Environmental Degradation by Economic Activity: An Empirical Comparison Study in Indonesia and Germany

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Abstract. Sustainable economic growth must be the primary concern in every country to avoid environmental degradation, especially in G20 members. As a form of multilateral cooperation, policies and outcome of G20 discussions can be influenced globally, including ecological issues. This study uses the ECM method to compare factors against CO_2 emissions as a proxy for environmental degradation in Indonesia and Germany from 1990–2019. The results indicate that in the short term, only variable coal consumption and renewable energy significantly influence CO_2 emissions in both countries.

Meanwhile, the variables of economic growth and FDI has an insignificant effect. In the long run, the variables of economic growth and FDI have a significant impact on CO_2 emissions in Indonesia and Germany. Coal consumption significantly has a negative effect in Indonesia and a positive effect in Germany on CO_2 emissions. Renewable energy consumption in Indonesia and Germany has a negative and significant impact. There are similarities between Indonesia and Germany. The variables of economic growth and FDI in the long term have a significant effect on CO_2 emissions. Meanwhile, coal consumption and renewable energy in the short and long time significantly affect CO_2 emissions. The recommendations are that the government should firmly support reducing coal consumption because it impacts environmental degradation, and the government should support the use of renewable energy to be more massive by issuing legislation.

Keywords: CO_2 Emissions · Environmental Degradation · Error Correction Model

1 Introduction

The green economy is synonymous with the concept of sustainable development, which is a collective goal of global that every country wants to reach through the Sustainable Development Goals (SDGs) program [1]. The Green economy is carried out to achieve sustainable development that does not damage the preservation of nature. The green economy is a process of change towards dynamic progress, promoting economic goals to be more efficient by minimizing the impact of economic activities on the environment [2].

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The "business as usual" approach as an effort to fulfill global demand for food, energy, and infrastructure will impact the world's ecology by the occurrence of commodity and energy price volatility, pollution, disrupted human health, and threats to biodiversity. Therefore, it is necessary to formulate a green growth policy concept oriented towards eco-friendly economic progress [3]. The green growth issue is also a priority agenda in the G20 international forum.

Economic growth can cause externalities for the surrounding environment, for example, the occurrence of climate change and the phenomenon of global warming. The correlation between economic growth and environmental degradation can explain by Environmental Kuznets Curve (EKC) theory. This theory states that environmental damage will decrease along with economic growth at a certain point [4]. The EKC was used for ecological studies that describe the inverted U-shaped relation between GDP and environmental quality [5]. The welfare of society, such as parameters used to measure economic growth. Economy escalation will also increase interest.

Nevertheless, in other aspects, economic growth also results in environmental damage and pollution [6]. Economic growth is closely related to exploiting natural resources and the environment. If environmental issues continue to be ignored, they will cause ecological damage. One of them is climate change due to the effects of greenhouse gases; CO_2 emissions are the most significant contributor to the increase in greenhouse gas effects [7].

Indonesia has the potential for new renewable energy abundant, consisting of geothermal, water, wind, nuclear, solar, ocean current energy, and bioenergy, which can almost be applied or utilized in every region in Indonesia [8]. Energy needs in society as the spearhead of various sectors of human life such as agriculture, education, health, transportation, and economy [9]. Reducing CO_2 emissions must involve the intervention of policymakers to support national biogas to preserve the environment and sustainable development [10]. CO_2 emission is an emission of the life cycle of any renewable energy technology as a power generator. Renewable energy contributes to the supply of electrical energy. Afterward, the RE can mitigate the number of CO_2 emissions produced resulting from electricity generation activities [11].

Indonesia and Germany are members of the G20, a global economic cooperation forum of 20 countries with the largest economies. Environmental issues and climate change are essential agendas in the forum. Therefore researchers want to compare ecological degradation caused by economic activity in the two countries as representatives of developing and developed countries. Indonesia is one of the countries with the most considerable economic power in Southeast Asia. This country is also the only ASEAN member of the G20, which is classified as a new industrial country. German is a developed country that is a member of the G20 and is known as an industrial country in the European Union.

