



The Effect of Economic Growth, Foreign Direct Investment, and Energy Use on Environment Degradation: Evidenced from ASEAN Nations

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ABSTRACT

Literature evidenced that environmental degradation creates hurdles in economic development. So, this study highlights the leading macroeconomic indicators which affect the environment and investigates the nexus among FDI, energy utilization, economic development, and environmental pollution for ASEAN nations from 1990 to 2018. Panel Autor Regressive Distributive lag (ARDL) methodology is used to examine the impact of economic growth, foreign direct investment and energy use on environment degradation. Different panel unit roots (Im, Pesaran and Shin W-stat, Levin, Lin & Chu, ADF - Fisher Chi-square, PP - Fisher Chi-square) tests are applied to confirm the intergradation order, and results confirm that there exists I (0) and I(1) order of intergradation. There exists a unidirectional relationship between energy consumption and carbon emission of CO₂ and CO₂ to foreign direct investment in the long run. While in the short run, there does not exist any relationship. The results confirm the existence EKC hypothesis, which confirms there exists negative and positive effects of GDP and square of GDP on carbon emission. Hence this study concludes that its essential to develop some strategies and policies to guarantee economic stability. Additionally, reliable and sustainable power resources should be used for positive environmental changes. The carbon dioxide emission should be reduced for the GDP growth by utilizing different eco-technologies and renewable energy resources, which can nullify the effect of emission of CO₂ to maintain the greenhouse environment.

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1. Introduction

The economic growth of ASEAN countries was improved from 1990 to 2018 due to the improved economic environment and price stability. But some ASEAN countries are less growth from their prediction in 2017 to 2018. So, for stable growth, the policymakers must emphasize enhancing manufacturing, minimizing resource wastage, and human capital investment (Ndambiri et al., 2012). The investigations show that the government of ASEAN countries should empower the policymakers to manage different strategies for the economy's progress. Furthermore, the energy system should be boosted for the constant progress of the economy. Energy is very much necessary for the development of the economy because one of the crucial variables of the economy's growth is energy for ASEAN and the whole world.

Bazilian et al. (2012) identified the energy services accessibilities and reported that it is vital for present social oppositions and global economies. The countries are rich in energy resources, but sustainable economic growth is necessary because the energy comes from a

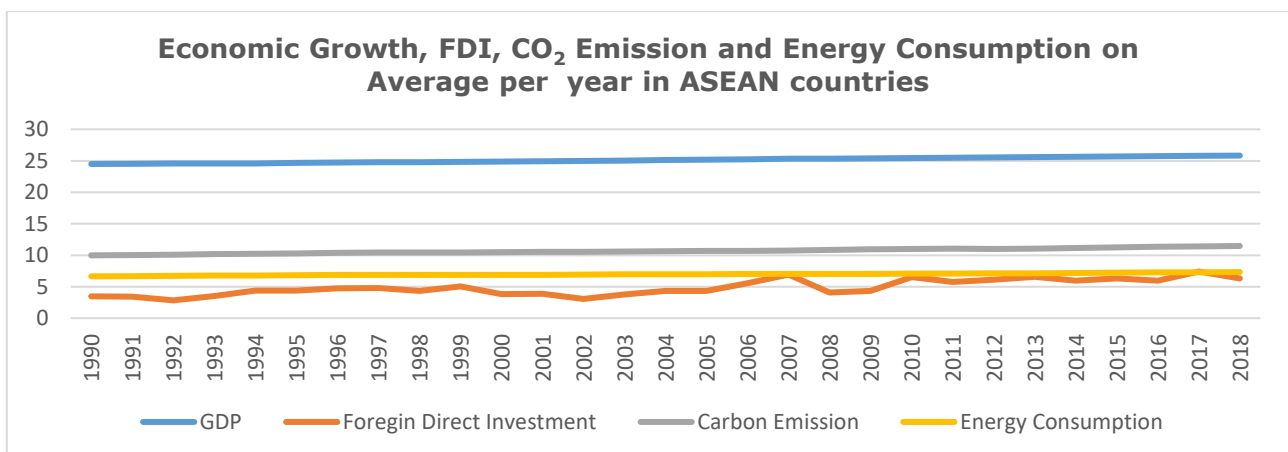
cheap and reliable source, which is not the case in fossil fuel-based energy generation. Economic stability will only occur when some renewable energy resources should be emphasized and policies prepared for zero CO₂ emission (Fankhauser & Jotzo, 2018).

