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Analysis of The Effect on Economic Growth, Foreign Investment, Population and Energy Consumption on Co2 in Asean Economies

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Abstract: ASEAN member states have proactively taken steps to address climate change issues at the national, regional and global levels. However, the rapid growth of the global economy and human activities on climate is increasing and has become a cause of environmental damage. This study aims to examine the effect of economic growth (GDP), foreign investment (FDI), population and energy consumption on CO2 emissions and examine the determinants of dynamic interaction of long- and short-term relationships using fixed effects panel data models and vector error correction models (VECM) for five ASEAN countries namely Indonesia, Malaysia, Philippines, Thailand and Vietnam using panel data with a time span of 1997 to 2020. The results of the fixed effects panel model test confirmed that economic growth, foreign investment and energy consumption affect CO2 emissions while population has no effect on CO2 emissions. In simultaneous testing, economic growth, foreign investment, population and energy consumption variables jointly affect CO2 in ASEAN countries. In addition, the VECM test results confirm that economic growth, foreign investment and energy consumption affect the CO2 of ASEAN countries in the long run, while population has no effect on CO2 of ASEAN countries in the long run. Other findings confirmed the existence of homogeneous causality relationship of GDP and FDI to CO2 and vice versa CO2 has homogeneous causality relationship to GDP and FDI. Population and Consumption have heterogeneous causality relationship to CO2. These variables are different in different situations and in different countries. The above results are expected that stakeholders can formulate appropriate policies.

Introduction

ASEAN member states have proactively taken steps to address climate change issues at the national, regional and global levels, as reflected in ASEAN member states' national reports (AMS), the ASEAN community vision 2025, and active participation in the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC) (ASEAN Secretariat, 2021). For the Paris Agreement, ASEAN countries pledged to reduce their emissions by 2030 and introduced various policies to fulfill their pledges (MIT, 2017). The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) is an important step in addressing the environmental crisis (Nur Mozahid, Akter, & Hafiz Iqbal, 2022). The main goal of this agreement is to reduce CO2 emissions to keep global warming below 2°C (Plakitkina, Plakitkin, & Dyachenko, 2021). The Association of Southeast Asian Nations (ASEAN) countries face the challenge of reducing greenhouse gas (GHG) emissions while expanding energy supplies to meet the needs of their rapidly growing economies (MIT, 2017). From an economic standpoint, developing countries face many challenges; poverty, unemployment, and low per capita income are still more important to local residents than protecting the environment (Hanif, Faraz Raza, Gago-de-Santos, & Abbas, 2019). Moreover, efforts to increase per capita income in developing countries trigger new negative externalities in the form of natural resource depletion, environmental degradation and global warming (Hanif et al., 2019).

According to the Intergovernmental Panel on Climate Change (IPCC) report established in its 5th assessment report that there is more than 95% probability that human activities are responsible for global temperature rise (M. A. Abbasi, Parveen, Khan, & Kamal, 2020). One of the key factors for the mid-20th century increase in global warming in Asian countries is economic activity. Among greenhouse gas emissions, carbon dioxide (CO2) is the most polluting source accounting for more than 60% of the global greenhouse effect (M. A. Abbasi et al., 2020). CO2 emissions from fossil fuel combustion and various economic activities are major contributors to global climate change. Floods, droughts and forest fires are some of the climate change impacts caused by CO2 emissions (Savage and Qi Feng., 2020). Climate change also adversely affects crop productivity in many areas, resulting in food insecurity and poverty, particularly in developing countries, and is responsible for the accumulation of anthropogenic CO2 emissions, which account for the majority of global GHG emissions (Nur Mozahid et al., 2022). Developing countries with large land masses, populations, and emerging economies have great potential for carbon reduction, but they require substantial financial and technical support to utilize their physical capital for global goals as stated in the Paris agreement (Lateef, Kong, Javeed, & Sattar, 2021). The ASEAN region consists of diverse environmental zones and experiences different climate change impacts. CO2 emissions are consistently increasing in the ASEAN region. There are several economic factors that contribute to CO2 emissions such as foreign investment, economic growth, energy consumption, labor force, population, inflation, tourism, transportation (Bakhsh, Rose, Ali, Ahmad, & Shahbaz, 2017).

