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The Role of Globalization on Carbon Dioxide Emission in Vietnam Incorporating Industrialization, Urbanization, Gross Domestic Product per Capita and Energy Use

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ABSTRACT

This study examines the impacts of crucial factors associated with Vietnam's socio-economic development including globalization, industrialization, urbanization, energy consumption and gross domestic product (GDP) per capita on carbon dioxide (CO2) emission. The 31-year data (from 1985 to 2015) is analyzed by autoregressive distributed lag method, and bound test result denotes the long-run relationship between the CO2 emission and its determinants. The long-run and short-run effects can be assessed by the cointegration among the variables and error correction model respectively. We find that energy consumption, industrialization and GDP per capita increase CO2 emission in the long-run while, in contrast, globalization negatively influences it, which implies pragmatic suggestions for policymakers in promoting pertinent strategies for sustainable economic development in Vietnam.

Keywords: Energy Consumption, Carbon Dioxide Emission, Globalization
JEL Classifications: C32, Q43, Q56

1. INTRODUCTION

Economic growth is of vital importance and normally deemed as an indicator for the development level of a country. Nevertheless, it can generate unfavorable effects on environmental quality induced by an upsurge of energy consumption as a transmission channel of incremental socioeconomic activities. Consequently, many countries face a serious challenge of fostering economies without destroying the environment; and in order to achieve this objective, it is significant that environmental quality is appraised as an essential factor in development strategies.

In recent past decades, economists as well as policy makers have attempted to investigate the connection among economic growth, energy consumption and environmental quality, and their efforts can considerably contribute to the implementation of appropriate policies for supporting sustainable development. Nonetheless, the energy - environment relationship remains a highly controversial topic (Omri, 2013). Hence, the thorough inspection of various agents affecting environmental quality is necessary.

Globalization not only affects economic, social and cultural aspects of a country together with its relevant policies but also impacts environmental quality at both national and international levels. Indubitably, globalization has stimulated global trade, investment and other economic activities in the 21st century, which possibly causes an upturn in energy consumption and impinges environmental quality (Latif et al., 2018; Cole, 2006). Variously, globalization also enhances knowledge and technology transfers, thus promoting efficient energy use and decreasing negative influences on the environment (Shahbaz et al., 2016b). Furthermore, globalization facilitates economic structure transformation towards tertiary sector growth and provides consequential benefits to the environment (Jena and Grote, 2008). Besides, globalization persuades many countries to follow international standards and treaties concerning environmental quality (Bernauer et al., 2010).

Owing to globalization resulting in knowledge and technological transitions, developing countries have experienced economic transformation in which industrialization grows. Urbanization defined as a process of social and economic shifting from rural areas (where agriculture dominates) to urban areas (where industrial and service sectors play important roles) is also considered being facilitated by globalization. The incremental urbanization tends to boost energy usage and unfavorably affects the environment (Shahbaz et al., 2016a).

Since the economic reform, Vietnam has rapidly globalized and improved the trade openness as well as attracted foreign investment. The overall globalization index of Vietnam substantially increased from about 25.7 in 1986 to 59.7 in 2015. Also, foreign direct investment dramatically soared from around 40 thousand United States Dollar (USD) in 1986 to 11.8 billion USD in 2015. Furthermore, during period 1986–2015, Vietnam witnessed a sharp rise in trade openness (measured as percentage of gross domestic product [GDP]) from nearly 23% to 180% and afterwards became the 28th largest export country in 2017. The upsurge of trading and investing activities was vital for Vietnam in terms of economic transform and industrialization boost promoted by knowledge and technological transitions. Vietnam's economic growth demonstrated a remarkable upward trend when the GDP per capita in 2015 was approximately 2,065.2 USD compared to 421.7 USD in 1986. Besides, the urbanization significantly expanded when the ratio of total population living in urban areas continually rose from roughly 19.6% to 33.6% in the period 1986–2015.

Energy was absolutely requisite for the aforementioned development when energy demand exponentially increased by around 2,746 times during 1986–2015. Vietnam, therefore, had to deal with the diminishing environmental quality as evidenced by the high carbon dioxide (CO2) emission of 2.0 metric tons in 2015 while that of the year 1986 was only 0.37 metric tons. Expressly, globalization could pose a major threat to the environment. Nevertheless, globalization can also bring incremental knowledge, technology and income benefits, thus contracting damage to the environment.

