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Corruption and Environmental Damage: Evidence from Panel Data in ASEAN-6

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ABSTRACT

Environmental damage is a topic of great concern among researchers and receives special attention in global circles. One of the major contributors to environmental damage is the emission of greenhouse gases, such as carbon dioxide. In this research, the influence of corruption on carbon emissions in six ASEAN countries is investigated, using indicators of economic growth, renewable energy, and urbanization. The fixed effect model (FEM) is used as the method of analysis, and the research data used is from 1996 to 2019, based on its availability. The research findings suggest that there is an existence of Environmental Kuznets Curve in the form of an inverted U relationship. Renewable energy has a negative effect, while urbanization has a positive effect on carbon emissions. Additionally, control of corruption has been found to have a positive effect on carbon emissions. Based on these findings, it is essential to promote maximum economic growth, use renewable energy, limit urbanization, and increase control of corruption to help mitigate carbon emissions and environmental damage.

Keywords: Carbon Dioxide, Economic Growth, Renewable Energy, Urbanization, Controlling Corruption, ASEAN
JEL Classifications: Q50, O11

1. INTRODUCTION

Environmental damage has been a topic of concern among researchers for several decades. It has also become a major area of focus in global circles. One specific type of environmental damage is the emission of greenhouse gases such as carbon dioxide, methane gas, and nitrous dioxide. According to Cohen et al. (2018), the increasing amount of gas emissions has become a serious problem in recent years. In their study, Dong et al. (2018) explained that there has been a significant increase in global CO_2 emissions over the past 25 years. In 1990, the amount was 21,571.7 million metric tons, while in 2014, it was 33,472.0 million metric tons. This equates to a 55.1% increase in CO_2 emissions in just a quarter of a century.

According to a report by British Petroleum (2017), CO_2 gas emissions have been increasing by approximately 1.8%/year. This has led to abnormal climate change, resulting in a significant rise in global temperatures, forest fires, floods, and damage to ecosystems (Keshavarzian and Tabatabaienasab, 2022). Climate change is not just a problem for one country, but for all countries. The evidence of climate change is visible and felt by everyone (Nathaniel and Khan, 2020). The consequences of climate change are not just short-term, but they also have a long-term impact. Therefore, environmental problems should not be underestimated as they are complex issues that require urgent attention.

The economy and environmental damage are often linked by policymakers, who believe that economic growth and negative environmental effects go hand in hand (Puntoon et al., 2022). However, reducing environmental damage can slow down economic growth, creating a dilemma for countries that aim to develop their economy. In most cases, countries prioritize welfare over the environment, ultimately leading to environmental sacrifices.

Encouragement of the use of fossil fuels is becoming increasingly widespread, particularly in developing countries, due to their affordability and ease of accessibility. However, the use of fossil fuels is a major concern due to the large amount of emissions they produce. Therefore, it is crucial to promote the use of alternative energy sources such as renewable wind energy, geothermal energy, and nuclear energy, in order to reduce emissions. Unfortunately, these technologies are not widely used yet due to their high cost (Karim et al., 2022). It should be noted that environmental damage is not solely caused by economic factors, but demographic factors also play a significant role. Urbanization is one such factor, and it continues to increase in developing countries. People move to cities in search of a better life, where they can access all the necessary amenities, including electricity, food, transportation, and education (Akalin et al., 2021).

Previous researchers have rarely discussed corruption, which is an issue prevalent in all social and political systems. As corruption is dangerous, it is a major concern worldwide. It is common in both developed and developing countries (Avis et al., 2018), but the latter often have weaker and less efficient government institutions, making them more susceptible to corruption (López and Mitra, 2000). Most member countries in ASEAN are vulnerable to corruption, except for Singapore and Malaysia. Corruption negatively impacts development and welfare (d'Agostino et al., 2016), preventing the realization of previously planned development goals (Lv and Gao, 2021). Furthermore, it leads to environmental damage as well.

The issue of environmental damage is an interesting study among researchers because it is related to human survival in the future. The greater the environmental damage, the greater the potential for harm to humans that awaits. Apart from growth and energy problems, there is something that is not looked at more deeply which is the cause of environmental damage itself, namely corruption. Based on the description that has been mentioned, the formulation of the problem raised in the paper is: Does economic growth, energy consumption, urbanization and corruption have a significant impact on carbon emissions in the six ASEAN countries?

The paper's systematics comprise several parts, including the second part, about previous research literature. The third part is the research method. The fourth section explains the findings and discussion. Finally, the fifth section is a conclusion and suggestions that need to be taken.

