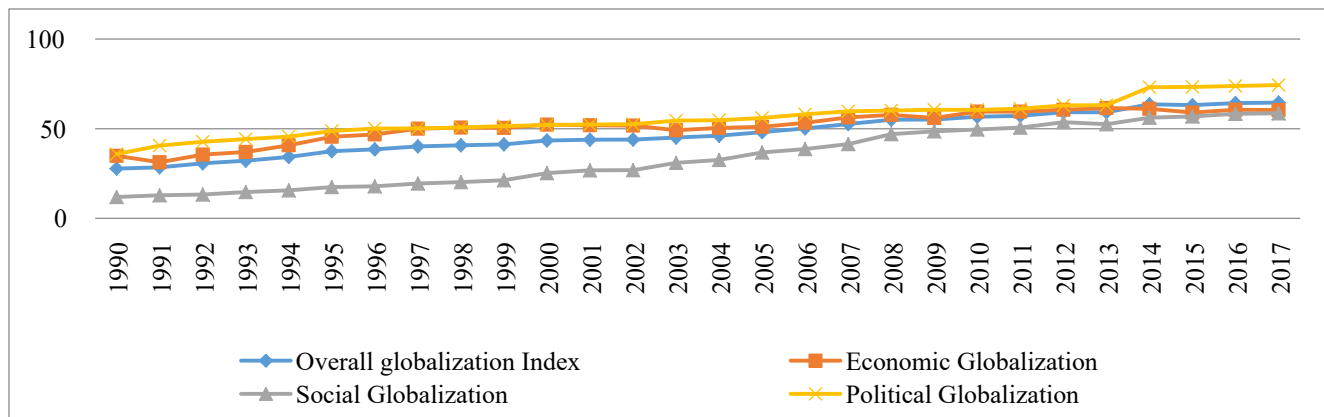


Figure 1. Development of globalization in Vietnam

Table 3: ADF unit root test results

Variables	Level		1 <sup>st</sup> Difference		Results
	t-statistic	Prob.	t-statistic	Prob.	
LCOALC	-5.245650	0.0013			I(0)
LKOF	-2.081737	0.5323	-7.027544	0.0000	I(1)
LGDP	-3.765224	0.0354			I(0)
LPOP	-2.842269	0.1971	-3.799987	0.0385	I(1)
LCO2	-1.111278	0.9084	-5.082113	0.0019	I(1)

ADF test type: Trend and intercept

Table 4: Result of ARDL Bound test for cointegration

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	k
F-statistic	11.16428	4
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

difference. The results in Table 3 show that LCOALC (Coal consumption), LGDP series are stationary at level while LKOF, LPOP and LCO2 are non-stationary at level. The table also indicates LKOF, LPOP and LCO2 variables are stationary at the first difference and integrated of order 1. Thus, all considered variables are not integrated at second level of difference. This suggests that the application of ARDL model is appropriate.

#### 4.2. Bound Test Results for Cointegration

The result of ARDL bound test for the presence of cointegration shown in Table 4 suggests the rejection of the null hypothesis of no long-run relationship at 1% level of significance when LCOALC is treated as dependent variable and LKOF, LGDP, LPOP, LCO2, are explanatory variables. This means there is a long-run equilibrium relationship

between coal consumption and its determinants as the calculated F-statistic value 11.16428 is evidently greater than the upper bound critical value of 5.06.

### 4.3. Autoregressive Distributed Lag Model Estimates

After the existence of a long-run relationship among the variables in the model is confirmed, the determination of an appropriate and correctly-specified ARDL model is based on test criteria such as the Schwarz–Bayesian criterion (SBC), adjusted R<sup>2</sup> and the diagnostic statics for econometric problems. The results of estimated optimal ARDL model are shown in Table 5. The optimal number of lags for each of the variables is shown as ARDL (2,2,1,0,0).