The main objective of our study is to assess the impacts of globalization and energy use on CO_2 emission in Vietnam incorporating industrialization, urbanization and GDP per capita in a multivariate framework. The remaining of this study is ordered in the following structure: "Literature Review" section emphasizes pertinent important researches in this discipline; "data and econometric methodology" section clarifies the variables, estimation model as well as econometric methodology; "empirical results" section explains the findings; and finally, "conclusions" section concludes the study with policy implications based on the empirical results.

2. LITERATURE REVIEW

CO_2 emission has exponentially increased in the last few decades. As a result, the association between environmental quality and economic growth remains the concern for researchers and policy makers, and it has been debated by various empirical studies. Typical papers in this discipline address the link between environmental quality and economic growth by employing the inverted U-shaped effect proposed by Grossman and Krueger (1991) which is referred to as the environmental Kuznets curve (EKC). The EKC assumes that CO_2 emission rises in the initial stage of economic development until it reaches the threshold connected with certain income per capita and subsequently declines, thus resembling an inverted U-shape.

Based on Grossman and Krueger (1991), manifold studies test the occurrence of EKC in numerous countries, and the findings are non-consensus due to the differences in selecting the polluting agents, research areas, time frames and statistical procedures. The EKC hypothesis is detected and evidenced by Shafik and Bandyopadhyay (1992); Shafik (1994); Selden and Song (1994); Cole et al. (1997); Heil and Selden (1999); List and Gallet (1999); Dinda et al. (2000); Stern and Common (2001); Friedl and Getzner (2003); Stern (2004); Ang (2007); Managi and Jena (2008); Managi et al. (2009); Lean and Smyth (2010); Brajer et al. (2011); Hamit-Haggar (2012); Omri (2013); Shahbaz et al. (2013a); Shahbaz et al. (2014); Dogan and Turkekul (2016). No detection of EKC is observed by Torras and Boyce (1998); Roca et al. (2001); Day and Grafton (2003); Luzzati and Orsini (2009); Pao and Tsai (2011); Du et al. (2012); Wang et al. (2013); Bölük and Mert (2014). Additionally, Friedl and Getzner (2003) and Onafowora and Owoye (2014) report N-shape pattern in the relationship between CO_2 emission and economic growth.

Besides the previously listed studies attempting to testify to the EKC hypothesis, recent papers inspect the dynamic link between CO_2 emission and its determinants, especially including an important variable known as energy consumption. A series of researches examining the connection between CO_2 emission, economic growth and energy consumption, for instance, includes Soytas et al. (2007); Zhang and Cheng (2009); Apergis and Payne (2010); Alam et al., (2011); Al Mamun et al. (2014); Asif et al. (2015); Nguyen and Wongsurawat (2017); Dar and Asif (2017); Phuong and Tuyen (2018); and virtually all of them witness the significant positive impacts of economic growth and energy consumption on CO_2 emission. Along with energy consumption, industrialization and urbanization also affect environmental quality in the manner that boosts energy usage and exacerbates the environment (York, 2007; Ma and Du, 2012), which is analogous with the results of other similar studies such as Parikh and Shukla (1995); York et al. (2003); Cole and Neumayer (2004); Shahbaz (2016a).

It is significant that environmental quality should be scrutinized under the influence of globalization. Globalization can positively or negatively affect the environment directly or indirectly through the economic growth transmission channel. As a facilitator of economic benefits, globalization eliminates cross-border trade and investment barriers, hence contributing to expand the size of a country's economy and subsequently leading to escalating pollution. However, after establishing a certain national income, pollution is hypothesized to decrease because of the economic structure transition towards tertiary sector and technology advancement with respect to production efficiency. Globalization can also directly raise pollution via the scale effect when trade activities accrue (Cole, 2004; Shandra et al., 2009), yet trade permits access to better technology and management knowledge which in turn ameliorates the environment (Esty, 2001).

Besides, the political globalization has feasible impact on environmental quality. When citizens have already attained adequate life standards, they tend to care more about the environmental quality and might demand governments to appropriately act to minimize or eradicate pollution; for example, promulgating environmental regulations (Grossman and Krueger, 1995). In addition, the majority of empirical researches finds that more democratic political institutions are associated with higher environmental standard requirements and quality (Dasgupta and Mäler, 1995; Panayotou, 1997; Harbaugh et al., 2002; Bernauer and Koubi, 2009; Lin and Liscow, 2013; You et al., 2015). Moreover, political globalization can influence both environmental policies and quality in countries that are members of international organizations (Bernauer et al., 2010; Spilker, 2012).