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Usually, gross domestic product (GDP) per capita, foreign direct investment (FDI), and remittances are used when estimating the economic status of a country. Economic growth in various countries triggers intensive energy use, thereby increasing CO2 emissions, thus, there is a direct relationship between pollution and development and economic growth of GDP (Mohsin, Naseem, Sarfraz, & Azam, 2022). Foreign investment inflows, which can also act as a determinant of CO2 emissions, refer to the value of cross-border transactions involving direct investment during a certain period, thus creating close links between different economies (Shaari, Lee, Ridzuan, Lau, & Masnan, 2022). Some argue that foreign investment can harm the environment as higher production releases more CO2 into the air (Nie et al., 2022). Environmental degradation is caused by rapid population growth, economic growth (GDP) driven through industrialization in developing countries, which in turn increases carbon emissions (Nur Mozahid et al., 2022). From the description above, there is a gap between economic activity and CO2. On the one hand, ASEAN countries want to encourage the economic development of their countries by carrying out various kinds of economic activities, while these economic activities can contribute to an increase in CO2. On the other hand, the increase in CO2 will have an impact on environmental conditions which will further affect economic activities that run ineffectively and efficiently.

The relationship between economic activity and CO2 has been empirically studied by many researchers (Rafique, Li, Larik, & Monaheng, 2020) showing that foreign direct investment has a negative and statistically significant long-term relationship with CO2 emissions, while economic growth, population, and energy use were found to contribute statistically significantly and positively to carbon emissions. Similarly, (Hanif et al., 2019) stated that in developing countries, efforts to promote economic growth contribute to CO2 emissions, and fossil fuel consumption contributes to carbon emissions and environmental damage at the regional level. In addition, empirical results highlight that foreign direct investment is a source of environmental degradation that increases carbon emissions at the domestic level. The relationship between CO2 and economic growth is shown by (Iqbal, Tang, & Rasool, 2023) that carbon emissions, renewable energy consumption, and FDI, have a significant long-term positive impact on economic growth. In research (Mai, 2023) shows that FDI flows bring positive aspects to the renewable energy sector, while GDP and CO2 emissions have a negative impact. Energy use is one of the factors detrimental to environmental quality in BRICS countries. Similarly, economic growth increases CO2 emissions (Rauf et al., 2023). The same thing was also conveyed by (M. A. Abbasi et al., 2020) the results showed a positive and significant impact of population and energy consumption on CO2 emissions, also highlighting a two-way causality relationship between energy consumption and population, while a one-way causality relationship exists between energy consumption and CO2 emissions. The results of the study (Muhammad Waqas Ashraf, Hafeez ur Rehman, & Imran Sharif Chaudhry, 2020) show that economic growth, foreign investment, population and fossil fuel consumption generate CO2 emissions and worsen the environmental situation at the regional level.

Establishing a relationship between carbon emissions, renewable energy consumption, and economic growth has attracted the attention of researchers around the world. Numerous empirical studies have been conducted to investigate the relationship between economic growth and environmental quality but have found mixed and uncertain results. While other studies show an inverse relationship between economic growth and environmental quality.

The use of renewable energy ensures the development of energy processes but also minimizes the negative impact on the environment. In recent years, the role of renewable energy has been increasingly emphasized and attracted the attention of academics and energy policy analysts around the world. Most studies use the Johansen cointegration test and Granger causality test to show the relationship between renewable energy and economic sectors such as GDP and FDI (Grabara et al., 2021). From the findings (Rafique et al., 2020) provide results that Foreign Direct Investment in BRICS countries have a negative and statistically significant long-term relationship with CO2 emissions, while economic growth, population, and energy use are found to contribute statistically significantly and positively to carbon emissions. (Handy Wijaya, 2017) also revealed that foreign direct investment has nothing to do with CO2. While there is a positive relationship between GDP, population and energy consumption to CO2. Regarding the population, different results are shown by (Agung PS, Prima; Hartono, Djoni; Alam Awirya, 2017) showing that population has no significant impact on CO2 emissions while economic growth has a significant relationship with CO2 emissions. (Febriyastuti Widyawati, Hariani, Lopa Ginting, & Nainggolan, 2021) economic growth has a negative and significant effect on carbon dioxide gas emissions, while the urban population variable has a positive and significant effect on carbon dioxide gas emissions in ASEAN countries in 2000-2014. different results are also shown by (Wang et al., 2019) that increasing population has contributed to reducing CO2 emissions and energy intensity has a positive impact on CO2 emissions.

