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Article

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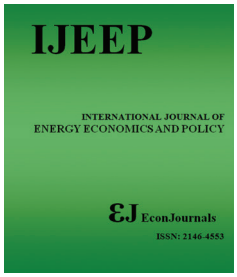
International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Dung Tien Pham/Hieu Van Pham et. al. (2023). Renewable energy consumption, energy efficiency, trade, economic development and FDI on climate change in Vietnam. In: International Journal of Energy Economics and Policy 13 (6), S. 8 - 14. https://www.econjournals.com/index.php/ijeep/article/download/14571/7541/34954. doi:10.32479/ijeep.14571.



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(6), 8-14.

Renewable Energy Consumption, Energy Efficiency, Trade, Economic Development and FDI on Climate Change in Vietnam

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Received: 07 June 2023 **Accepted:** 12 September 2023 **DOI:** https://doi.org/10.32479/ijeep.14571

ABSTRACT

This study aimed to investigate the impact of green energy consumption, energy efficiency, foreign direct investment, economic growth, and trade (import and export) on greenhouse gas emissions (GHG) in Vietnam between 1990 and 2019. This study investigates the long-term cointegration relationship to find out the impact of renewable energy consumption, energy efficiency, trade, economic development, and foreign direct investment on climate change in Vietnam. The research results show a long-term relationship between the above variables and the reduction of greenhouse gas emissions. These findings highlight the profound importance of renewable energy consumption for ecologically sustainable development in Vietnam and serve as an important resource for other countries worldwide. world when it comes to ecological security. This study recommends using environmentally friendly and energy-saving technologies, using renewable energy to mitigate climate change, and implementing the most recent government policies to neutralise greenhouse gas emissions to achieve sustainable development goals.

Keywords: Trade Openness, Greenhouse Gas Emission, Renewable Energy, Climate Change
JEL Classifications: O1, O4, Q2, Q3, Q5

1. INTRODUCTION

One of the world's most serious problems is climate change. In most countries, efforts are being made to reduce greenhouse gas (GHG) emissions regardless of economic expansion. Recent emissions reduction policies have encouraged more sustainable consumption and production behaviour, actively managed potential impacts on the environment and local communities, and promoted resource management throughout the supply chain. Dong et al. (2021) studied the effect of economic growth on greenhouse gas emissions using panel data and found out that economic growth affects GHG emissions in most countries. When assessing the impact of economic development on the environment, many scholars have emphasised the differential impact of economic progress on greenhouse gas emissions at different stages of development, corresponding to the principle of economic development and Environmental Kuznets Curve Theory (EKC) (Azam and Khan, 2016). According to EKC, economic growth and the environment have an inverted U-shaped relationship. The EKC is the level of pollution that increases as countries develop but begins to decline when incomes rise above a certain threshold.

Furthermore, economic growth will not reduce greenhouse gas emissions. Economic development impacts the environment due to scale, composition, and technology. The scale effect illustrates that more energy consumption and production emit more pollutants than greenhouse gas emissions increase. When the growth in the economy drives a structural change in the economy towards less polluting activity, a synergy effect occurs. The technical effect states that developed economies use more resources to replace dirty technology with clean technology as environmental quality improves. So these assumptions say that other factors besides GDP affect the EKC hypothesis negatively and positively Aslan et al. (2022), Beşe and Kalayci (2021).

Many studies have determined that green or renewable energy sources are important in reducing greenhouse gas emissions thanks to clean energy sources and technical advances. Foreign direct investment (FDI) promotes technological innovation, which may create a cleaner environment. However, the main issues of climate change policy are globalisation and expansion of the economy, which increases output with energy use, causing an increase in greenhouse gas emissions. Furthermore, when assessing the effect of trade on greenhouse gas emissions, it is important to take into account leakage, which has yet to be overlooked in previous studies. Leakage is the process by which greenhouse gas emissions decrease as the industry moves from developed to developing countries. Due to stricter rules, rich nations shift their polluting areas to poorer countries, reducing their emissions (Steffen and Smith, 2013).