There are vast numbers of empirical researches scrutinizing the causality of globalization on environmental deterioration. Grossman and Krueger (1991) analyzes the environmental impact of North American Free trade Agreement and witnesses the scale effect of globalization (proxied by trade openness) on the reduction of environmental quality. Antweiler et al. (2001) reports that trade openness improved environmental quality through the technique effect in 43 countries over the 1971–1996 period. Liddle (2001); Sigman (2004); Bernauer and Kuhn (2010) also confirm the positive causation of globalization on environmental enhancement. Frankel and Rose (2005) employs the data from 41 countries in 1990 and explores that trade helped decrease pollution, which is analogous to the study of Li et al. (2015) on both developed and developing countries. On the contrary, Dean (2002); Magani (2004); McAusland (2008); Shandra et al. (2009); Frankel (2009) perceive environmental destruction as a consequence of trade openness, which is in line with the findings of Shahbaz et al. (2013a) concerning the case of Indonesia. Omri et al. (2015) studies the cointegration among energy consumption, economic growth, trade openness, urbanization, financial development and CO_2 emission in 12 Middle East and North Africa countries during 1990–2011 and concludes that trade openness raised CO_2 emission for the entire panel data; nonetheless, at national level, the result is not statistically significant for 9 out of 12 countries.

Recently, Mrabet and Alsamara (2017) tests EKC hypothesis utilizing energy consumption, financial development and trade openness in Qatar during 1991–2000 and identifies positive influence of trade openness on CO_2 emission in the long-run together with insignificant effect in the short-run. Shahbaz et al. (2017) examines the role of globalization in China and proves that globalization helps reduce CO_2 emission. Hasanov et al. (2018) researches the link between international trade of oil exporting countries and CO_2 emission and explores that export and import can significantly lower CO_2 emission in both short-run and long-run.

3. DATA AND ECONOMETRIC METHODOLOGY

3.1. Data

For the purpose of assessing CO_2 emission and its determinants in Vietnam, we employ annual data from 1985 to 2015, including CO_2 emission, GDP per capita, energy consumption, globalization, urbanization and industrialization series. The time range is limited by the availability of the data.

CO_2 emission, GDP per capita, industrialization and urbanization are collected from world Development Indicators (published by world bank), while globalization is retrieved from KOF index of globalization. Specific description of the variables is listed in Table 1.

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

3.2. Econometric Methodology

3.2.1. Model specification

A notable attribute of recent studies is estimating long-run dynamics between CO_2 emission and energy consumption, controlling the model for economic growth, globalization, urbanization, and industrialization. We apply the model proposed by Shahbaz et al. (2013b) and Shahbaz et al. (2017):

$$CO_2 = f\,(GDP, EC, KOF, IND, URB) \quad (1)$$

Where CO_2 represents CO_2 emission per capita; GDP denotes GDP per capita calculated at the constant price (2010US\$); EC stands for primary energy consumption per person; KOF is Globalization index; IND is value added Industry; and URB indicates the urban population share of the total population measured in percentage.

According to Dar and Asif (2018), log-linear specification surpasses simple linear specification and generates more reliable estimates. The empirical model thereupon is in this form:

$$LCO2t=\alpha+\alpha 1LGDPt+\alpha 2LECt+\alpha 3LKOFt+\alpha 4LINDt+\alpha 5LURBt+\varepsilon t \quad (2)$$

Where LCO_2 represents the natural logarithm of CO_2 emission per capita; LGDP denotes the natural logarithm of GDP per capita calculated at the constant price (2010US\$); LEC stands for the natural logarithm of primary energy consumption per person; LKOF is the natural logarithm of Globalization index; LIND is the natural logarithm of value added Industry; LURB indicates the natural logarithm of the urban population share of the total population measured in percentage; t illustrates year; and designates the white noise error term.