However, since the results are inconsistent, further exploration is needed to clarify the issue. Therefore, this study seeks to investigate potential factors such as economic growth, foreign direct investment (FDI), population and energy consumption on CO2 emissions.

The resulting pollution problems, such as CO2 emissions, have also become the focus of global research and attention (He, Chang, Li, Li, & Li, 2020). Several studies have been conducted on the effect of economic activities that contribute to the increase of CO2 with different indicators of economic activities, the existing literature provides mixed results, many of the studies are centered on developed countries, and others concentrate on developing countries. However, few of the existing studies have examined developing Asian countries, focusing on the ASEAN region with more indicators of economic activity. Moreover, it focuses on ASEAN countries that produce high CO2 such as Indonesia, Malaysia, Philippines, Thailand and Vietnam (ASEAN Secretariat, 2021) where these countries are geographically close.

Therefore, this study presents a panel with five ASEAN countries and indicators of economic activity, namely economic growth, foreign investment, population and energy consumption to gain an understanding of the influence and relationship of indicators on CO2 in ASEAN countries with the title Analysis of the Effect of GDP, FDI, Population and Energy

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Consumption on CO2 in ASEAN Economies. To solve certain pollution problems, countries need to pay more attention to their annual economic development (Mohanty & Sethi, 2022). This panel data will start from 1997 to 2020, during which time many economic events occurred involving the Asian financial crisis in 1997-1998, structural reform economic recovery, and strong economic growth in the early 21st century. Over time, there have also been economic developments related to globalization, changes in government policies, and the impact of the COVID-19 pandemic in 2019-2020 which have affected various economic sectors in developing countries in the ASEAN region. To see the influence of variables and the relationship between variables, the data were analyzed with a fixed-effects panel data regression model and a Vector Error Correction Model (VECM) model. The general objective of this study is to examine the effect of independent variables namely economic growth (GDP), foreign investment (FDI), population and energy consumption on CO2 in ASEAN countries and to find out whether the independent variables have a long and short-term relationship with CO2 by providing a complete and accurate picture and presenting data in a way that is easy to understand and interpret.

The end result of this study hopes to add to the existing literature by exploring the influence and interrelationship between economic growth, foreign investment, population, energy consumption and the environmental impact caused by additional CO2 in the context of developing countries. The findings of this study provide empirical evidence on the role of these factors in determining environmental impacts in ASEAN countries, and have implications for policy makers and stakeholders in addressing environmental challenges such as global warming and climate change.

Research Method

Sample and Data Source

A quantitative research approach was used in this study and this research is classified as descriptive research. The sample of this study consists of five ASEAN countries. Data collection is done by identifying data sources and selecting relevant data on the World Bank or World Development Indicators by using data collected from the World Bank website. For this study, we used balanced panel data from 1997 to 2020 from five ASEAN countries: Indonesia, Malaysia, Philippines, Thailand, and Vietnam. One dependent variable (Y) and four independent variables (X1, X2, X3, X4) namely Carbon Dioxide Emission (Y), Economic Growth (X1), Foreign Investment (X2), Population (X3), and Energy Consumption (X3). This study will investigate the effect of the independent variables on carbon dioxide emissions in ASEAN countries and determine if there is a long and short-term relationship between the independent variables and carbon dioxide emissions.

Measurement variables

The selection of variables was based on three strategies: first, it was decided that these indicators had an influence on the dependent variable based on the literature survey. Second, it was also necessary to ensure that the five key data related to the variables should be available in all five countries under study. Third, the research location was determined based

on the ASEAN State of Climate Change Report (ASEAN Secretariat, 2021) which states that Indonesia, Thailand, Malaysia, Vietnam and the Philippines are the largest emitters in ASEAN.

Table. 1 Description of variables and data

Variables	Simbol	Measurement	Definition
Economic Growth	PDB	*Gross Domestic Product per kapita (Current US$)*	GDP per capita is the total gross value added of the economy of all producers, plus product taxes (minus subsidies) not included in the valuation of output, divided by the population at mid-year.
Foreign Investment	PMA	*Foreign direct investment, net inflows (BoP, current US$).*	Equity flows of direct investment in the economy are reported.
Population	PDDK	*Urban population growth (annual %).*	As defined by the Office of National Statistics, urban population is people living in urban areas.
Energy Consumption	KE	*Renewableenergy consumption (% of total final energy consumption)*	Renewable energy consumption is the share of renewable energy in total final energy consumption i.e. fossil fuels consisting of coal, oil, petroleum and natural gas products.
Carbon Dioxide Emissions	CO2	*CO2 Carbon Emissions (Metric tons per capita)*	Carbon dioxide produced by the consumption of solid, liquid and gaseous fuels and the combustion of gases is also included in emissions from cement manufacture and fossil fuel combustion.