However, there needs to be more research that takes into account the impact of green energy consumption, energy efficiency, trade, economic development, and FDI on climate change in Vietnam. To bridge this research gap, this analysis increases the relationship between renewable energy consumption, energy efficiency, trade, economic development, FDI, and climate change. Therefore, the primary goal of climate change policy should be to increase green energy consumption, use energy efficiently and develop green technology to slow the growth rate of greenhouse gas emissions. Therefore, the main objective of this study was to evaluate the main factors affecting greenhouse gas emissions, both negative and favorable.

A few things about this study set it apart from previous studies. To the best of our knowledge, this is the first study to examine the specific impacts of renewable energy consumption, energy efficiency, trade, economic development, and FDI on climate change in Vietnam from 1990 to 2019. The study's results will allow economists to understand better the environmental impacts of renewable energy consumption and energy efficiency, which will assist in formulating policies in a suitable environment. They will also help to predict better the importance of green technology and green energy consumption in reducing environmental pollution. Second, this is the first study to examine the effects of green energy consumption, energy efficiency, trade, economic development, and FDI on greenhouse gas emissions, which have been overlooked in other studies. Third, this study uses the ARDL model to address endogeneity, variance, autocorrelation, and the presence of regression coefficients with different integration levels, this study uses powerful estimators ADSL model. The research results will help policymakers have a more general view of the impacts on the environment.

2. LITERATURE REVIEW

According to most studies, economic development is the main factor causing greenhouse gas emissions (Tran et al., 2022). Thus, the EKC theory indicates that environmental degradation increases higher as per capita economic growth increases until the turning point, when there is a decline in the environmental pollution (Beşe and Kalayci, 2021).

Natural resource rents have been used in BRICS countries to investigate the links between carbon emissions, economic development, renewable energy use, and natural resources. Using total natural resource rents, Balsalobre-Lorente and colleagues assessed the associations between renewable energy, economic progress, natural resources, and carbon dioxide emissions. Many researchers have tried to study the relationship between renewable energy use, economic growth and ecological damage (Baloch and Meng, 2019).

According to Omri et al. (2019), FDI contributed to environmental degradation in Saudi Arabia, while it found a reduction in environmental damage in Asian countries caused by FDI. According to Cheng et al., (2019), FDI has an important effect on environmental degradation and investment in sustainable energy reduces environmental devastation. Zhang and Zhou (2016) investigated the link between FDI and environmental degradation in China. It concluded that FDI reduces environmental damage and equipment level, as well as industrial structure, reduces environmental pollution in China. Phung et al. (2022) support the pollution hypothesis that foreign direct investment can stimulate green growth in Southeast Asian countries. (Quang and Thao, 2022) explained how green bonds have adverse short-term effects on energy intensity. In addition, factors that may affect energy intensity include per capita income, economic integration, and availability of renewable energy sources. In contrast, ASEAN modernisation may affect the energy intensity in the other direction.

Trade is one of the critical drivers of the growth (Kong et al., 2021). Furthermore, trade includes two variables, export and import. Most researchers measure openness to trade as the ratio of exports plus imports to GDP (Tran et al., 2022). In EKC theory, this representation is not valid because it involves two variables. Still, it is valid if both are included because exports are directly related to increased production, but imports decrease production levels. Many studies consider import and export instead of trade openness Sun et al. (2018). According to Jebli and Youssef (2015), imports and exports per capita in Tunisia have a positive relationship with GHG emissions per capita. Furthermore, Jebli et al. (2016) demonstrated that import and export activities in OECD countries reduce greenhouse gas emissions. In the case of the UAE increasing exports reduces greenhouse gas emissions in the long run. (Xu and Lin, 2015) reveal that exporting reduces greenhouse gas emissions in China. In addition, research that includes export and import data may reveal leakage. Leakage is transferring dirty industries from developed countries to less developed countries through trade (Najarzadeh et al., 2021). Meanwhile, in less developed countries, growth in exports and production can increase greenhouse gas emissions.