3.2.2. Unit root test

As spurious regression arises in case of nonstationary data, it is significant that the stationarity (i.e., unchanged mean and

Table 1: Variable description and sources

Variable name	Symbol	Description	Unit	Data source
Carbon dioxide emissions	CO_2	Carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	Metric tons per capita	World development Indicators
Energy consumption	EC	It includes petroleum products, natural gas, electricity, and combustible renewable and waste	Kg of oil equivalent per capita	World Development Indicators
Economic growth	GDP	Is the gross domestic product divided by the midyear population (GDP per capita)	In constant 2010 U.S. $	World Development Indicators
Globalization	KOF	Globalization implies the interaction among people in perspectives to a broader outlook of free transfer of capital, goods, and services	Index	KOF index of Globalization
Industrialization	IND	Industry (including construction), value added	% of GDP	World Development Indicators
Urbanization	URB	Urban population refers to the number of people living in urban areas of a country	Total urban population, %	World Development Indicators

Source: Author's collection

Table 2: Descriptive statistics of variables

Variable	Mean±SD	Max	Min
LCO_2	−0.345±0.668	0.693	−1.338
LGDP	6.638±0.480	7.409	5.945
LEC	5.977±0.366	6.601	5.560
LKOF	3.685±0.273	4.098	3.248
LIND	3.461±0.169	3.694	3.121
LURB	3.211±0.177	3.514	2.974

Source: Author's calculations

covariance) is validated (Granger and Newbold, 1974). Common tools for checking stationarity include Augmented Dickey-Fuller (ADF) of Dickey and Fuller (1979), Phillips-Perron (PP) of Phillips and Perron (1988), and KPSS of Kwiatkowski et al. (1992). We utilize the ADF test because it is often exploited in unit root test, which is shown in equation (3).

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{j=1}^{p} \delta_j \Delta Y_{t-j} + \varepsilon_t \quad (3)$$

In equation (3), the difference operator, constant, coefficient of trend, autoregressive order of lag and white noise are denoted by Δ, α, β, p and ε_t respectively. The lag length (p) is determined by Schwarz information criterion. The null hypothesis of ADF test assumes non-stationarity (i.e., Y_t has unit root), whereas the alternative hypothesis assumes stationarity (i.e., Y_t has no unit root). Besides, when the null hypothesis is rejected, the notation I(0) or I(1) refers to the stationarity of data at level form or first level of difference.

3.2.3. Cointegration and analyzed by autoregressive distributed lag approach (ARDL)

Cointegration can be defined as the existence of a stationary linear combination among the variables, which can be tested by the two common methods provided by Engle-Granger (1987) and Johansen (1988). The aforesaid methods might be biased in case there are both I(0) and I(1) variables in the model. To overcome this constraint, Pesaran and Shin (1999) and Pesaran et al. (2001) develop the analyzed by autoregressive distributed lag (ARDL) cointegration approach producing unbiased result, thus giving more flexibility for the variables. Also, the ARDL approach can be superior to other techniques (Phong et al., 2018). Specifically, it requires smaller sample size than Johansen cointegration method to gain statistically significant result (Pesaran et al., 2001). Furthermore, it does not require solving a set of equations in order to estimate the short-term and long-term effects of independent variables on the dependent variable; rather, it only necessitates a single equation (Bentzen and Engsted, 2001; Srinivasana and Kalaivanib, 2013). In addition, the ARDL model itself chooses the optimal lag length and permits differences in the optimal lag length of variables, which noticeably enhances the fit of the model (Nkoro and Uko, 2016). Finally, the ARDL approach can avoid endogenous problems and provide unbiased long-run estimates associated with valid t statistics (Harris and Sollis, 2003; Narayan, 2005).

There are two notable elements in ARDL model: "AR" (i.e., the dependent variable is allowed to be affected by its past values) and "DL" (i.e. the dependent variable is allowed to be impacted by independent variables with lags). The equation (2) below denotes the ARDL model where LCO_2 is the dependent variable:

$$LCO_{2t} = \begin{matrix} \alpha + \sum_{i=1}^{p_0} \beta_{0,i} LCO_{2t-i} + \sum_{j=0}^{p_1} \beta_{1,j} LGDP_{t-j} + \\ \sum_{k=0}^{p_2} \beta_{2,k} LEC_{t-k} + \sum_{l=0}^{p_3} \beta_{3,l} LKOF_{t-l} + \\ \sum_{m=0}^{p_4} \beta_{4,m} LIND_{t-m} + \sum_{n=0}^{p_5} \beta_{5,n} LURB_{t-n} + \varepsilon_t \end{matrix} \quad (4)$$