Data Source: World Development Indicators

Model Specification

Panel data regression

The panel data model used in this study is as follows:

$CO2_{it} = \alpha + \beta1PDB_{it} + \beta2PMA_{it} + \beta3PDDK_{it} + \beta4KE_{it} + \varepsilon it$; t=1,…,T, i=1,…,N

Here GDP is Gross Domestic Product, PMA is Foreign Direct Investment, PDDK is population, KE is Energy Consumption. ε is the error term. Index i (i = 1, ..., N) indicates the sector, α indicates the magnitude of the constant, β notation indicates the magnitude of the coefficient. Index i indicates the distribution of the observed units, t is the observation time, , , index t (t = 1, ..., T) also indicates the period.

Table 2. Model selection

The Testing	Result	Decisio
Chow Test	Prob. > 0,05	CEM
	Prob. < 0,05	FEM
Hausman Test	Prob. > 0,05	REM
	Prob. < 0,05	FEM

Source: (Savitri et al., 2021).

Table 3. Chow Statistical Test

P-ISSN 2828-4976
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Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	67.176642	(4,111)	0.0000
Cross-section Chi-square	147.584228	4	0.0000

Sources: output EViews 10

Based on the Chow Test results in the table, it can be seen that the significant level is 5% where the Prob value. < 0,05. That is, it can be concluded that the appropriate panel data regression model is the FEM model.

Table 4. Hausman Statistical Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	268.706569	4	0.0000

Sources: output EViews 10

Based on the results of the Hausman Test in the table, it can be seen that the significant level is 5% where the Prob value. < 0,05. That is, it can be concluded that the appropriate panel data regression model is the FEM model. In conclusion, based on the results of the Chow and Hausman Statistical tests, the best model in the study is the Fixed Effect (FEM) model).

VECM Equation Model

$\Delta \boldsymbol{Z_t} = \boldsymbol{\Gamma_i} \Delta \boldsymbol{Z_{t-1}} + \prod \boldsymbol{Z_{t-1}} + \boldsymbol{\varepsilon_t}$

Where $\Delta \boldsymbol{Zt}$ is the determinant vector of the tth predictor variable of size n x 1, ∏ is the cointegration coefficient matrix (∏ = $\boldsymbol{\alpha\beta}'$) of size $nn \times kk$, $\boldsymbol{\alpha}$ is the long-run adjustment vector, $\boldsymbol{\beta}$ is the vector of long-run parameters, $\boldsymbol{Zt\text{-}1}$ is the vector of the 1st lag independent variable of size $n \times 1$, $\boldsymbol{\Gamma i}$ is the coefficient matrix of the i-th independent variable of size $n \times n$ at i = 1,2,.... , p-1, and $\boldsymbol{\varepsilon t}$ is an $n \times 1$ residual vector (Ayundari & Setiawan, 2023).

Results and Discussion

Table 5 shows that each variable consists of 120 data which are explained as follows: the minimum GDP emission value obtained shows 3,527,831, the maximum is 1,113,210 and the average is 3,556,573 with positive Skewness greater than 0 (normal distribution skewness is at 0). This indicates that the distribution has a long right tail. The value of CO2 as revealed in

table 5 the minimum value obtained is 0.536993, the maximum is 7,719,436 and the average is 2.838171 with positive Skewness greater than 0 (normal distribution of skewness is at 0). This indicates that the distribution has a long right tail. Table 5 shows that the minimum value of FDI is -4.95E+09, the maximum value is 2.51E+10 and the average is 6.93E+09. Minimum value of population 1,655,073, maximum 4,872728 and average 2,856521. The energy consumption values in Table 5 show a minimum of 1.960000, a maximum of 60.53000 and an average of 26.79608.