Avila, Carvalho, Shaw, and Kammen (2017) reported that countries have excellent energy resources, but the main challenge is equal distribution. Over 130 million of Africa's population relies on fossil fuel and relevant products such as candles, and around 620 million people do not have access to electricity. However, Africa is not able to meet the challenge of equal distribution of energy for its citizens. World Economic Forum (World Economic Forum, 2016) reported that only 24% population of Africa is consuming energy. Avila et al. (2017) emphasize that the economy's growth depends on energy resources and consumption; therefore, renewable energy's financial resources and investments are necessary. The progress of any country can be affected if it does not focus on its energy resources. ASEAN's economic growth is slow, which needs some acceleration by making some policies to encourage foreign stockholders to invest in the countries. Although, few countries such as Singapore are increasing economic growth at a good pace. For example, the FDI in sub-Saharan Africa increases by \$30 billion from 2000 to 2012. Rodríguez-Pose and Cols (2017) concluded that economic growth could be enhanced with foreign direct investment, which promotes the economy and uplifts the citizen's living status.

In countries such as Malaysia, environmental sustainability is a challenge, along with economic growth energy security. A few ASEAN countries are trying to decrease fossil fuel usage up to 40% (United Nations Framework Convention on Climate Change, 2011) and want to improve their economic growth (National Economic Advisory Council, 2009). Both variables are mutually exclusive; for example, environmental strategies will be affected by the slow economic growth, and petroleum prices will increase. However, fossil fuel subsidies by the government can enhance additional energy consumption. ASEAN countries are dominating in economic growth because there shifting from their primary agriculture sector to secondary industrial sector. As well as promoting the service sector, which is a tertiary sector and with these changes, we can foresee that the reduction of 40% emission of CO₂ can be achieved if these countries shifts from production to the services sector and uses renewable energy resources (Fazal, Gillani, Amjad, & Haider, 2020; Hasan, 2007).

Regarding environmental degradation, this paper explores the nexus of FDI, energy consumption, growth of the economy, and environmental contamination throughout 1990-2018. The selected countries have the theoretical relationship between these variables, as shown in figure 1. The panel data analysis was combinedly used for the data set compilation (Begum, Sohag, Abdullah, & Jaafar, 2015; Bekhet, Matar, & Yasmin, 2017; Lin & Ouyang, 2014; Salahuddin, Alam, Ozturk, & Sohag, 2018) and no research was available to find the relation of all variables for above mentioned nine ASEAN countries in the manners.

Figure 1: Economic Growth, FDI, CO₂ Emission and Energy Consumption on Average per year in ASEAN countries



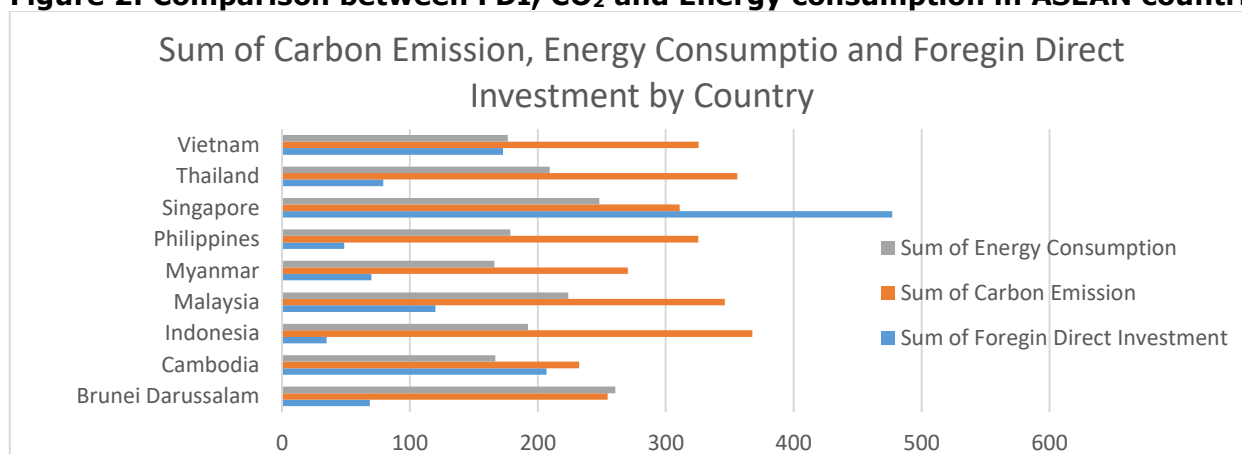
Their graphs show a positive theoretical association among the GDP, FDI, and energy consumption with carbon emission on average of ASEAN countries. Furthermore, in table 1 and