Figure 1 shows the range of differences in CO_2 emission levels in Germany and Indonesia to extremes. From the figure, we can see that CO_2 emissions in Indonesia have a trend increase every year. In 1990, CO_2 emissions were at 0.81 (metric tons per capita) and continued to increase until 1997. From 1998 to 2015, the growth of CO_2 emissions tended to fluctuate. From 2016 to 2019, it showed an increasing trend, with the highest intensity of CO_2 emissions in 2019, which is 2.29 (metric tons per capita). The

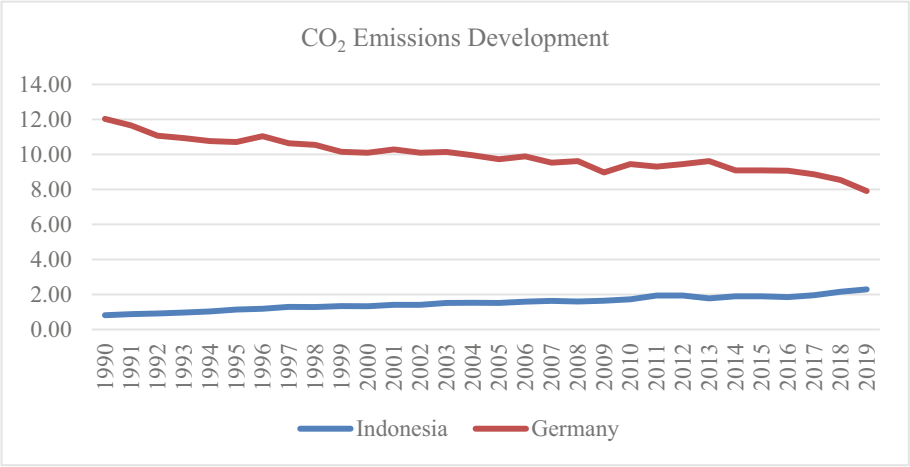

Fig. 1. CO_2 Emissions Development from 1990–2019.

growth of industrialization is one of the factors causing CO_2 emissions to increase [12]. Germany is such an industrial country in the European Union. Although the level of CO_2 emissions in Germany is higher than in Indonesia, the graph shows a downward trend every year. This issue is because the European Union is determined to tackle climate change and strive to achieve neutral greenhouse gas emissions by 2050.

2 Literature Review

2.1 Environmental Degradation

Environmental degradation is environmental damage that can happen and cause the depletion of natural resources. One of the ecological degradation consequences is an increase in greenhouse gases that cause global warming and impact climate change [13]. CO_2 is one of the gasses that form greenhouse gases [14] or the main trigger of global warming. CO_2 emission levels can be used to measure environmental quality.

2.2 The Effect of Gross Domestic Bruto on CO_2 Emissions

GDP and CO_2 emissions are explained in the EKC theory. The contribution of economic growth can increase emissions, but economic growth in the long term can reduce environmental degradation. Every increase in GDP will increase CO_2 emissions [15]. Acceleration in economic growth for a higher GDP increase in the long term can positively and significantly impact CO_2 emissions [16]. Indonesia, Thailand, Vietnam, Malaysia, and the Philippines indicate that GDP affects CO_2 emissions positively and especially [17].

2.3 The Effect of Foreign Direct Investment on CO_2 Emissions

Foreign Direct Investment is a net inflow in a company from one country investing long-term in companies in other countries. FDI increase positively affects host countries, including the transfer of capital, skill and technology, market access, and export promotion [18]. FDI can positively and significantly affect environmental damage, namely CO_2 emissions [19, 20]. Improving energy efficiency and ultimately reducing emissions of pollutants are facilitated by FDI inflows [21].

2.4 The Effect of Coal Consumption on CO_2 Emissions

Coal is used to fulfilling energy needs. Coal consumption is used as a source of electrical energy [22]. Coal serves as the essential fuel for the production of steel and cement. Coal has a negative character because coal such as the most polluting source of energy. Coal consumption affects CO_2 emissions significantly [23]. Coal consumption affects CO_2 emissions positively and significantly. Every increase in CO_2 emissions will be accompanied by coal consumption [24]. Coal burning is the largest emitter of carbon [25].

2.5 The Effect of Renewable Energy Consumption on CO_2 Emissions

Renewable or green energy can support sustainable economic growth and enhance environmental quality. Renewable energy is an energy formulation derived from several energy sources that can prevent global warming. It indicated that renewable energy could negatively affect CO_2 emissions [26]. The use of non-renewable energy provides facilities for production processes in every field, but this non-renewable energy is a significant factor in environmental degradation. Therefore, we should intensify renewable energy sources again to protect the environment [27].