Table 5. *Descriptive Statistic*

	PDB	PMA	PDDK	KE	CO2
Mean	3556.573	6.93E+09	2.856521	26.79608	2.838171
Median	2955.113	5.69E+09	2.845332	27.61000	1.925496
Maximum	11132.10	2.51E+10	4.872728	60.53000	7.719436
Minimum	352.7831	-4.95E+09	1.655073	1.960000	0.536993
Std. Dev.	2809.745	6.15E+09	0.861526	14.87627	2.123780
Skewness	1.213840	0.906133	0.559186	-0.030871	1.011539
Kurtosis	3.742041	3.588435	2.368872	2.510601	2.774545
Jarque-Bera	32.22127	18.15281	8.245404	1.216620	20.71838
Probability	0.000000	0.000114	0.016201	0.544270	0.000032
Sum	426788.8	8.32E+11	342.7826	3215.530	340.5805
Sum Sq. Dev.	9.39E+08	4.50E+21	88.32506	26335.09	536.7426
Observations	120	120	120	120	120

Source: output EViews 10

Table 6. Multicollinearity Test Results

	PDB	PMA	PDDK	KE
PDB	1.000000	0.346780	-0.193666	-0.793992
PMA	0.346780	1.000000	-0.170011	-0.267999
PDDK	-0.193666	-0.170011	1.000000	-0.021578
KE	-0.793992	-0.267999	-0.021578	1.000000

Sumber: output EViews 10

The information in table 6 above that it is free of multicollinearity or passes the multicollinearity test with information from the multicollinearity test results shows the correlation coefficient of GDP (X1) and FDI (X2) of 0.346780 < 1, GDP (X1) and PDDK (X3) of 0. 193666 < 1, GDP (X1) and KE (X4) of 0.793992 < 1. The correlation coefficient of FDI (X2) and

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PDDK (X3) of 0.170011 < 1, PDDK (X2) and KE (X4) of 0.267999 < 1. The correlation coefficient of PDDK (X3) and KE (X4) of 0.021578 < 1..

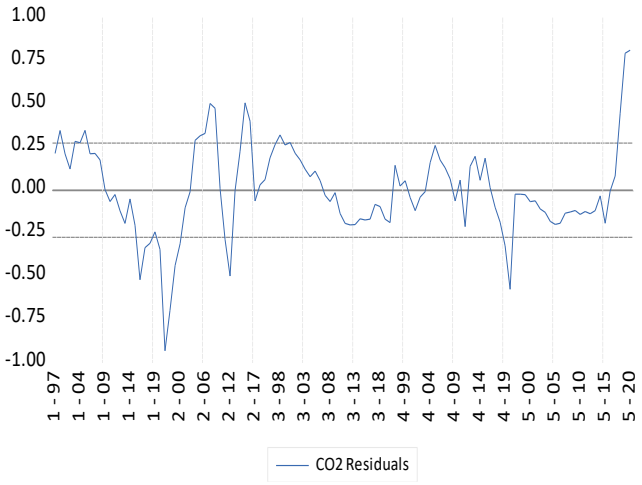

Figure 2. Residual Graph
Source: output EViews 10

Figure 2 shows that the residual graph, represented by the blue color, does not cross the 500 and -500 boundaries. This indicates that the residual variance is equal. therefore, there are no symptoms or results of the heteroscedasticity test. In addition, this result is also reinforced by the heteroscedasticity test of the ABS (RESID) Panel Least Squares (PLS) table, which reveals a probability value> 0.05, that is, it can be concluded that there are no symptoms of Heteroscedasticity or the Heteroscedasticity test passes.
So that the following Panel Data Regression Equation results are found as follows:

$$CO2 = 2.73 + 0.02*PDB – 1.79*PMA + 0.08*PDDK - 0.03*KE$$

From the results above, the constant value is 2.73, meaning that without the economic growth variable (X1), foreign investment (X2), population (X3), and energy consumption (X4), the CO2 variable (Y) will increase by 273 percent. The beta coefficient value of the economic growth variable is 0.02, if the value of other variables is constant and the economic growth variable has increased by 1 percent, the CO2 variable will increase by 1 percent. The beta coefficient value of the foreign investment variable is -1.97, if the value of other variables is constant and the foreign investment variable increases by 1 percent, the CO2 variable will decrease by 1 percent. The beta coefficient value of the population variable is 0.08, if the value of other variables is constant and the population variable has an increase of 1 percent, the CO2 variable will increase by 1 percent. The beta coefficient value of the energy consumption variable is - 0, 03, if the value of other variables is constant and the energy consumption variable increases by 1 percent, the CO2 variable will decrease by 1 percent.