figure 2, we can see that Singapore has the highest FDI, Thailand has the highest carbon emission, and Brunei Darussalam has the highest energy consumption compared to nine selected ASEAN countries.

Table 1: Comparison between ASEAN countries among FDI, CO₂, and Energy use

Country	Sum of Foreign Direct Investment	Sum of Carbon Emission	Sum of Energy Consumption
Brunei Darussalam	68.724	254.617	260.594
Cambodia	206.761	232.313	166.629
Indonesia	34.882	367.567	192.168
Malaysia	119.901	346.112	223.855
Myanmar	69.950	270.405	165.887
Philippines	48.566	325.469	178.476
Singapore	477.148	310.989	247.976
Thailand	79.076	356.008	209.206
Vietnam	172.682	325.637	176.628

Figure 2: Comparison between FDI, CO₂ and Energy consumption in ASEAN countries



This research aims to associate FDI, energy utilization, economic growth, and environmental pollution for nine ASEAN countries. The study will help define new strategies for a sustainable environment, better economic growth, and utilize better energy resources. This research will also add valuable literature about ASEAN countries.

2. Literature Review

From the year 2000, the relationship of FDI, energy consumption, growth of the economy, and CO₂ emission was a hot topic of research (Achour & Belloumi, 2016). Many researchers (Chai, Tonjes, & Mahajan, 2016; Gergel, Nijssen, Abatzoglou, Lettenmaier, & Stumbaugh, 2017) indicated severe environmental degradation required much time and effort to find out the solution to these challenges.

Jones (2016); Schreier (2017) reported that carbon dioxide emission was a primary concern for the environment. Not only carbon dioxide but sulfur dioxide & methane emissions also harming the environment. Therefore, environmental sustainability depends on these emissions, while other variables like FDI and economic growth were independent variables. Begum et al. (2015) studied the effect of energy utilization, economic development, and the population's development on emissions of CO₂. The results show that carbon dioxide release was reduced with an increase in economic development. However, throughout 1980-2009, the carbon dioxide production boosts with the increasing growth of the economy. Furthermore, economic growth and consumption of energy had a positive effect in the long run on emission of CO₂. Therefore, they suggest that it is very necessary for sustainable economic growth that the energy should be shifted to low carbon technologies to reduce the emission of CO₂.

Kasman and Duman (2015) showed the relationship of trade, urbanization, growth in the economy, consumption of energy, and carbon emissions from 1992 to 2010 for EU countries. Panel cointegration approach, panel unit root test, and panel causality tests were

used to find the results which support the EKC hypothesis. There was a reversed U-shaped relation between the environment and economic development for selected nations. Salahuddin et al. (2018) showed the effects of financial development, FDI, energy use, and economic development on carbon dioxide discharge in Kuwait using time series analysis from 1980 to 2013 with ARDL methodologies. The result shows that the emission of carbon dioxide was stimulated by energy use and economic development. VECM outcomes show that energy use, economic development, and foreign direct investment toughly Granger-cause emission of CO₂. Furthermore, the re-newable energy consumption such as wind energy and solar energy projects can reduce carbon dioxide emission.