In the outset of ARDL procedure, bound test is used for detecting the cointegration among the variables (also known as the long-run relationships among the variables) (Pesaran and Pesaran, 1997). The Unrestricted Error Correction Model (UECM) form of ARDL is indicated as follows:

$$\Delta LCO_{2t} = \begin{aligned} &\alpha + \sum_{i=1}^{p_0} \beta_{0,i} \Delta LCO_{2t-i} + \sum_{j=0}^{p_1} \beta_{1,j} \Delta LGDP_{t-j} + \\ &\sum_{k=0}^{p_2} \beta_{2,k} \Delta LEC_{t-k} + \sum_{l=0}^{p_3} \beta_{3,l} \Delta LKOF_{t-l} + \\ &\sum_{m=0}^{p_4} \beta_{4,m} \Delta LIND_{t-m} + \sum_{n=0}^{p_5} \beta_{5,n} \Delta LURB_{t-n} + \\ &\lambda_0 LCO_{2t-1} + \lambda_1 LGDP_{t-1} + \lambda_2 LEC_{t-1} + \\ &\lambda_3 LKOF_{t-1} + \lambda_4 LIND_{t-1} + \lambda_5 LURB_{t-1} + \varepsilon_t \end{aligned} \quad (5)$$

For identifying cointegration, the null hypothesis presuming non-cointegration (i.e., H_0: $\lambda_0=\lambda_1=\lambda_2=\lambda_3=\lambda_4=\lambda_5=0$) is tested against the alternative hypothesis supposing cointegration (i.e., H_1: $\lambda_0\neq\lambda_1\neq\lambda_2\neq\lambda_3\neq\lambda_4\neq\lambda_5\neq0$). The conclusion as regards H_0 varies subject to the comparison between the F statistic and critical values. Going into details, H_0 is rejected if the F statistic is greater than the upper bound critical value at the predetermined level of significance. H_0 is not rejected if the F statistic is smaller than the lower bound critical value. As long as the F statistic falls between the two aforementioned critical values, there is no conclusion concerning H_0.

After the examining the cointegration, it is essential to confirm the stability of ARDL model in terms of serial correlation, normality, model misspecification, and heteroscedasticity. First, serial correlation can be verified by the Breusch-Godfrey Lagrange multiplier test of Breusch (1978) and Godfrey (1978). Second, the normality is checked by the Jarque-Bera test (Gujarati and Porter, 2009). Third, model misspecification can be detected through the Ramsey's RESET test (Ramsey, 1969). Fourth, heteroscedasticity is inspected by the Breusch and Pagan test (Breusch and Pagan, 1979). 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.

Table 3: Augmented Dickey-Fuller and Phillips-Perron tests results for stationarity

Variable	ADF test	PP test	Integration order
LCO_2	−2.296	−2.310	
ΔLCO_2	−4.390***	−4.399***	I(1)
$LGDP$	−3.054	−3.317**	I(0)
$\Delta LGDP$	−3.813**	−3.669**	I(1)
LEC	−2.195	−2.183	
ΔLEC	−3.546**	−3.942**	I(1)
$LKOF$	−2.471	−2.466	
$\Delta LKOF$	−7.192***	−8.349***	I(1)
$LIND$	−1.718	−1.252	
$\Delta LIND$	−3.816**	−3.81**	I(1)
$LURB$	−3.969**	−7.512***	I(0)

***, ** and * are respectively the 1%, 5% and 10% significance levels. Source: Authors' calculation. ADF: Augmented Dickey-Fuller, PP: Phillips-Perron

4. EMPIRICAL RESULTS

4.1. Unit Root Test

ARDL necessitates non-stationarity at second level of difference. Thereupon, we utilize ADF and PP tests to verify the aforementioned prerequisite for the trustworthiness of the subsequent bound test (Phong et al., 2018; Ouattara, 2004). The results are displayed in Table 3.

The variables are not integrated at second level of difference; namely, LURB and LGDP are I(0) while other variables are I(1). Hence, the application of ARDL model is appropriate.

4.2. Bound Test

The outcome shown in Table 4 proves the cointegration (or long-run relationship) between CO_2 emission and its determinants as the F statistic (4.392) exceeds the upper bound critical value (3.805) at 5% significance level.

4.3. Autoregressive Distributed Lag (ARDL) Estimates

Table 5 demonstrates the optimal model ARDL (2, 0, 0, 0, 1, 2) stemming from the optimal lag length choice based on schwartz bayesian criterion.