Table 7. Results of the t-test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.731485	0.249437	10.95062	0.0000
PDB	0.000290	2.26E-05	12.86441	0.0000
PMA	-1.79E-11	6.75E-12	-2.653592	0.0091
PDDK	0.084220	0.047061	1.789575	0.0762
KE	-0.038915	0.004967	-7.834683	0.0000

Sources: output EViews 10

The effect of the independent variable on the dependent variable partially is as follows: Results of t table: 1,980272249. The results of the t test on the growth variable obtained the t value of 12.86441> t table, namely 1.980272249 and a significant value of 0.0000 <0.05, then H0 is rejected and Ha is accepted, meaning that the economic growth variable has an effect on CO2 in ASEAN countries, namely a positive and significant effect on CO2 carbon emissions in the long run, implying that the EKC hypothesis does not apply, indicating that there is a relationship between economic growth and environmental pollution. This is due to the greater use of natural resources, more pollution emissions, and demands for increased output, thus showing the contribution of economic growth to higher emissions and being able to increase the level of pollution or environmental degradation. The results of the t test on the foreign investment variable obtained the value of t count of 2.653592> t table which is 1.980272249 and a significant value of 0. 0091 < 0.05, then H0 is rejected and Ha is accepted, meaning that the foreign investment variable affects CO2 in ASEAN countries, which has a negative and significant effect, identifying that an increase in FDI can reduce CO2 emissions, this implies the acceptance of the Pollution Halo hypothesis and the rejection of the Pollution Haven hypothesis, meaning that foreign investment reduces environmental pollution in countries; in other words, guest countries that invest foreign direct investment have higher energy efficiency, better management capabilities, and technology diffusion. Therefore, foreign direct investment makes the environment of the developing host country better. Along with the increase in productivity, energy efficiency, and management skills caused by foreign investment, it will also cause greenhouse gas emissions to decrease in the host country. The Halo pollution hypothesis is then supported by many studies.

The results of the t test on the population variable obtained a calculated t value of 1.789575 < t table, namely 1.980272249 and a significant value of 0.0762 > 0.05, then Ha is rejected and H0 is accepted, meaning that the population variable has no effect on CO2 of ASEAN countries. Similar results are addressed (Shaari et al., 2021), (Zhao & Xi, 2022) and (PS et al., 2017) that population has no significant effect on CO2 emissions. The t test results on the energy consumption variable obtained the t value of 7.834683> t table, namely 1.980272249 and a significant value of 0.0000 <0.05, then H0 is rejected and Ha is accepted, meaning that the energy consumption variable has an effect on CO2 in ASEAN countries, which has a negative and significant effect. this can happen because renewable energy is

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preferred by most countries because of its clean and sustainable characteristics, especially in the midst of rapidly increasing carbon emissions.

Table 8. F Test Results

R-squared	0.984654
Adjusted R-squared	0.983548
S.E. of regression	0.272405
Sum squared resid	8.236697
Log likelihood	-9.539083
F-statistic	890.2864
Prob(F-statistic)	0.000000

Source: output EViews 10

The calculated f value of 890.2864> F table which is 2.450570518 and a significant value of 0.000000 <0.05 then H0 is rejected and Ha is accepted, meaning that the variables of economic growth, foreign investment, population and energy consumption together affect the CO2 of ASEAN countries.

Table 9. R test

R-squared	0.984654
Adjusted R-squared	0.983548
S.E. of regression	0.272405
Sum squared resid	8.236697
Log likelihood	-9.539083
F-statistic	890.2864
Prob(F-statistic)	0.000000

Source: output EViews 10

The Adjusted R-squared value is 0.983548 or 98.3548%. The coefficient of determination shows that the independent variables consisting of economic growth, foreign investment, population and energy consumption are able to explain the CO2 variable of ASEAN countries by 98.3548% while the remaining 1.6452 (100 - Adjusted R-squared value) is explained by other variables that are not included in this research model.

In addition, from the results of the stationary test of economic growth variables, foreign investment, population, energy consumption and CO2 at the Difference level of one individual intercept and Difference one individual intercept and ternd with the unit root test method on Levin, Lin & Chu t * and ADF - Fisher Chi-square has a prob value <0.05, then the data does not contain unit roots which means the data is stationary.