3 Research Method

This research used a quantitative and comparative study method, where we will use quantitative methods to explain between variables based on numerical data in the form of numbers. We will use the analysis method with comparative studies to compare two research objects. The research data sources from websites were relevant to the study variables, CO_2 emissions, GDP, FDI, and Coal and Renewable Energy Consumption. This study used time series from 1990 to 2019, sourced from the World Bank and BP Statical of World Energy Website.

This research used Error Correction Model (ECM) regression analysis. The software used is EViews 9. Test of classical assumption, the goodness of the model, and validity effect are used for estimation. Then use the comparative study method to compare the two groups of research objects. The short-run estimator model is as follows:

$$\begin{aligned}\Delta \ln(CO2_t) &= \gamma_0 + \gamma_1 \Delta \ln(GDP_t) + \gamma_2 \Delta FDI_t + \gamma_3 \Delta \ln(COAL_t) + \gamma_4 \Delta REC_t \\ &+ \gamma_5 \ln(GDP_{t-1}) + \gamma_6 FDI_{t-1} + \gamma_7 \ln(COAL_{t-1}) + \gamma_8 REC_{t-1}\end{aligned}$$

$$+ \gamma_9 ECT + \omega_t \quad (1)$$

The long-run function is as follows:

$$\ln(CO2_t^*) = \gamma_0 + ln(GDP_t) + FDI_t + ln(COAL_t) + REC_t \quad (2)$$

4 Analysis Results

This study tries to analyze and compare the factors, which consist of Gross Domestic Product (GDP), Foreign Direct Investment (FDI), Coal Consumption (COAL), and Renewable Energy Consumption (REC) on CO_2 emissions in Indonesia and Germany. The estimation test in Indonesia shows that the model has a normal residual distribution with values of 0.8271 (>0.10). No autocorrelation with values of 0,3195 (>0.10) and no heteroscedasticity with values of 0.5421 (>0.10). Moreover, model specifications are linear, proven by values of 0.6002 (>0.10). All VIF values < 10, except for logGDPt-1, FDIt-1, logCOALt-1, RECt-1, and ECT, which are 640.9687; 1494.056; 450.8195; 86439.89; and 598970.61.

The results using the Error Correction Model (ECM) in Germany show that the empirical statistical probabilities of residual normality are 0.6080 (>0.10). This result

Table 1. ECM Estimation and Diagnostic Test Results (Indonesia).

Error Correction Model (ECM)		
Variable	Coefficient	Prob.
C	0.6685	0.5286
DLOG(GDP)	-0.0432	0.2094
D(FDI)	0.0051	0.4189
DLOG(COAL)	0.1396	0.0292
D(REC)	-0.0176	0.0004
C(-1)	53.0556	
LOG(GDP(-1))	-29.5793	0.0200
FDI(-1)	-28.5397	0.0124
LOG(COAL(-1))	-23.6111	0.0097
REC(-1)	-28.9920	0.0128
ECT	0.3745	0.0126
R^2	0.7824	
Adjusted R^2	0.6793	
F-stat.	7.5912	
Prob (F-stat.)	0.0001	
Durbin Watson	2.3475	
Jarque Bera	0.8271	
Breusch Godfrey	0.0319	
White	0.5421	
Ramsey Reset	0.6002	

Source: Secondary data (processed)

Table 2. ECM Estimation and Diagnostic Test Results (Germany).

Error Correction Model (ECM)		
Variable	Coefficient	Prob.
C	1.3680	0.3243
DLOG(GDP)	-0.0199	0.6688
D(FDI)	-0.0021	0.2163
DLOG(COAL)	0.3796	0.0000
D(REC)	-0.0201	0.0058
C(-1)	1.3732	
LOG(GDP(-1))	0.0217	0.0002
FDI(-1)	-0.0023	0.0001
LOG(COAL(-1))	0.3072	0.0001
REC(-1)	2.0097	0.0001
ECT	0.9962	0.0001
R^2	0.8252	
Adjusted R^2	0.7424	
F-stat.	9.9697	
Prob (F-stat.)	0.0000	
Durbin Watson	1.9329	
Jarque Bera	0.6080	
Breusch Godfrey	0.0412	
White	0.5097	
Ramsey Reset	0.0365	