4.4. Diagnostic Tests

Four components (serial correlation, functional form, normality, and heteroscedasticity) are conducted in the diagnostic tests presented in Table 6, showing no issue with our ARDL model (Pesaran and Pesaran, 1997).

Furthermore, Figure 1 and 2 illustrate CUSUM and CUSUMSQ tests employed by Brown et al. (1975) to validate the stability of the model.

As the graphs representing the CUSUM and CUSUMSQ lie within the critical bounds, the stability of our ARDL model is confirmed, thus short-run and long-run coefficient estimation is reliable at 5% significance level.

4.5. Long-run Estimation Results

Table 7 displays the estimation of long-run coefficients of our ARDL model.

4.6. Short-run Estimation Results

The estimation concerning the short-run coefficients of our ARDL model is listed in Table 8. Markedly, the negative error correction

Table 4: The result of bound tests for cointegration test

F statistic	90%		95%		97.5%		99%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
4.392***	2.262	3.367	2.649	3.805	3.056	4.267	3.516	4.781

***, ** and * are respectively the 1%, 5% and 10% significance levels. Source: Author's calculation

Table 5: Autoregressive distributed lag estimation results (dependent variable: LCO_{2t})

Variable	Coefficient	Standard Error	t-statistic	P value
$LCO2_{t-1}$	0.664***	0.220	3.017	0.008
$LCO2_{t-2}$	−0.566***	0.195	−2.898	0.009
$LGDP_t$	1.598***	0.475	3.368	0.003
LEC_t	0.698***	0.232	3.012	0.008
$LKOF_t$	−1.333**	0.503	−2.649	0.015
$LIND_t$	0.062	0.343	0.182	0.858
$LIND_{t-1}$	0.425	0.259	1.642	0.119
$LURB_t$	0.745***	0.235	3.164	0.006
$LURB_{t-1}$	−1.328***	0.386	−3.441	0.003
$LURB_{t-2}$	0.042***	0.014	2.958	0.009
constant	−10.200***	2.530	−4.032	0.001
$\overline{R}^2$	0.993			
DW - statistics	2.467			
SE of Regression	0.052			

***, ** and * are respectively the 1%, 5% and 10% significance levels. Source: Author's calculation

Table 6: Results of the diagnostic tests

Types of test	Test statistics	P value
Serial correlation	1.611	0.204
Functional Form	1.693	0.212
Normality	0.619	0.734
Heteroscedasticity	0.892	0.345

Source: Author's collection

Table 7: Result of long-run coefficients (Dependent Variable: LCO_{2t})

Variable	Coefficient	Standard Error	t-statistic	P value
$LGDP_t$	1.771***	0.596	2.972	0.008
LEC_t	0.774***	0.242	3.198	0.005
$LKOF_t$	−1.477**	0.581	−2.544	0.020
$LIND_t$	0.540***	0.103	5.223	0.000
$LURB_t$	−0.600	1.976	−0.304	0.765
Constant	−11.301***	1.702	−6.640	0.000

***, ** and * are respectively the 1%, 5% and 10% significance levels.Source: Author's calculation

term (i.e., EC_{t-1}<0) with extremely low P-value verifies the occurrence of cointegration among the variables. Also, it denotes the adjustment pace from the short-run to the long-run; specifically, CO_2 emission will return to equilibrium subsequent to the short-run shock stemming from the impacts of energy consumption, GDP per capita, globalization, urbanization, and industrialization.

It is noticeable that GDP per capital, energy consumption and urbanization display positive influences on CO_2 emission in the short-run, as evidenced by the positive coefficients associated with small p-values. In contrast, globalization considerably reduces CO_2 emission, and the urbanization level of the previous year (i.e. the urbanization variable with 1 lag) does likewise at lower magnitude.