The R<sup>2</sup> adjusted result reveals that more than 99% of the total variation of coal consumption can be explained by changes in the level of globalization and remaining explanatory variables. Also, the F-statistic results show that the simultaneous interaction of globalization with other

variables has significant effects on coal consumption in Vietnam during the review period.

To ensure the goodness of fit of the model, diagnostic and stability tests are conducted. The results of diagnostic tests are represented in Table 6. The ARDL model passes the Ramsey test for functional form misspecification (p-value of Ramsey test is 0.9467). To identify the problem of heteroskedasticity, the Breusch-Pagan-Godfrey test shows that the variance of unobserved error was constant (p-value of the test is 0.9340). Also, the Breusch-Godfrey Serial correlation LM test used to find out whether the model is free from autocorrelation problem shows that the residuals are serially uncorrelated (p-value of this test is 0.2518) and model do not have the problem of autocorrelation. The normality test indicates the score of Jarque-Bera probability was (0.744635) larger from and it can be concluded that the model would distribute normally. Thus four components of diagnostic tests as presented in Table 6 show that there is no issue with our ARDL model. This evidence indicates that the relationship between coal consumption and the explanatory variables is verified.

**Table 5:** Autoregressive distributed lag model estimation results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOALC(-1)	0.507388	0.152436	3.328522	0.0043
LCOALC(-2)	-0.340500	0.164252	-2.073033	0.0547
LKOF	-0.821879	0.617762	-1.330414	0.2020
LKOF(-1)	1.111075	0.578807	1.919596	0.0729
LKOF(-2)	2.324374	0.661563	3.513460	0.0029
LGDP	9.342529	2.183902	4.277907	0.0006
LGDP(-1)	-6.047343	2.697646	-2.241712	0.0395
LPOP	-12.50411	4.531308	-2.759492	0.0140
LCO2	-0.707273	0.301604	-2.345039	0.0323
C	150.9641	60.65723	2.488806	0.0242
R-squared	0.996403	F-statistic		492.5241
Adjusted R-squared	0.994380	Prob(F-statistic)		0.000000
S.E of regression	0.061625	Durbin-Watson stat		2.561648

Dependent variable: LCOALC.

**Table 6:** Diagnostic test results

Types of test	Test statistic	P_value
Serial correlation	F-statistic = 1.524388	0.2518
Heteroscedasticity	F-statistic = 0.368347	0.9340
Functional form	F-statistic = 0.004626	0.9467
Normality	Jarque-Bera = 0.589721	0.744635

The stability test is conducted by employing the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ). Figures 2 and 3 plot the results for CUSUM and CUSUMSQ tests for the stability of the model. The results indicate the absence of any instability of the coefficients because the plot of the CUSUM and CUSUMSQ statistic fall inside the critical bands of the 5% confidence interval of parameter stability. The null hypothesis of all coefficients in the given regression is stable cannot be rejected, thus short-run and long-run coefficient estimations are reliable at 5% significance level.

#### 4.4. Estimated Long-Run Coefficients

Based on the optimal ARDL (2,2,1,0,0) model, the long-run coefficients of the variables under investigation are reported in Table 7. The estimated coefficient of 3.137116 shows that globalization has a positive and significant effect on coal consumption in the long run. This means that an increase in the overall globalization index as big as 1 percent is associated with an increase of coal consumption by 3.13 percent, *ceteris paribus*. The long-run test statistic reveals that globalization is the key determinant of the coal

consumption. In addition, gross domestic product was found to exert positive impact on coal consumption in Vietnam. The estimated coefficient of LGDP is 3.955273 and statistically significant at 1% level. This implies an increase in the GDP growth of 1 percent will lead to the increase of coal consumption growth by 3.95 percent, *ceteris paribus*.

Population is another important variable, which has significantly and negatively affected coal consumption in the long run. Its partial elasticity is  $-15.008918$ . This shows that a 1 percent increase in population of the country will decrease the amount of coal consumption by 15 percent. This implies that increase in population do not encourage the coal consumption growth because of the increasing awareness among the people regarding the harmful impact of environmental pollution. In this context, the consumption of coal may be replaced with renewable alternatives, such as wind, solar and hydropower, which do not emit CO<sub>2</sub>. However, the result of the study conflicts the result of Shaari et al. (2013) regarding the effect of population on coal consumption.