Source: Secondary data (processed)

indicated that the estimated model has normal residual distribution. The estimation model has no autocorrelation and heteroscedasticity with values of 0.0422 > 0.01; and 0.5097 (>0.10), respectively. The model specification also shows linear proof by values of 0.0365 (>0.01). All VIF values < 10, except for logGDPt-1, FDIt-1, logCOALt-1, RECt-1, and ECT, which are 370.5598; 30272.47 47.1108; 13615.9; and 186429.5 (Tables 1 and 2).

5 Discussion

5.1 The Effect of Gross Domestic Bruto on CO_2 Emissions

The estimation using the Error Correction Model (ECM) shows that the GDP variable in Indonesia in the short term has a regression coefficient of -0.0432 with a probability of 0.2094 > 0.10, meaning that the GDP variable has no significant effect on CO_2 emissions in the short term. For a long time, the GDP has had a regression coefficient of -29.5793 with a probability value of 0.0200 < 0.10, which means that the GDP has a negative and significant effect. If GDP increases by 1%, CO_2 emissions will decrease by 29.573%.

The empirical study findings are supported by previous research by Kasperowicz, which shows that the long-term estimation results indicate that the GDP has a negative effect [28]. Moreover, Andarini, Idris, and Ariusni's research results show that the industrial sector's GDP affects CO_2 emissions negatively and significantly in Indonesia [29]. This situation can happen because of government policies regarding implementing green industries and encouraging low-carbon technologies.

This research is also supported by Putriani, Idris, and Adry, which show that short-term and long-term economic growth has a negative linear effect and a positive quadratic effect on environmental quality in Indonesia [30]. This result indicates that the pattern of the variable relationship resembles a U-shaped, which the Environmental Kuznets Curve contradicts. When economic growth increases by 1%, the level of carbon dioxide emissions will decrease to a certain minimum point, reducing the quality of the environment.

The regression results on German data show that the GDP variable in the short term has a regression coefficient of -0.0199 with a probability of $0.6688 > 0.10$, which means that in the short time, the GDP variable has no significant effect on increasing the number of CO_2 emissions. In the long term, the GDP has a coefficient of 0.0217 and a probability value of $0.0002 < 0.10$, which means that GDP affects CO_2 emissions positively and significantly. This result implies that if the GDP increases by 1%, the intensity of CO_2 emissions will also increase by 0.0217%.

This result is in line with Kartiasih and Setiawan's research showing the positive effect between GDP and environmental degradation [31]. The results of this research were supported by Pratama's, which represents a significant positive effect. An increase will follow every rise in the GDP variable in CO_2 emissions. According to the EKC hypothesis, the positive and significant influence between GDP and environmental degradation indicates that a country only focuses on increasing state income or productivity without paying attention to ecological aspects [32].

5.2 The Effect of Foreign Direct Investment on CO_2 Emissions

The estimation results using the ECM method show that in the short term, the FDI variable in Indonesia has a coefficient of 0.0051 with a probability value of $0.4189 > 0.10$, which means that FDI has no significant effect on increasing CO_2 emissions. In the long term, FDI has a regression coefficient of -28.5397 with a probability value of $0.0124 < 0.10$, meaning that in a long time, Foreign Direct Investment has had adverse and significant effects. This situation implies that if FDI increases by 1%, CO_2 emissions will decrease by 28.5397%.

Likewise, the results of FDI research in Germany in the short term show coefficient of -0.0021 with a probability value of $0.2163 > 0.10$, which means that FDI in Germany in the short term has no significant effect on CO_2 emissions. In the long time, FDI has a regression coefficient of -0.0023 with a probability value of $0.0001 < 0.10$, meaning that the Foreign Direct Investment variable has a negative and significant effect in the long term. This result suggests that every 1% increase in FDI will reduce CO_2 emissions by 0.0023%.

FDI has an impactful job in controlling carbon dioxide emissions in both Indonesia and Germany. FDI is more conducive to reducing CO_2 emissions in countries with

high emission levels; this phenomenon is caused by different environmental policies adopted by other countries to regulate FDI activities. By transferring environmentally friendly technologies, FDI can directly reduce environmental impact and increase energy efficiency [21].