5. CONCLUSION

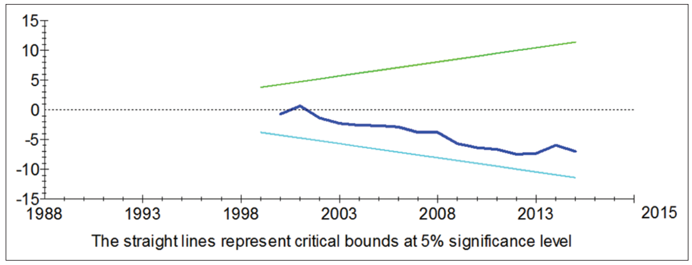
This study inspects the impacts of energy consumption and globalization on CO_2 emission incorporating GDP per capita, industrialization, and urbanization in Vietnam over the period

Table 8: Result of short-run coefficients (dependent variable: LCO_{2t})

Variable	Coefficient	Standard Error	t-statistic	P value
$\Delta LCO2_{t-1}$	0.566***	0.195	2.898	0.009
$\Delta LGDP_t$	1.598***	0.475	3.368	0.003
ΔLEC_t	0.698***	0.232	3.012	0.008
$\Delta LKOF_t$	−1.333**	0.503	−2.649	0.015
$\Delta LIND_t$	0.062	0.343	0.182	0.858
$\Delta LURB_t$	0.745***	0.235	3.164	0.005
$\Delta LURB_{t-1}$	−0.042***	0.014	−2.958	0.008
constant	−10.200***	2.530	−4.032	0.001
EC_{t-1}	−0.903***	1.629	−5.542	0.000
$\overline{R}^2$	0.757			
DW - statistics	2.467			
SE of Regression	0.052			

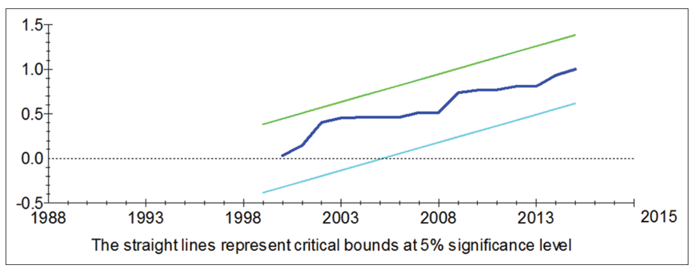
***, ** and * are respectively the 1%, 5% and 10% significance levels. Source: Author's calculation

Figure 1: Plot of cumulative sum of recursive residuals



Source: Author's calculation

Figure 2: Plot of cumulative sum of squares of recursive residuals



Source: Author's calculation

1985–2015 by employing ARDL model. We ensure the absence of I(2) variables by utilizing the ADF and PP tets, which validates the appropriate use of the ARDL model for further analysis. The bound test result affirms the cointegration among the variables, and thus, the estimation of ARDL model can be implemented. The diagnostic tests demonstrate no errors concerning serial correlation, normality, model misspecification, and heteroscedasticity and implies the stability of our model. Besides, the Error Correction Model (ECM) is necessary for evaluating the short-run effects. Also, the negative error correction term with considerably small p-value acknowledges the cointegration among the variables and shows that CO_2 emission will return to equilibrium subsequent to the short-run shock stemming from the impacts of its determinants.

Our findings indicate that energy consumption, industrialization and GDP per capita can raise CO_2 emission, while globalization lowers

CO_2 emission in the long-run. Energy consumption positively impacts CO_2 emission as it is one of the major inputs for economic growth and development in Vietnam. Consequently, it is essential to enact policies encouraging efficiency (especially reducing electricity waste), saving energy sources and upgrading obsolete technology towards modern and energy-saving one. Furthermore, Vietnam should develop and exploit renewable sources providing green energy and minimally influencing the environment such as solar, wind, geothermal and biofuels power because Vietnam has favorable geographical and natural conditions.

Also, we detect the beneficial effect of globalization on Vietnam's environmental quality as evidenced by its negative causal connection with CO_2 emission. This necessitates, concerning globalization and environmental aspects, stricter environmental standards for foreign investment projects and trade activities in Vietnam, the prohibition against importing outdated technology, the limitation on using high-energy-consuming machinery and equipment, the promotion of environmentally friendly technology and knowledge transferred through globalization, which can be incorporated into industrialization and urbanization processes so as to achieve sustainable development.

Although this study overall evaluates the impacts of several important factors for Vietnam's socioeconomic development including globalization, industrialization, urbanization and GDP per capita on CO_2 emission, the time series are inadequately large due to the availability of data. Moreover, the scrutiny of influences from components of energy consumption (e.g., consumption by each category of energy, by industrial sector and population), globalization, and industrialization (e.g., industrialization by economic sector) on CO_2 emission in Vietnam has not been inspected, which should be addressed in future researches.

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