Table 10: Optimum Lag Test Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2877.590	NA	4.54e+21	64.05756	64.19644 *	64.11357 *
1	-2852.166	47.45893	4.51e+21 *	64.04813 *	64.88140	64.38416
2	-2832.988	33.66846	5.16e+21	64.17750	65.70517	64.79355
3	-2813.365	32.26844	5.89e+21	64.29700	66.51905	65.19306
4	-2786.120	41.77587 *	5.74e+21	64.24711	67.16355	65.42319
5	-2772.323	19.62230	7.67e+21	64.49607	68.10690	65.95217

Source: output EViews 10

Based on the lag test results seen from the lowest/minimum AIC value is at lag 1, then the selected lag is lag 1.

Gambar 2. AR Roots Graph

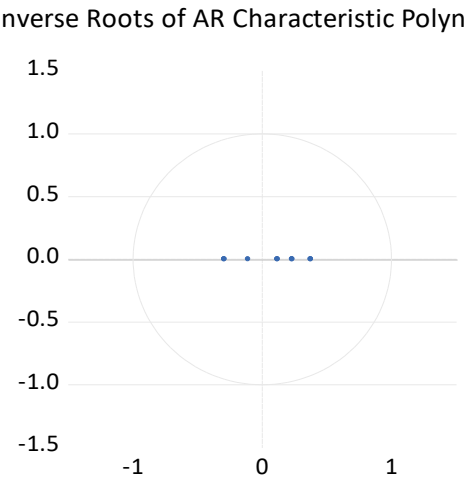

Figure 2. AR Roots Graph

Sumber: output EViews 10

The dots are in the circle meaning the data is stable at the VAR level. This is reinforced by the VAR stability test table which shows that the VAR model is declared stable because its root has a modulus value of less than 1 (one) meaning the data is stable at the VAR level.

Tabel 11. Uji Kointegrasi

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**

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None *	0.542207	254.9472	69.81889	0.0000
At most 1 *	0.452178	172.9066	47.85613	0.0000
At most 2 *	0.316858	109.7171	29.79707	0.0000
At most 3 *	0.297678	69.70660	15.49471	0.0000
At most 4 *	0.266926	32.60341	3.841466	0.0000

Sumber: output EViews 10

The cointegration test results using Johansen's cointegration test show a probability value of <0.05, which means that there is an equilibrium in the long run, that is, there is a similarity of movement and stability of the relationship between the variables.

Table 12. VECM Model

Cointegrating Eq:	CointEq1
D(CO2(-1))	1.000000
D(PDB(-1))	-0.001597 (0.00050) [-3.18581]
D(PMA(-1))	6.57E-10 (6.2E-11) [10.5183]
D(PDDK(-1))	-0.023301 (0.58515) [-0.03982]
D(KE(-1))	0.490904 (0.10772) [4.55705]
C	0.275855

Error Correction:	D(CO2,2)	D(PDB,2)	D(PMA,2)	D(PDDK,2)	D(KE,2)
CointEq1	-0.012460 (0.01575) [-0.79137]	-33.96468 (34.7767) [-0.97665]	-2.61E+09 (2.9E+08) [-9.06746]	0.003750 (0.02393) [0.15670]	-0.144207 (0.14190) [-1.01625]
D(CO2(-1),2)	-0.421373 (0.13617) [-3.09449]	-388.0698 (300.757) [-1.29031]	1.92E+09 (2.5E+09) [0.77188]	-0.001846 (0.20697) [-0.00892]	-1.167840 (1.22720) [-0.95163]
D(PDB(-1),2)	-5.38E-05 (6.4E-05) [-0.84174]	-0.236001 (0.14110) [-1.67260]	-3082323. (1167669) [-2.63972]	-3.79E-05 (9.7E-05) [-0.39004]	0.000473 (0.00058) [0.82211]
D(PMA(-1),2)	4.39E-12 (6.3E-12) [0.69689]	1.94E-08 (1.4E-08) [1.39329]	0.332260 (0.11503) [2.88845]	-5.45E-12 (9.6E-12) [-0.56998]	5.72E-11 (5.7E-11) [1.00896]
D(PDDK(-1),2)	0.027090 (0.06325) [0.42833]	-34.36773 (139.691) [-0.24603]	-1.06E+09 (1.2E+09) [-0.91930]	-0.339925 (0.09613) [-3.53604]	-0.240882 (0.56999) [-0.42261]