The linkage between carbon dioxide emissions and FDI was discussed as a blistering topic to enhance environmental stability and positive climate change. Both variables have positive and negative impacts mentioned by the policymakers and researchers. It is true that FDI can motivate economic growth, provides direct capital investment, enhances productivity, and transfer technology (Bakhtyar, Kacemi, & Nawaz, 2017; J. W. Lee, 2013; Ning & Wang, 2018; Shafiq, Hua, Bhatti, & Gillani, 2021; Yang & Shafiq, 2020). At the same time, the emission of carbon dioxide should be reduced by developing and regulating different strategies. Jain (2016) investigated the FDI effect on ecological degradation in emerging countries, and the result is that the FDI can reduce the emission of carbon dioxide with different policies. Salahuddin et al. (2018) explored the influence of FDI, electricity consumption, and economic development on carbon dioxide emanation and showed that foreign direct investment motivates carbon dioxide emission. Bekhet et al. (2017) investigated the association between the emission of CO₂, energy use, FDI, economic development, and financial development for Gulf Cooperation Council nations from 1980 to 2011 using the ARDL methodology. Outcomes reflect that there is unidirectional causality from financial development to the emission of CO₂ in the long run. Tang and Tan (2015) reported that the Nexus between economic development, foreign direct investment, energy usage, and emission of CO₂ in Vietnam between the interval of 1976-2009. According to the conclusion, the long-run equilibrium for all variables was present. The causality is bidirectional among income and emission of carbon dioxide and FDI and carbon dioxide emission. Furthermore, the emission of CO₂ was reduced with FDI by using different technologies and in technology transfer terminology.

Heidari, Katircioğlu, and Saeidpour (2015) choose five ASEAN countries to find the association among the emission of CO₂, energy utilization, and economic development (Nawaz, Azam, & Bhatti, 2019). The study reflects that the emission of CO₂ is increasing because of energy consumption. Mirza and Kanwal (2017) described that causality was present between environmental pollution, consumption of energy, and growth in Pakistan's economy with the ARDL method. The long-term relationship showed that the causality is bi-directional in all the variables mentioned above. They also recommended that the Pakistani administration must raise renewable energy resources. Isik, Dogru, and Turk (2018) inspected the long-run correlation among urbanization, energy usage, GDP, and carbon dioxide emission. The study showed an important impression on energy use and GDP on carbon dioxide emission in China. Ahmad et al. (2018) studied the effect of development in the economy, total population, and energy on carbon dioxide emission in China from 1971-2013. The outcome reflects the long-run relation, and the causality is unidirectional between the development of the economy and emission of CO₂. According to them, the government should focus on renewables for sustainable economic development and to enhance the living standard of the population.

Topcu and Payne (2018) investigated the nexus between energy and trade utilization from 1990 to 2015 in OECD countries. The study revealed a reversed u-shaped pattern between trade and energy and that it had very much influence on energy, which shows that the emission of CO₂ had more effect on energy than the development of an economy. Behera and Dash (2017) examined the affiliation among foreign direct investment, energy consumption, urbanization by using Pedroni cointegration in 17 SSEA countries from 1980 to 2012. The outcome showed that fossil fuel energy usage increased CO₂ emissions.

Balcilar, Ozdemir, Ozdemir, and Shahbaz (2018) utilized the historical decomposition method for studying the relation between energy, carbon dioxide release, and the development of the economy for G-7 countries. The finding shows that countries like the USA, Japan, Italy, and Canada were trying hard to reduce carbon dioxide emissions by using

different renewable energies and reducing fossil fuel energy consumption. However, the EKC hypothesis does not hold for the UK, Japan, Germany, Canada, and the USA, indicating that economic growth does not affect environmental quality.