2. LITERATURE REVIEW

2.1. Economic Growth on Carbon Emissions

Economic growth is the main indicator of carbon emissions. Increasing carbon emissions as a consequence of pursuing high economic growth. Especially for developing countries with low and middle-income status (Li et al., 2023). According to Dinda (2004), economic growth and carbon dioxide are closely related to the environmental Kuznets curve. There are two forms of the EKC curve: the inverted U curve (pollution conditions decrease when economic growth increases in the second stage) and the U curve (pollution conditions increase when economic growth increases in the second stage). Empirically, the inverted U curve was confirmed by Liu et al. (2021), Muhammad and Long (2021), Ren et al. (2021), Karim et al. (2022). Meanwhile the U curve is confirmed by Sekrafi and Sghaier (2018), Arminen and Menegaki (2019), Ahmad et al. (2021), and Lv and Gao (2021).

2.2. Renewable Energy on Carbon Emissions

Energy is a crucial factor in driving the economy, but when energy is not environmentally friendly, it causes carbon dioxide pollution. Therefore, we need alternative energy sources, such as renewable energy, to address this problem. Many studies in the empirical literature have shown that renewable energy can reduce carbon dioxide emissions. For instance, Yang et al. (2022) found that investing in renewable energy reduces pollution problems in 13 countries that predominantly invest in the sector. Similarly, Li et al. (2023) studied 130 countries and found that renewable energy could significantly reduce carbon emissions, particularly in low and middle-income countries.

Moreover, Bozatli and Akca (2023) examined this relationship in OECD countries and discovered that not only renewable energy but also taxes play a role in reducing carbon emissions. Zhu et al. (2023) made similar findings in 51 developing and developed countries. Meanwhile, Saqib et al. (2022) used the Augmented Mean Group (AMG) and CS-ARDL methods in E-7 countries. They found that renewable energy has both short- and long-term impacts. Lastly, Voumik et al. (2023) studied Kenya and found that renewable energy had a significant negative effect. According to Liu et al. (2021), in China, renewable energy consumption can reduce carbon intensity.

2.3. Urbanization on Carbon Emissions

Several studies have been carried out to investigate the impact of urbanization on carbon dioxide emissions. Lv and Gao (2021) found that urbanization has a positive impact on carbon emissions in China. Similarly, Sinha et al. (2019) used the GMM method to study N-11 and BRICS countries, and concluded that urbanization has a positive impact on carbon emissions. Akhbari and Nejati (2019) used FEM estimates to study the impact of urbanization on pollution in both developed and developing countries, and found that urban population significantly contributes to pollution. However, Arminen and Menegaki (2019) and Akalin et al. (2021) found that urbanization has no effect on carbon emissions.

2.4. Corruption Control of Carbon Emissions

Corruption has a severe impact on the economic system, leading to inefficiency and encouraging the adoption of technology. Therefore, it is crucial to improve corruption control. According to empirical studies, Khan and Rana (2021) discovered that controlling corruption, as the role of economic institutions, is essential in reducing carbon by up to 0.349%. These findings are similar to those of Muhammad and Long (2021), who reported a 0.317% reduction. Specifically, controlling corruption contributes significantly at low-income countries (0.482%) and middle-income countries (0.275%).

Karim et al. (2022) found that controlling corruption can only reduce carbon in the long term, based on CS-ARDL estimates. Liu and Dong (2021) found a significant negative effect directly and in mediation. However, Liu et al. (2021) used a different approach, namely the corruption perception index. Based on the FMOLS and DOLS methods, they found that an increase in corruption rankings led to an increase in carbon emissions. Moreover, Akhbari and Nejati (2019) used a threshold on the human development index, showing that controlling corruption significantly impacts countries with a human development index below 0.753.

2.5. Study Hypothesis

Based on the literature that has been expressed, the researcher took the following hypothesis:

H1: Economic growth has a positive effect and there is an inverted U relationship with carbon emissions.
H2: Renewable energy has a negative effect on carbon emissions.
H3: Urbanization has a positive effect on carbon emissions.
H4: Corruption control has a negative influence on carbon emissions.

3. RESEARCH METHODS

This research focuses on studying the economies of six countries in the ASEAN region, namely Indonesia, Laos, Malaysia, Philippines, Singapore, and Thailand, between the years 1996 to 2019. These countries were selected based on their highest and lowest levels of corruption control. The study aims to analyze the impact of economic growth, renewable energy, urbanization, and controlling corruption on carbon emissions, which is a major contributor to environmental degradation. Details regarding the sources of research data can be found in Table 1, and the data is accessible online.