The obtained results show that CO<sub>2</sub> emissions negatively influenced coal consumption in the long run. This means that with the increase in CO<sub>2</sub> emissions, growth coal consumption

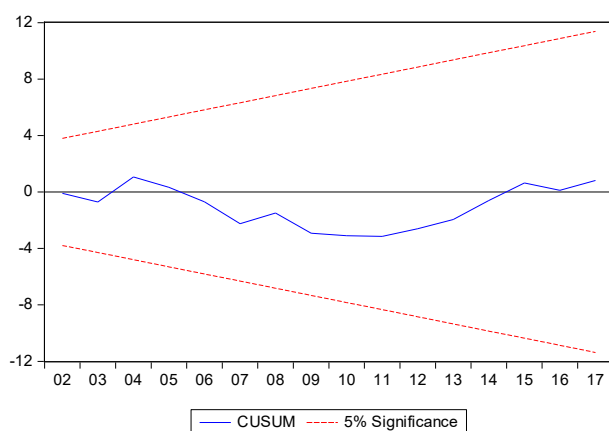


Figure 2. Plot of cumulative sum of recursive residuals

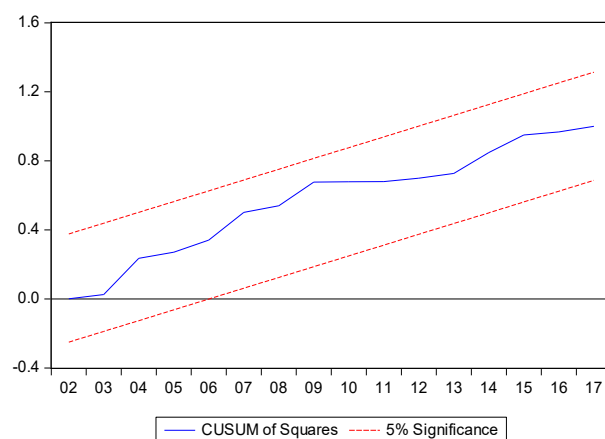


Figure 3. Plot of cumulative sum of squares of recursive residuals

Table 7: Estimated long run coefficients of the ARDL approach

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LKOF	3.137116	1.547727	2.026919	0.0597
LGDP	3.955273	0.771303	5.128039	0.0001
LPOP	-15.008918	4.455092	-3.368935	0.0039
LCO2	-0.848953	0.278880	-3.044146	0.0077
C	181.204990	68.323400	2.652166	0.0174



decreases. The result of this study is consistent with the empirical work of Lin et al. (2018) that CO<sub>2</sub> emissions also reduce coal consumption in China and India.

#### 4.5. Estimated Short-Run Coefficients of Error Correction Model

With the acceptance of long-run coefficients of coal consumption equation, the short-run coefficients are estimated. The results are presented in Table 8. The estimated coefficient of globalization indicates that globalization has a negative effect on coal consumption in the short run, but it is statistically insignificant. However, the lag of the variable has a significant role in explaining the coal consumption. Its partial elasticity is -2.324 and is statistically significant. Furthermore, gross domestic product is another important variable, which has significantly affected the coal consumption of the country in the short run. This confirms that, as the GDP of the country growth, more coal will be consumed. The result of the study is consistent with the empirical finding of Mehrara (2007).

Population is also among the important variable to influence the coal consumption. A change in the population has a statistically significant negative effect on the change in coal consumption. The partial elasticity of population is -12.504 which reveals that population has a considerable negative impact on the coal consumption in the short run.