Energy efficiency and green energy are predicted to be key indicators of how climate change policy can alleviate the problem of climate change. Other scholars (Li et al., 2020; Li et al., 2022) have demonstrated that energy efficiency can help mitigate the increase in greenhouse gas emissions. Özbuğday and Erbas (2015) found that 24 out of 36 countries'

energy efficiency strategies effectively reduced greenhouse gas emissions. Energy intensity is a negative factor slowing the rate of increase in greenhouse gas emissions. (Haron et al., 2005) established a bidirectional relationship between greenhouse gas emissions and energy intensity. Green energy is an alternative to carbon energy, which helps reduce greenhouse gas emissions. According to Khan et al. (2021), greenhouse gas emissions in the United States are adversely related to renewable energy. Similar conclusions have been verified in 17 OECD countries. Regarding the use of renewable energy in EU countries, Bölük and Mert (2014) indicates that green energy can reduce energy consumption by 50% compared to fossil energy. Less developed countries such as Tunisia, Indonesia, Malaysia, Turkey, India, and BRICS have stated that using renewable energy has a negative effect on greenhouse gas emissions. Apergis and Payne (2010) found that renewable energy use did not impact greenhouse gas emissions in 19 developing and developing countries. In the United States example, Menyah and Wolde-Rufael (2010) showed a one-way causal relationship between renewable energy use and greenhouse gas emissions. Adebayo (2022) concluded that economic growth and renewable energy use have positive and negative impacts on environmental pollution, respectively. Innovation significantly and negatively reduces the association between financial inclusion and environmental degradation in all quintile distributions. In the long run, Adebayo (2022) finds that using renewable energy, political risks, and commercial globalisation all help slow environmental degradation.

FDI is an indicator that promotes economic growth by introducing management skills, production processes, increased productivity and technology transfer (Shahbaz et al., 2015). Foreign investors use advanced technology and management skills to clean up the host country's environment. Thus, FDI promotes technological innovation, low-carbon growth and increased energy efficiency. The polluting paradise hypothesis states that FDI supports economic growth at the expense of the environment. Adebayo (2022) analysed the relationship between variables at different frequencies and time frames using an innovative wavelet matching method. The wavelet correlation results show that renewable energy consumption improves environmental quality in the short and medium term; fossil fuel use degrades environmental quality in the short and medium term; FDI inflows improve environmental quality at all frequencies; and economic complexity degrades environmental quality in the short, medium and long term. Adebayo et al. show that at different quintiles, environmental degradation is accelerated by globalization, tourism, economic expansion, and energy consumption. Akadiri et al. (2022) concluded a positive relationship between ecological footprint and the use of renewable and non-renewable energy, economic growth, and economic complexity. Using ARDL, Xie et al. (2022) show that economic growth and structural change lead to an increase in CO_2, while an increase in renewable energy and technological innovation leads to a decrease in CO_2 emissions. Du et al. (2022) revealed that high-tech industry, economic growth, and FDI increase CO_2 emissions, while renewable energy consumption reduces CO_2 emissions.

Furthermore, at the Gulf Corporations Council, Al-Mulali and Tang (2013) found that FDI has a neutral effect on greenhouse gas emissions. FDI increases greenhouse gas emissions in China, Malaysia, and sub-Saharan Africa. However, FDI reduces greenhouse gas emissions in developing countries such as Vietnam and China. (Omri and Kahouli, 2014) focused on three regions: Latin America and the Caribbean, Europe, and Central Asia, North and Sub-Saharan Africa, and the Middle East, and discovered a two-way causal relationship between greenhouse gas emissions and FDI, excluding North Asia and Europe. However, research on the impact of energy efficiency, green energy use, economic development, trade, and FDI on greenhouse gas emissions in Vietnam is still very limited. Therefore, the aim of this study is to fill that gap.