Based on the data that has been described, the researchers carried out carbon emissions modeling based on the pollution function by Arminen and Menegaki (2019) and Karim et al. (2022), as follows:

$$CO_2 = f\,(GDP,\ GDPSQ,\ REN,\ URB,\ CC) \tag{1}$$

From equation (1) it is set into econometric form, namely:

$$CO_{2it} = \gamma_0 + \gamma_1 GDP_{it} + \gamma_2 GDPSQ_{it} + \gamma_3 REN_{it} + \gamma_4 URB_{it} + \gamma_5 CC_{it} + \varepsilon_{it} \tag{2}$$

Where i is region, t is year, CO_2 is carbon dioxide emissions, *GDP* is economic growth, *GDPSQ* is quadratic economic growth, *REN* is renewable energy consumption, *URB* is urban population, *CC* is corruption control. γ_0 is a constant, γ_1–γ_5, is the variable slope, and is error term. To reduce problems of multicollinearity, autocorrelation, and heteroscedasticity, all variables were transformed using natural logarithms (Fachrurrozi et al., 2022; Ikhsan et al., 2022).

In order to estimate equation (2), we have utilized a traditional panel approach called a static panel. This approach involves three models: The Common Effect Model, FEM, and Random Effect Model (Kurniadi et al., 2021). The best model was selected after testing these three models using the Chow test, Hausman test, and Lagrange Multiplier (LM) test. The decision regarding the selection of the best model was based on the results of the Chow Test, Hausman Test, and LM Test. The Chow test helps to determine whether H_0 is a common effect or a fixed effect. The Hausman test, on the other hand, helps to determine whether H_0 is a random effect or a fixed effect. Meanwhile, the LM test assists in determining whether H_0 is a common effect or a random effect. In order to accept or reject the hypothesis, the P-value should be greater or less than 0.05, respectively. The results of these tests and the best estimates can be found in the analysis and discussion chapters.

4. RESULTS AND FINDINGS

The first step in data analysis is to conduct descriptive statistics of the research data. In Table 2, we can see an overview of the research data used. The table shows that the carbon emissions variable has an average of 11,170, corruption control has an average of −0.048, economic growth has an average of 8,942, renewable energy is 27,360, and urbanization is 16.58. The standard deviation of each variable has fluctuating data, particularly renewable energy, which has a standard deviation of 23,757. The data distribution displayed by Jarque-Berra indicates that all variables have non-normal distributions.

Before proceeding to the analysis stage, the best model needs to be tested. The static panel model has three forms: Common effect, fixed effect, and random effect. Table 3 shows the test results of the best model. The Chow test resulted in a Chi-square figure of 210.64 with a P-value of 0.000. This indicates that the FEM is the best. Similarly, the Hausman test showed a Chi-squared figure of 174.227 with a P-value of 0.000, suggesting that the FEM is optimal. Both tests led to the same conclusion of fixed effects being the best model. Therefore, there is no need to continue with the LM testing.

Once the best model has been selected from the test results, the next step is to interpret it. In this case, we interpret the FEM, as shown in Table 4. The model's first interpretation concerns the

Table 1: Description and data source

Variable	Description	Sign	Source
CO_2	CO_2 emissions in kilo tons (kt)	N/A	WDI (2023)
GDP	Constant GDP 2015 in USD	+	WDI (2023)
GDPSQ	Quadratic GDP	−	Author's calculations
REN	Percentage of renewable energy consumption from total energy consumption	−	WDI (2023)
URB	Population in urban areas	+	WDI (2023)
CC	Estimation of corruption control (-2.5 to 2.5)	−	WGI (2023)

WDI: World development indicator, WGI: World governance indicator.

economic growth variable and its relationship with the EKC concept. According to Dinda (2004), an EKC is valid when the first stage is positive, the second stage is negative and both stages are significant. In Table 4, the growth coefficient is 2.030, while the second stage of quadratic GDP is −0.091. The inverted U curve pattern from stage one to stage two is calculated using the turning point formula $\left(-\frac{\gamma_1}{2\gamma_2}\right)$, which yields a result of 11.15%. This pattern is illustrated in Figure 1.

Based on the regression analysis conducted, it was found that renewable energy use has a significant negative impact on carbon dioxide emissions. The latest energy use variable as a control variable has a coefficient of −0.027 with a P-value of 0.000. If the consumption of renewable energy increases by 1%, carbon dioxide emissions decrease by 0.027%. This finding is in line with the studies conducted by Yang et al. (2022), Li et al. (2023), Bozatli and Akca (2023), Saqib et al. (2022), Voumik et al. (2023), Liu et al. (2023), and Zhu et al. (2023).