Similarly, CO<sub>2</sub> emissions were found to have a negative influence on the coal consumption in the short run. The estimated coefficient result of CO<sub>2</sub> emissions is statistically significant at 5%. This finding is consistent with the results of Shahbaz & Hamdi (2014), which indicated that carbon emissions lead to a declining energy demand. Moreover, the lag of coal consumption positively affects coal consumption. The coefficient of the lag of LCOALC is 0.340, which is statistically significant at the 10 percent level.

The results in Table 8 clearly show that the error correction variable (ECT) was significant validating the error correction model specification. The coefficient of error

correction term has negative sign (-0.833112) as expected and it is significant at 1% level. Error correction term shows how fast the model returns to stability at any disturbance or shock. The speed of adjustment between short-run dynamics and long-run equilibrium value is 83%, it means about 83% of the discrepancy between long-term and short-term coal consumption is corrected within a year (yearly data). The significance of the coefficient of ECT connotes the existence of a long-run equilibrium relationship between coal consumption and the explanatory variables.

#### 5. Conclusions

This study empirically examined the impact of globalization on coal consumption in Vietnam over the period 1990-2017 by employing autoregressive distributed lag approach to cointegration analysis. The absence of I(2) variables was ensured by utilizing the ADF test, which validates the appropriate use of the ARDL model for further analysis. The results based on the bounds testing procedure confirm that a stable, long-run relationship exists between coal consumption and its determinants, including globalization, gross domestic product, population and carbon dioxide emissions. After confirming the long-run equilibrium among variables, the short-run coefficients are estimated by an error correction model developed within an ARDL framework.

In terms of key empirical findings, we conclude that globalization increases coal consumption in Vietnam in the long run. This result mainly suggests that the increase in the level of globalization in Vietnam increases coal consumption. Thus, the findings of this paper support the previous literature that globalization has an impact on coal consumption. The study further shows that rapid economic growth promotes more coal consumption in the short run as well as in the long run. It should be noted that a larger population reduces coal consumption and the population is an important factor towards the lessening in coal consumption. The study also confirms that environmental

**Table 8:** Error correction representation of the ARDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOAL(-1))	0.340500	0.164252	2.073033	0.0547
D(LKOF)	-0.821879	0.617762	-1.330414	0.2020
D(LKOF(-1))	-2.324374	0.661563	-3.513460	0.0029
D(LGDP)	9.342529	2.183902	4.277907	0.0006
D(LPOP)	-12.504111	4.531308	-2.759492	0.0140
D(LCO <sub>2</sub> )	-0.707273	0.301604	-2.345039	0.0323
ECT(-1)	-0.833112	0.205210	-4.059809	0.0009

pollution decreases coal consumption both in the short run and the long run. This implies that coal consumption may be green consumption in Vietnam.