5.3 The Effect of Coal Consumption on CO_2 Emissions

Coal is Coal consumption (COAL) in Indonesia in the short term has a regression coefficient of 0.1396 with a probability of 0.0292 < 0.10, which means that coal consumption has been affected by CO_2 emissions positively and significantly. In the long term, coal consumption has a regression coefficient of -23.6111 with a probability of 0.0097 < 0.10, which means that coal consumption has a negative and significant impact. This result implies that if COAL increases by 1%, CO_2 will decrease by 23.6111%.

In the short term, Germany's coal consumption (COAL) has a regression coefficient of 0.3796 and 0.3072 in the long run. This result means that if coal consumption increases by 1%, the intensity of CO_2 emissions will also increase by 0.3796% in the short term. The result will increase by 0.3072% in a long time. On the other hand, if coal consumption decreases by 1%, CO_2 emissions will also reduce by 0.3796% in the short term and by 0.3072% in the long time.

Lin, Lotz, and Chang show in their result research that coal consumption and CO_2 emissions are mutually influential [33]. The results of a study by Perwithosuci, Hadibasyir, and Arif show that coal consumption as a proxy for energy use has a positive and significant effect on carbon emissions [24]. Coal consumption encourages an increase in CO_2 emissions, but on the other side, an increase in CO_2 emissions will also reduce coal consumption.

The regression results show that coal consumption significantly affects CO_2 emissions. When coal consumption increases, the intensity of CO_2 emissions will also increase. Coal is used as fuel for power generation, where burning coal produces CO_2. One of the main contributors to the emissions of greenhouse gases that cause climate change is coal power plants.

5.4 The Effect of Renewable Energy Consumption on CO_2 Emissions

Renewable energy consumption (REC) in Indonesia has a regression coefficient of -0.0176 in the short term and -28.9920 in the long time, which means that coal consumption negatively and significantly on CO_2 emissions. This result implies that if the consumption of renewable energy increases by 1%, the intensity of CO_2 emissions will decrease by 0.0176% short term and by 28.9920% in the long time.

In the short term, Germany's renewable energy consumption (REC) has a regression coefficient of -0.0201 with a probability of 0.0058 < 0.10, which means that REC affects CO_2 emissions negatively and significantly. If REC consumption increases by 1%, CO_2 emissions will decrease by 0.0201%. In the long term, REC has a regression coefficient of -0.0097 with a probability value of 0.0001 < 0.10, which means that every 1% increase in renewable energy consumption will reduce the intensity of CO_2 emissions by 0.0097%.

Based on the results of research by Audrey, Sasana, and Septiani suggested that renewable energy exists to reduce dependence on fossil energy, so if the use of renewable energy is optimized, it will reduce CO_2 emissions [34]. This result was supported by Boontome, Therdyothin, and Chontanawat, who that renewable energy does not affect CO_2 emissions positively. Renewable energy is closely related to reducing CO_2 emissions that harm the environment [35].

6 Conclusion

In the short-term equation, GDP affects CO_2 emissions in Indonesia and Germany negatively and not significantly. However, in the long term, Indonesia's GDP affects CO_2 negatively and significantly. Meanwhile, in Germany, GDP affects carbon emissions positively and significantly. In the long term, Foreign Direct Investment in Indonesia and Germany negatively and significantly affect CO_2 emissions. However, in a short time, FDI in Indonesia had a positive and insignificant effect, while FDI in Germany was negative and petty. Coal consumption affects CO_2 in Indonesia and Germany positively and significantly in the short term. However, for a long time, coal consumption has had a significant negative effect in Indonesia and a significant positive effect on CO_2 emissions in Germany. REC affects CO_2 emissions in Indonesia and Germany negatively and significantly in the short and long term.

This research suggests being more careful and aware of environmental issues and natural resources in economic activities. Coal consumption influences carbon emissions, so the government should make regulations related to reducing CO_2 emissions and start to consider production processes utilizing low-carbon technology. They can construct government policies to reduce coal consumption and replace it with renewable energy sources that are more environmentally friendly. Thus, a country can contribute to protecting the environment, achieving environmental sustainability, and overcoming the impact of climate change. On another side, it can reach economic growth.

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