3. RESEARCH DATA AND METHODS

3.1. Theoretical Analysis

In recent decades, countries have changed how they consume energy to promote green sources. However, these energies have a significant effect on environmental degradation. Therefore, regardless of whether all economies use green energy, it is important to understand why this issue must be solved. Therefore, this study has evaluated the relationship between green technology development and environmental pollution. The model can be expressed as;

Dong (2021) states that green energy burns cleaner than oil and coal. To further assess the impact of green energy consumption, FDI, trade and energy efficiency on greenhouse gas emissions in Vietnam, this study extended the equation (1) as follows:

$$GHG=a0+\delta_1 GDP+\delta_2 GE+\delta_3 EF+\delta_4 FDI+\delta_5 TO \quad (2)$$

where
GHG: Greenhouse gas emissions
α: is the intercept
GE: is green energy, where renewable energy is used as a representative of green energy
EF: refers to energy efficiency
FDI: Foreign direct investment
TO: represents the open trade variable
GDP: Gross Domestic product.

All variables are converted to the natural logarithm before model estimation to normalise the data and provide accurate estimates by supporting the elastic regression coefficient evaluation. As a result, the equation. The log-linear econometric functions of Table 1 can now be written as:

$$LnGHG_t=\alpha_0+\delta_1 lnGDP_t+2lnGE_t+\delta_3 lnEF_t+\delta_4 lnFDl_t+\delta_5 TO_t+ +\varepsilon_t$$

where t represents the time interval
and ε is the variance of the error.
δ_1–δ_5: reference coefficients of the variables.

3.2. Experimental Data

Data sources are described in Table 2. This study used data collected from WDI to meet the objectives. Data series, including

Table 1: Descriptive statistics

	GHG	EF	FDI	GDP	GE	TO
Mean	1.175730	48.11168	5355.943	7.791768	9.987234	130.8
Median	1.130500	45.01000	2307.500	6.733303	9.994669	131.8
Maximum	2.71400	76.08164	16120	9.540480	11.378	210.4
Minimum	0.306	18.65000	180.0000	4.773587	7.8635	66.21
SD	0.727447	16.90182	5007.049	1.242498	0.8976	43.17
Skewness	0.547864	0.049456	0.771182	0.574759	−0.4572	0.174
Kurtosis	2.311940	1.957212	2.260129	2.652364	2.9688	1.992
Jaruque-bera	2.092560	1.371489	3.657867	1.802804	1.1304	1.420

Table 2: Description of variables

Variable name	Short variable name	Measurement unit	Database
Greenhouse gas of Viet Nam	GHG	Kilo tons	WDI
Foreign direct investment in Viet Nam	FDI	Foreign direct investment, net inflows (% of GDP)	WDI
Trade openess	TO	Imports and export of goods and services (% of GDP)	WDI
Gross domestic product	GDP	PPP (constant 2011 international $)	WDI
Energy efficiency	EF	GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	WDI
Green energy	GE	Renewable energy consumption (% of total final energy consumption)	WDI

Table 3: Unit root test results

Test	LogGHG	logFDI	logTO	logGDP	logEF	logGE
At level I (0) Constant	−1.513944	−1.301228	−0.867519	−2.994745	−2.399520	1.488579
	(−3.699871)	(−3.689194)	(−3.699871)	(−3.689194)	(−3.679332)	(−3.724070)
At first difference I (1)	−4.808585	−3.997124	−4.524879	−5.063016	−4.466671	−4.164540
	(−3.699871)	(−3.689194)	(−3.699871)	(−3.699871)	(−3.689194)	(−3.724070)

Table 4: Optimal lag selection results

Lag	LL	LR	FPE	AIC	SC	HQ
0	−26.74182	NA	0.494676	2.133986	2.1823	2.1479
1	25.820161	97.0351	0.009373	−1.83232	−1.7355	−1.8044
2	25.827763	0.013448	0.010124	−1.75598	−1.6108	−1.7141
3	29.668554	6.499801*	0.008149*	−1.9745*	−1.7809*	−1.9187*
4	30.24781	0.935835	0.008437	−1.70020	−17002	−1.8724

Table 5: Cointegration test

Model	F-statistics	LCB (I [0])	UCB (I [1])
logGHG=f (*logFDI*, *logTO*, *logGDP*, *logEF*, *logGE*)	5.427	2.63	3.35

*1% critical value for the bounds test. LCB: Lower critical bound

greenhouse gas emissions (GHG), energy efficiency (EF), renewable energy consumption, were used as proxies for green energy (GE), TO (trade openness), and foreign direct investment (FDI), gross domestic product (GDP) is used in this study. The time period of this study is 1990–2019. Descriptions of variables are provided in Table 2.