## References

- Abduli, M., & Hammami, S. (2017). Exploring links between FDI inflows, energy consumption and economic growth: Further evidence from MENA Countries. *Journal of Economic Development*, 42(1), 95-117.
- Abidin, I.S.Z., Haseeb, M., Azam, M., & Islam, R. (2015). Foreign direct investment, financial development, international trade and energy consumption: Panel data evidence from selected ASEAN countries. *International Journal of Energy Economics and Policy*, 5(3), 841-850.
- Amri, F. (2017). Intercourse across economic growth, trade and renewable energy consumption in developing and developed countries. *Renewable and Sustainable Energy Reviews*, 69, 527-534.
- Antweiler, W., Brian, R., Copeland, M., & Scott, T. (2001). Is free trade good for the environment? *The American Economic Review*, 91(4), 877-908.
- Belmokaddem, M., Ghouali, Y.Z., Guellil, M.S., & Sahraoui, M.A. (2014). Causal interactions between FDI, electricity consumption and economic growth: Evidence from dynamic panel coin tegration models. *Journal of Social and Economic Statistics*, 3(2), 1-30.
- Bekhet, H.A., & Othman, N.S. (2011). Causality analysis among electricity consumption, consumer expenditure, gross domestic product (GDP) and foreign direct investment (FDI): Case study of Malaysia. *Journal of Economics and International Finance*, 3(4), 228-236.
- Bento, J.P. (2011). Energy savings via foreign direct investment? – Empirical evidence from Portugal, Working paper Number 2011/24, Maastricht School of Management, Maastricht, The Netherlands.
- Breusch, T.S. (1978). Testing for autocorrelation in dynamic linear models. *Australian Economic Papers*, 17, 334-355.
- Breusch, T.S., & Pagan, A.R. (1979). A simple test for heteroscedasticity and random coefficient variation. *Econometrica*, 47, 1287-1294.
- Dreher, A. (2006). Does globalization affect growth? Evidence from a new index of globalization. *Applied Economics*, 38, 1091-1110.
- Doytch, N. & Narayan, S. (2016), Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption, *Energy Economics*, 54, 291-301.
- Elliot, R.J.R., Sun, P., & Chen, S. (2013). Energy intensity and foreign direct investment: A Chinese city level study. *Energy Economics*, 40(November), 484-494.
- Engle, R.F., & Granger, C.W.J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, 55(2), 251-276.
- Gokmenoglu, K., & Taspinar, N. (2015). The relationship between CO2 emissions, energy consumption, economic growth and FDI: The case of Turkey. *The Journal of International Trade and Economic Development*, 25(5), 706-723.
- Gujarati, D. N., & Porter, D. C. (2009). *Basic Econometrics*. New York, NY: McGraw-Hill Irwin.
- Ibrahiem, D.M. (2015). Renewable electricity consumption, foreign direct investment and economic growth in Egypt: An ARDL approach. *Proceed Econ Finance*, 30, 313-323.
- Islam, M.Z., Ahmed, Z., Saifullah, M.K., Huda, S.N., & Al-Islam, S.M. (2017). CO2 Emission, Energy Consumption and Economic Development: A Case of Bangladesh. *Journal of Asian Finance, Economics and Business*, 4(4), 61-66. <http://dx.doi.org/10.13106/jafeb.2017.vol4.no4.61>
- Khan, M.A., Khan, M.Z., Zaman, K., & Arif, M. (2014). Global estimates of energy growth nexus: Application of seemingly unrelated regressions. *Renewable and Sustainable Energy Reviews*, 29(January), 63-71.
- Kyophilavong, P., Shahbaz, M., Anwar, S., & Masood, S. (2015). The Energy-Growth Nexus in Thailand: Does Trade Openness Boost Up Energy Consumption?. *Renewable and Sustainable Energy Reviews*, 46, 265-274.
- Kwakwa, P.A. (2017). Electricity consumption in Egypt: A long-run analysis of its determinants. *OPEC Energy Review*, 41, 3-22.
- Lean, H.H., & Smyth, R., (2010a). Multivariate Granger causality between electricity generation, and GDP in Malaysia. *Energy*, 35, 3640-3648.
- Lean, H.H., & Smyth, R., (2010b). On the dynamics of aggregate output, electricity exports in Malaysia: evidence from multivariate Granger causality tests. *Applied Energy*, 87, 1963-1971.
- Lee, J.W. (2013). The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. *Energy Policy*, 55(April), 483-489.
- Lin, F.L., Chang, T., & Inglesi-Lotz, R. (2018). Revisit coal consumption, CO2 emissions and economic growth nexus in China and India using a newly developed bootstrap ARDL bound test. *Energy Exploration & Exploitation*, 36(3), 450-463.
- Mehrara, M. (2007). Energy consumption and economic growth: the case of oil exporting countries. *Energy Policy*, 35, 2939-2945.
- Mielnik, O., & Goldemberg, J. (2002). Foreign direct investment and decoupling between energy and gross domestic product in developing countries. *Energy Policy*, 30 (2), 87-89.
- Mohamed, K.M., & Mamat, M.N. (2016). Examining the relationship between FDI, economic growth, energy consumption and exports in Yemen. *Journal of Advanced Social Research*, 6(6), 1-22.