3. Data and Methodology

This study contains four indicator variables; the first one is FDI, the second one is energy consumption, the third is economic growth, and the last one is the emission of CO₂. The linear, logarithmic, quadratic form is very beneficial for this kind of analysis. Therefore, it is used to investigate the linkage of these indicators by using the following regression model;

$$CO_{2it} = \alpha_0 + \alpha_1 GDP_{it} + \alpha_2 GDP_{it}^2 + \alpha_3 EC_{it} + \alpha_4 FDI_{it} + \varepsilon_{it} \quad (1)$$

GDP represents economic growth, EC energy use (kg of oil equivalent per capita), FDI is foreign direct investment net inflow % of GDP, and CO₂ is carbon emission (metric tons per capita), and the last one is the error term. To check the impact of all the four variables mentioned above, it is necessary to check the order of integration of indicators. For this purpose, this study used the Hadri, IPS, and LLC unit root tests. A cointegration relationship is one of the essential outcomes, which reflects that the dependent and independent variables have a long-run relationship. However, various estimators can be used for this kind of study, but it is also challenging to determine which one is more preferable to find unbiased outcomes. The ordinary least squares (OLS) estimator is used most widely, and this kind of study is very popular. However, if the variables have the same order of integration, then DOLS and FMOLS estimators have recently referred to the OLS estimator. According to G. Lee (2007), the DOLS and FMOLS estimators overcome the serial correlation and identification problem. According to Fei, Dong, Xue, Liang, and Yang (2011), the nonparametric approach is used to eliminate autocorrelational and endogeneity problems with the FMOLS estimator's with the help of parametric approaches and DOLS estimator eliminate the explanatory problem variables. When we have the longer panel data, the DOLS estimator's performance is superior and efficient if the sample is small, then the FMOLS and OLS estimators (Kao & Chiang, 2000; Narayan & Smyth, 2007). Furthermore, if the variables have mix order of integration, then the FMOLS and DOLS give biased results because they cannot handle the mixed unit root problem. Hence Auto Regressive Distributive lag (ARDL) model easily minimize that effect and also give the short and long-run effect of exogenous indicators towards endogenous indicator.

3.1 Data Source

The data of nine ASEAN countries are used annually in this study from the period 1990-2018. The study used four variables to find out their relationship. The variables are FDI, energy consumption, growth of the economy, and emission of CO₂, and data is taken from WDI (World Bank, 2020).

4. Results and Discussion

Summary statistics are shown in table 2.

Table 2: Summary Statistics

Variable	CO ₂	EC	FDI	GDP
Average	4.935	2160.383	4.895	3.027
Max	33.965	13276.420	28.017	14.526
Mini	0.100	246.517	-2.757	-213.657
Std. Dev.	6.540	2676.962	5.356	20.198
bs.	261	261	261	261

According to table 2, we use CO₂ emission in (mt) as a proxy of the environment, consumption of the energy, FDI, and growth rate of ASEAN countries. The CO₂ mean value is 4.985, which shows the average CO₂ emission in ASEAN countries is almost 5 metric tons annually with a maximum value of 33.965, the minimum value is 0.100, and the standard deviation of data is 6.540%. The energy consumption means the value is 2160.38, which shows the energy use in ASEAN countries annually is almost 2160 kg of oil equivalent per capita with a maximum value of 12376. The minimum value is 246, with a standard deviation of 2676%. FDI and GDP have a mean value of 4.89 and 3.027, and the maximum and

minimum value is 28.017, 14.526, -2.757, -213.675 respectively. We have long-time panel data of ASEAN countries, so first need to check the stationarity level of variables. For this, the study applied different unit root tests, and outcomes are given in table 3.

Table 3: Unit root test

Tests	Levin, Lin & Chu	Im Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square
Variables	Statistic	Prob.	Statistic	Prob.
CO₂	4.737	1.000	5.363	1.000
DCO₂	-4.722	0.000	-5.318	0.000
GDP	-4.208	0.000	-6.298	0.000
DGDP	-----	-----	-----	-----
EC	-0.041	0.484	2.536	0.994
DEC	-3.773	0.000	-5.546	0.000
FDI	-1.691	0.046	-2.559	0.005
DFDI	-----	-----	-----	-----

According to Levin Lin Chu and other unit root tests, they indicate that GDP and FDI have stationarity at the level, and carbon emissions and energy consumption are stationarity at first difference. Hence according to the unit root test, it confirms that there exists a mixed order of integration so we used the panel ARDL approach to examine the short as well as the long-run effect of economic growth, energy consumption and foreign direct investment on carbon emission. Therefore, the properties of the variable are asymptotic. So the results of ARDL are given in table 3 reflects short-run results, while table 4 represents long-run estimates.