4. EMPIRICAL RESULTS AND ANALYSIS

4.1. Descriptive Statistics

The study uses data for the period 1990 - 2019. Descriptive statistics for variables include normal distribution, standard deviation, median, mean, Jarque-Bera statistics show that all series have finite covariance and zero mean.

4.2. ADF Unit Root Test

In this study, I use the ADF unit root test method to avoid spurious relationships. The results of the unit root test are shown in Table 3. The unit root test shows that the stationary variables are at the order difference.

4.3. ARDL Bounds Test and Lag Order

The study uses the Bounds test to determine the cointegration relationship between variables. We use the AIC criterion to determine the optimal lag and consider the long-run relationship between the series to perform the Bounds test.

After selecting a lag that matches the AIC criteria, the article uses lag 3 to determine the cointegration between the variables using the ARDL limit test (Table 4).

The results of the cointegration test are presented in Table 5. The hypothesis of the study is that if the F-statistic is lower than the lower critical limit chain, there is no cointegration, if the F-statistic is higher than the UCB chain, there is no cointegration. In this

Table 6: Long-run dynamics using ARDL (2,3,3,3,3,1) model

Variables	Coeff.	t-stats	Prob.
Constant	−14.87391	−8999	0.000
logFDI	0.107	2.999882	0.02
logTO	0.726	4.749203	0.003
logGDP	0.297	6.059802	0.0009
logEF	0.204	2.703584	0.003
logGE	−0.342	−1.44460	0.001
Diagnostic test			
Serial correlation (Breusch-Godfrey LM test for autocorrelation)	0.41 (0.67)		
R^2	0.99	Adjusted R^2	0.99

* is significant at 1% critical level, ** is significant at 5% critical level and ***is significant at 10% necessary level

study, there exists a long-run relationship between the variables because the calculated F-statistic (5,427) is higher than UCB [I_1] (3.35) at the critical value of 1%.).

4.4. ARDL Approach

Table 6 presents the long-run equilibrium relationship between the variables estimated by the ARDL (2,3,3,3,3,1) method using the ECM. The long-run coefficient estimation results show that FDI has a positive and significant impact on GHG emissions with a 1% increase in FDI, a 10.7% increase in emissions in the long run at a significant at 1%. Energy consumption has also long been considered a cause of environmental degradation. Results from the ARDL model show that a 1% increase in energy use increases emissions by 2.04%. Similarly, openness to trade also has a positive impact on emissions and increases emissions. However, the source of emissions has an inverse relationship with renewable energy consumption. Emissions will decrease by 0.3% if renewable energy use increases by 1%.

5. RESULTS AND DISCUSSION

Initiatives on energy saving and emission reduction put pressure on economic growth. Therefore, carbon-neutral strategies are essential. However, many factors, such as energy use, GDP, TO, and GE, affect reducing carbon. In the process of using energy, the primary energy activities in Vietnam are still fossil fuels such as petroleum, coal, and renewable energy sources that still need improvement. The results obtained from the research model show that most of the model's variables positively impact GHG emissions. Next, the long-term cointegration between the variables was tested, with the ARDL limit test and the Bounce cointegration test indicating no cointegration relationship.

The long-term ARDL test results show that an increase in fossil energy use significantly affects emissions over the long term. Using fossil fuels through the rise of vehicles has a considerable impact on climate change, increasing GHG emissions due to energy consumption. This study is also consistent with previous studies Xia et al. (2021) and Setyari (2021).

The relationship between GHG emissions due to energy consumption and economic development is also one of the hot topics in the global debate. Economic growth and energy use as the main transmission lines are responsible for environmental degradation. According to our long-term results, EF, GDP, and FDI contribute significantly to Vietnam's GHG increase. These results for Vietnam can be explained by the rapid economic growth in recent years and the high energy consumption that makes Vietnam among the largest emitters. Vietnam's energy sector is highly dependent on fossil fuels.