- Muhammad, S., Mazhar, I., & Tariq, M. (2016). Energy Consumption, Trade and GDP: A Case Study of South Asian Countries. *Pakistan Development Review*. <https://www.researchgate.net/publication/301214278>
- Narayan, P.K., & Smyth, R., (2009). Multivariate Granger causality between electricity, exports and GDP: evidence from a panel of Middle Eastern countries. *Energy Policy*, 37, 229-236.
- Nasreen, S., & Anwar, S. (2014). Causal Relationship between Trade Openness, Economic Growth and Energy Consumption: A Panel Data Analysis of Asian Countries. *Energy Policy*, 69, 82-91.
- Nguyen, T.C.V., & Tran, T.D. (2018). Impact of Globalization on Economic Growth in Vietnam: An Empirical Analysis. *Journal of Economics and Development*, 20(1), 32-47.
- Nguyen, T.C.V. (2019). Impact of Globalization on Industrial Development in Vietnam: Evidence from Time Series Analysis. *Journal of Economics and Development*, 21, Special Issue, 5-21.
- Nguyen, V.T. (2020). The Role of Foreign Direct Investment and Trade on Environmental Quality in Vietnam. *Journal of Asian Finance, Economics and Business*, 7(3), 289-294. <https://doi.org/10.13106/jafeb.2020.vol7.no3.289>.
- Omri, A., & Kahouli, B. (2014). Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous equations models. *Energy Policy*, 67(April), 913-922.
- Pesaran, M.H., & Shin, Y. (1999). Autoregressive distributed lag modelling approach to cointegration analysis. In: Storm, S. (ed.), *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Ch. 11. Cambridge: Cambridge University Press.
- Pesaran, M.H., Shin, Y., & Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326.
- Ramsey, J.B. (1969). Tests for specification errors in classical linear least squares regression analysis. *Journal of the Royal Statistical Society, Series B (Methodological)*, 31(2), 350-371.
- Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy*, 38(5), 2528-2535.
- Sadorsky, P. (2011a). Trade and energy consumption in the Middle East. *Energy Economics*, 33, 739-749.
- Sadorsky, P. (2011b). Energy consumption output and trade in South America. *Energy Economics*, 34, 476-488.
- Saifullah, M.K., Kari, F.B., & Ali, M.A. (2017). Linkage between Public Policy, Green Technology and Green Products on Environmental Awareness in the Urban Kuala Lumpur, Malaysia. *Journal of Asian Finance, Economics and Business*, 4(2), 45-53. <http://dx.doi.org/10.13106/jafeb.2017.vol4.no2.45>.
- Shaari, M. S., Pei, T. L., & Rahim, H. A. (2013). Effects of Oil Shocks on the Economic Sectors in Malaysia. *International Journal of Energy Economics and Policy*, 3(4), 360-366.
- Shahbaz, M., Nasreen, S., Ling, C H., & Sbia, R. (2014). Causality between Trade Openness and Energy Consumption: What Causes What in High, Middle and Low Income Countries?. *Energy Policy*, 70, 126-143.
- Sbia, R., Shahbaz, M., & Hamdi, H. (2014). A Contribution of Foreign Direct Investment, Clean Energy, Trade Openness, Carbon Emissions and Economic Growth to Energy Demand in UAE. *Economic Modelling*, 36, 191-197.
- Sohag, K., Begum, R., & Abdullah, S.M. (2015). Dynamics of Energy Use, Technological Innovation, Economic Growth and Trade Openness in Malaysia. *Energy*, 90(2), 1497-1507. <http://dx.doi.org/10.1016/j.energy.2015.06.101>.
- Sbia, R., Shahbaz, M., & Hamdi, H. (2014). A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic Modelling*, 36 (January), 191-197.
- Tang, C.F. (2009). Electricity consumption, income, foreign direct investment and population in Malaysia: New evidence from multivariate framework analysis. *Journal of Economic Studies*, 36(4), 371-382.
- Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, 58 (November), 237-248.