Table 4: Short Run Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.6568*	0.88482	-1.8725	0.0639
COINTEQ01	-0.3093**	0.046	-1.910	0.058
D (ICO₂MT(-1))	0.1275	0.17019	0.74918	0.4554
D (ICO₂MT(-2))	0.05103	0.16989	0.30036	0.7645
D (IGDPG)	-0.0163	0.02177	-0.7481	0.4561
D (IGDPG(-1))	-0.0298	0.03259	-0.9153	0.3622
D (IGDPG(-2))	0.01366	0.02862	0.47735	0.6341
D (IGDPG^2)	-0.0047	0.00802	-0.5896	0.5567
D (IGDPG(-1)^2)	-0.0061	0.0148	-0.411	0.6819
D (IGDPG(-2)^2)	-0.0089	0.00925	-0.9579	0.3403
D (IFDI)	0.00677	0.05997	0.1129	0.9103
D (IFDI(-1))	-0.0477	0.03811	-1.2504	0.214
D (IFDI(-2))	-0.0525**	0.01893	-2.7743	0.0066
D (LEC)	1.50939	1.55579	0.97018	0.3342
D (LEC(-1))	1.39151	2.26387	0.61466	0.5401
D (LEC(-2))	0.51286	1.16541	0.44007	0.6608
@TREND	0.05578	0.03215	1.73486	0.0857

Note: ***,** and * show 1%, 5% and 10% level of significance respectively.

Table 4 shows that the short-run variables do not affect the CO₂ emission by FDI. While the error correction term is important, and the value of its estimates is negative, it confirms the cointegration between the variables and the model. The error correction term expressed the speed of adjustment of the model. This further explains that if the model moves to the disequilibrium stage due to some external shock, then it tells the speed of the model converges to its equilibrium condition. The results show that the model has an almost 31% annual speed of adjustment, and the model will move to its equilibrium stage in nearly three years.

Table 5: Long Run Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP	0.041***	0.006	7.125	0.000
GDP²	-0.002***	0.000	-8.374	0.000
FDI	0.036***	0.005	7.713	0.000
LEC	0.851***	0.035	24.319	0.000

Note: ***,** and * show 1%,5% and 10% level of significance respectively.

Table 5 demonstrates that economic growth boosts the emission of CO₂, while the GDP square coefficient indicates that it further decreases the level of CO₂ production in ASEAN countries. FDI and consumption of energy boost the emission of CO₂. There are maximum chances that the increase in GDP increases the emission of CO₂, but the increasing GDP square reduces the emission of carbon dioxide for ASEAN countries. This result relates to the study of (Anastacio, 2017). According to this study, the connection between both variables was inverted U-shaped. Doğan (2018) reports that in the long-term GDP, increases in carbon emissions decrease. According to the findings of (Anastacio, 2017), GDP squared positively and negatively impacts economic growth and approves the EKC theory. Looking at the causality of all the variables, we can see that the short run's causality is bi-directional between the emission of CO₂ and energy utilization. In contrast, the long-term facility is unidirectional to the production of carbon dioxide from energy use.

In ASEAN nations, the emission of CO₂ increases because of the FDI; the causal relationship between these variables in the long term implies that anything in the emission of CO₂ will change the FDI, proving that the FDI has a significant effect on the emission of CO₂. Furthermore, it suggested that the amount of FDI in developing countries increased or decreased in environmental conditions. So, the recipient countries must establish policies to access environmental impact to FDI before they come there.