Moreover, Vietnam is facing a choice between economic development and GHG emissions. Our results show that GDP increases carbon emissions and is similar to the effects of Zmami and Ben-Salha (2020). The results are in agreement with those of (Zhang and Zhou, 2016), (Liobikienė and Butkus, 2018), and (Alvarez-Herranz et al., 2017). The GDP result is expected to be positive and statistically significant at the 9% level, meaning that a 1% increase in GDP would increase greenhouse gas emissions by 2%. This confirms that GDP growth has increased emissions, thereby causing environmental pollution. The results are consistent with (Sarkodie and Strezov, 2019).

In addition, variables such as trade openness and foreign direct investment also positively affect the increase in carbon emissions in Vietnam. This study is also consistent with the research results of Tran et al. when studying both long-term and short-term effects. However, using renewable energy such as solar energy and sea wind has opposite impacts on GHG emissions. This is one of the strategic suggestions for Vietnam in transitioning from fossil energy to renewable energy. In addition, Vietnam needs to increase its investment in low-carbon technologies to meet its emission reduction targets committed in COP26 and move towards a carbon-neutral economy by 2050.

The relationship between exports and greenhouse gas emissions is positive and significant; exports increased by 1%, leading to an increase of 0.8% in emissions; This result is consistent with Mohamued et al. (2021) and Iqbal et al. (2021). Table 6 also shows a negative and statistically significant relationship between energy efficiency and greenhouse gas emissions. The results showed that a 1% increase in energy efficiency pushed emissions by 31%. However, the use of renewable energy must last for a long time. If consumption is not sustainable, it can affect the environment. Therefore, green energy consumption in Vietnam negatively affects the climate when using the ARDL method.

The results of an empirical investigation into the relationship between green energy consumption, energy efficiency and trade, economic growth, and greenhouse gas emissions reveal much about strategies and policies that can help limit greenhouse gas emissions towards appropriate development goals. This study proves that green energy consumption and energy efficiency reduce emissions while open trade, GDP and FDI promote climate change mitigation. Furthermore, adopting green energy improves environmental quality and leads to reforming the energy-dependent economy, according to (Sarkodie and Strezov, 2019). The use of green energy is directly linked to long-term improvement, that is, economic and social development, access to power, and reduced impact on health and the environment.

6. CONCLUSION AND POLICY IMPLICATIONS

Climate change is a severe planet-wide problem. This study analysed the impact of energy efficiency, green energy consumption, trade, FDI and economic growth on greenhouse gas emissions. This study identified the most critical climate change issues and possibilities for policymakers to consider. Furthermore, regarding GHG emission factors, economic development significantly and positively impacts GHG emissions. In Vietnam, climate change remains the main challenge. While analysing the impact of import and export trade, both variables are considered to evaluate the influence of separate variables. The results show that GHG emissions are reduced because imports accept leakage.

Furthermore, economic growth increases greenhouse gas emissions in the long run. To solve the problem of climate change, Vietnam should apply new technological processes to reduce greenhouse gas emissions. Meanwhile, FDI significantly affects climate change. Thus, in Vietnam, FDI has yet to reach the stage of making a significant contribution to the reduction of greenhouse gas emissions. Furthermore, increasing the share of green energy consumption and using energy efficiently are Vietnam's main opportunities to reduce greenhouse gas emissions.

There are several important policy implications woven throughout the study results. First, economic growth exacerbates environmental pollution. The Vietnamese government must adopt appropriate strategies to reduce environmental pollution. The Government of Vietnam must take necessary measures to reduce climate change as economic expansion exacerbates this situation.

This study offers some innovative insights but has significant limitations that could open up new areas for further research. The impact of energy efficiency, green energy consumption, trade, FDI, and economic growth on greenhouse gas emissions are controversial issues influenced by many institutional and social influences and possibly discussion. It also guides future research on other developing countries that consume non-green energy and generates more emissions, using panel and country-specific data analysis to provide more accurate information. Finally, expand this study to include additional contributing aspects to different case studies, such as urbanisation and natural resources.

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