D(KE(-1),2)	-0.003485	-11.36835	8.39E+08	-0.001213	-0.423721
	(0.01146)	(25.3206)	(2.1E+08)	(0.01742)	(0.10332)
	[-0.30397]	[-0.44898]	[4.00193]	[-0.06961]	[-4.10117]
C	-0.000390	-12.39594	-61868954	0.003515	-0.009763
	(0.02242)	(49.5098)	(4.1E+08)	(0.03407)	(0.20202)
	[-0.01741]	[-0.25037]	[-0.15100]	[0.10316]	[-0.04833]
R-squared	0.252609	0.145027	0.659367	0.137868	0.190282
Adj. R-squared	0.206850	0.092682	0.638512	0.085084	0.140707
Sum sq. resids	5.131603	25033912	1.71E+21	11.85555	416.7974
S.E. equation	0.228830	505.4187	4.18E+09	0.347815	2.062289
F-statistic	5.520460	2.770581	31.61666	2.611940	3.838286
Log likelihood	9.484924	-799.0321	-2471.558	-34.47741	-221.3671
Akaike AIC	-0.047332	15.35299	47.21063	0.790046	4.349850
Schwarz SC	0.129599	15.52992	47.38756	0.966977	4.526781
Mean dependent	-0.007685	-25.74518	-2.07E+08	0.001670	0.021619
S.D. dependent	0.256942	530.6052	6.96E+09	0.363628	2.224738
Determinant resid covariance (dof adj.)		3.64E+22			
Determinant resid covariance		2.58E+22			
Log likelihood		-3454.174			
Akaike information criterion		66.55569			
Schwarz criterion		67.56672			
Number of coefficients		40			

Source: output EViews 10

The t table value obtained is 1.980808. The VECM estimation results on the GDP variable obtained a t value of 3.18581> t table, namely 1.980808, meaning that the GDP variable affects the CO2 of ASEAN countries in the long term. The VECM estimation results on the FDI variable obtained a t value of 10.5183> t table, namely 1.980808, meaning that the FDI variable affects the CO2 of ASEAN countries in the long term. The VECM estimation results on the population variable obtained a t value of 0.03982 < t table, namely 1.980808, meaning that the population variable has no effect on CO2 of ASEAN countries in the long run. The VECM estimation results on the energy consumption variable obtained a t value of 4.55705> t table, namely 1.980808, meaning that the energy consumption variable affects the CO2 of ASEAN countries in the long run. While the VECM estimation results on the GDP variable obtained a t value of 0.84174 < t table, namely 1.980808, meaning that the GDP variable in the previous period has no effect on CO2 of ASEAN countries in the short term. The VECM estimation results on the FDI variable obtained a t value of 0.69689 < t table, namely 1.980808, meaning that the FDI variable in the previous period has no effect on CO2 of ASEAN countries in the short term. The VECM estimation results on the Population variable obtained a t value of 0.42833 < t table, namely 1.980808, meaning that the population variable in the previous period has no effect on CO2 of ASEAN countries in the short term. The VECM estimation results on the energy consumption variable obtained a t value of 0.30397 < t table, namely 1.980808, meaning that the energy consumption variable in the previous period has no effect on CO2 of ASEAN countries in the short term.

Conclusion

From the panel data regression test results of the Fixed Effect model (FEM) and the results of the t test hypothesis test confirm that economic growth, foreign investment and energy consumption affect CO2 emissions while population has no effect on CO2 emissions. In simultaneous testing, economic growth, foreign investment, population and energy consumption variables jointly affect CO2 in ASEAN countries. In addition, the VECM test results confirm that economic growth, foreign investment and energy consumption affect ASEAN countries' CO2 in the long run, while population has no effect on ASEAN countries' CO2 in the long run. In addition, the EKC hypothesis and Pollution Haven hypothesis are rejected and the Pollution Halo hypothesis is accepted. Other findings confirmed the existence of homogeneous causality relationship of economic growth and foreign investment to CO2 and vice versa CO2 has homogeneous causality relationship to GDP and FDI. Population and consumption have heterogeneous causality relationship to CO2. The final result concludes that there is a relationship between the four variables on CO2 emission. Therefore, policy makers need to pay attention to making policies related to energy and economy that do not have an increasing impact on CO2 emissions.

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