Table 2: Descriptive statistics

Variable	Mean	Max	Min	Std. dev	Jarque-Berra
CO_2	11.170	13.337	6.659	1.178	46.479***
GDP	8.492	11.024	6.681	1.158	17.287***
RENEW	27.360	86.548	0.330	23.757	14.170***
URBAN	16.583	18.836	13.713	1.409	8.098**
COC	−0.048	2.301	−1.331	1.067	37.618***

Source: Author work. **, *** is significant 5% and 1%

Table 3: Best model testing

Testing	Chi-square stat	P-value
Chow	210.64***	0.000
Hausman	174.227***	0.000
LM	–	–

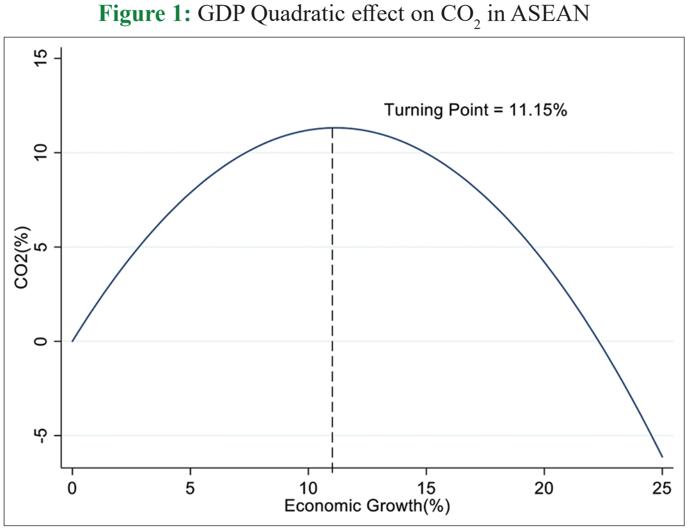
Source: Author work. *** is significant 1%.

Table 4: FEM model estimates

Variable	Coefficient	Std. error	t-stat	P-value
C	−5.145***	1.290	−4.196	0.000
GDP	2.030***	0.341	5.944	0.000
GDP2	−0.091***	0.015	−6.034	0.000
RENEW	−0.027***	0.003	−8.438	0.000
URBAN	0.410***	0.125	3.278	0.001
COC	−0.135**	0.067	−2.014	0.046

Source: Author work. **, *** is significant 5% and 1%.

Figure 1: GDP Quadratic effect on CO_2 in ASEAN



Furthermore, the analysis also revealed that urbanization has a significant positive effect on carbon dioxide emissions. An increase in urbanization of 1% causes carbon dioxide emissions to increase by as much as 0.41%. This finding is consistent with the research conducted by Shinra et al. (2019), Lv and Gao (2021), and Akhbari and Nejati (2019), but differs from the findings made by Akalin et al. (2021) and Arminen and Menagaki (2021), which showed no significant effect.

Finally, it was also found that controlling corruption has a significant impact on reducing carbon dioxide emissions. The corruption control variable has a coefficient of −0.135 with a P-value of 0.017, indicating that if corruption control increases by 1, carbon dioxide emissions will decrease by 0.135%. This finding is consistent with the studies carried out by Shinra et al. (2019), Khan and Rana (2021), Muhammad and Long (2021), Lv and Gao (2021), Liu et al. (2021), Liu and Dong (2021), and Karim et al. (2022), but differs from the findings made by Arminen and Menegaki (2019) and Leal and Marques (2021).

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

The objective of this study is to explore the relationship between corruption control and environmental damage caused by carbon dioxide. The study also takes into account other factors such as economic growth and renewable energy. Panel data is used in combination with the FEM estimation technique. The best model was chosen after conducting tests and analyzing conclusions drawn by Chow and Hausman. Based on FEM estimates, it was observed that GDP has a positive impact on environmental damage in the initial stage, but as the Indonesian economy reached 11.15%, it decreased in the second stage (GDP2). Renewable energy can reduce carbon dioxide levels by 0.027%, whereas urbanization can increase carbon dioxide by 0.410%. On the other hand, corruption control can reduce carbon dioxide by 0.135%.

Based on the findings, policymakers should consider the following recommendations: First, the government should adopt the best formula to increase economic growth, as this will lead to an indication of high economic growth. Second, ASEAN countries should shift from using fossil fuels to renewable energy sources. Fossil fuels are a major contributor to pollution, so using environmentally friendly alternatives is essential. Third, urbanization is an issue that must be addressed in order to reduce carbon emissions. People move to urban areas in search of better job opportunities and more amenities. To reduce urbanization, the government should create more job opportunities in rural areas and provide basic utilities to both urban and rural areas. Fourth, corruption is a serious concern that has a negative impact on the environment. Therefore, it is essential to enforce corruption control measures strictly. Failure to do so will have a negative impact on the economy, accompanied by low levels of education and wasteful use of resources.

The research study presented in this paper has some limitations that should be considered. Firstly, the study only focuses on the impact of economic growth, renewable energy, urbanization, and controlling corruption on carbon emissions in ASEAN. Future research can expand this by including the role of various institutions such as government regulations, political stability, and elements of human capital. Secondly, the linear analysis method used in this study has some limitations as it does not account for the influence of the past. For instance, current policies take time to come into effect and will take the next year or two. Therefore, future research should develop carbon emission models that incorporate short-term and long-term methods, such as Autoregressive Distributed Lag, especially in ASEAN. Lastly, future researchers can examine longer historical data to gain a better understanding of the trends over time.

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