The outcomes are similar to the study (Acaravci & Ozturk, 2010; Wang, Li, Fang, & Zhou, 2016). It shows that environmental pollution has an increasing trend because of the increase in energy consumption, which is similar to (Omri, Daly, Rault, & Chaibi, 2015) study, which identified the rise in the GDP and use of energy would directly impact the emission of CO₂. The level of the emission of CO₂ can be reduced if there is an increase in energy efficiency. Therefore, the government must take steps to save energy, and the public should also follow the government's orders to save energy and utilize it effectively. It matches with the study of (Vickers, 2017). Wang et al. (2016) discussed that it is necessary to make different strategies for developing the economy and the use of energy through which the emission of CO₂ and its relative problems can be addressed. There is a bidirectional relationship in the short run between the emission of carbon dioxide and the utilization of energy reflex that both variables are interconnected. It means if anyone wants to decrease the emission of CO₂ then and it can't be possible with the increase in energy (Ssali, Du, Hongo, & Mensah, 2018), whereas increasing emission of CO₂ mean higher consumption of energy. The long-run causality is present between in both variables from consumption of energy to the emission of CO₂, which implies that the impact of utilization of energy on the emission of CO₂ is significant for the selected nations.

5. Conclusion and Policy Recommendations

The current study finds the effect of economic growth, energy consumption, and FDI on CO₂ emission in the ASEAN economy. Levin, Lin & Chu, Lm, Pesaran, Shin W-stat, ADF - Fisher Chi-square, PP - Fisher Chi-square unit root test is applied, and results confirm that FDI and GDP are stationary at the level and CO₂ and energy consumption at the first difference. Therefore, the study applied panel ARDL instead of OLS because it provides better and efficient results with long-term coefficients from 1990 to 2018. This study relied on the five variables; carbon dioxide emissions, GDP, the square of GDP, energy consumption, and FDI.

The current climate change problem triggered by ecological degradation has made the government aware of this disaster before it abolishes things around the globe. Global climate change is a very important topic for researchers worldwide, and everyone is trying to find the main cause and provide their observations about the topic. To understand the effect on the environment, the researcher uses different variables. It is very vital to understand the

indicators because it is very beneficial in the strategy development process. This paper does not use the traditional testing methods; therefore, it is in humanity's best interest.

This study's empirical outcomes show that the emission of CO₂ is increased with the increase of development of the economy and use of energy. This reflects that the GDP and energy utilization are the main factors through which the emission of CO₂ is increasing, and it is harming the emerging nations. Furthermore, it is also concluded that the emission of CO₂ decreases with the increase in GDP square. This reflects that this inversely proportional relationship of both variables promotes the environment. It is also exposed that economic development and income can be increased if the technology is utilized for different ways to produce energy that have low emission of CO₂. But if the growth of the economy and energy use have an increasing trend in the developing countries, then the emission of CO₂ will continue to increase.

The emission of CO₂ has a significant and increasing effect on GDP while it has an increasing and negative influence on the square of GDP. There is a U-shaped relationship for both the variables, reflecting that Kuznets environmental curve is valid because there is a reversed U-shaped relation in the long run. Therefore, the economy's development will decline the emission of CO₂, but both the variables will be directly proportional in the long run. The square of GDP and the economy's growth will have negative and positive signs in the long run. This study suggests a long-term balance for the utilization of energy, FDI, and degradation of the environment. We pay attention that the system returns to balance.

6. Policy Implication

The interventions and implications are very necessary for the ASEAN region that the policymakers should focus on the policies to develop renewable energy sources with the help of fiscal policies and establishment codes to reduce the pollution of the environment. The ongoing policies have less emphasis on the utilization of renewable. It is also necessary not to emphasize unstable energy resources rather emphasize stable sources. Hydropower, wind power, atomic energy, and solar-based energy must advance in developing countries. Therefore, the supply of renewable energy must be expanded and strengthened in certain countries and worldwide and promote energy efficiency by the government. The emission of CO₂ can be reduced by investing in green technologies or carbon-storing technology. The government should make some strategies to motivate renewables, for instance, strengthen the renewable energy sector by increasing FDI. The interventions in the ongoing policies for encouraging the public are also necessary, along with the green technologies for the environment's positivity.

In short, the government of developing countries should take action to control environmental pollution. The number of deaths will be increased worldwide if environmental pollution is not addressed appropriately. Knowledge management's strategy to provide awareness to the public should be introduced to stay safe from the scare effect of climate change.

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