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How Financial Development Affects Carbon Dioxide Emissions In Indonesia? A Cointegration And Causality Analysis

Erlangga Gilang Pradana[1*], Akhmad Solikin[2]
[1]Fiscal Policy Agency, Ministry of Finance, Jakarta, Indonesia, [2]Polytechnic of State Finance STAN, Ministry of Finance, Tangerang Selatan, Banten, Indonesia

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ABSTRACT

Reducing carbon dioxide emissions is key to mitigating the adverse effects of global climate change. The expansion of the financial industry has become a vital aspect of economic growth, yet it may induce carbon dioxide emissions. This study investigates the relationship and causality between financial development and carbon dioxide emissions in Indonesia. The analysis uses data from 1971 to 2018 for per capita carbon dioxide emissions and credit provided by the financial sector as the main variables, while uses GDP, energy consumption, export value, and population density as the control variables. The Johansen cointegration test and VECM Granger causality are used to analyze the relationship and causality between main variables. The result indicates that financial development has a positive short-run and long-run relationship with carbon dioxide emissions, with bidirectional causation in the long run. It suggests that the government's program to develop the financial sector may harm Indonesia's carbon dioxide emissions. Therefore, the government should consider the environmental implications of financial development and introduce policies that incentivize financial actors to promote green finance and low-carbon technologies and support green initiatives.

Corresponding Author:
Erlangga Gilang Pradana
Fiscal Policy Agency, Ministry of Finance
Jl. Dr Wahidin No. 1, Jakarta Pusat
erlangga.pradana@kemenkeu.go.id

INTRODUCTION

Since the beginning of the industrial revolution in the eighteenth century, human activities have generated a 1° Celsius increase in global temperature. The temperature increase is worrisome since a temperature increase of only 0.5° Celsius might trigger significant climate change in the form of greater intensity and heavy rainfall or intensified drought in some regions (Intergovernmental Panel on Climate Change, 2018). An increase in greenhouse gases, one of which is carbon dioxide emissions, initiated the temperature rise that contributes to climate change (Intergovernmental Panel on Climate Change, 2001).

As shown in Figure 1, the growth of carbon dioxide emissions in Indonesia exhibits a similar upward trend to that of global carbon dioxide emissions. Carbon dioxide emissions had continued to undergo an increased trend since the New Order era when national development began to intensify. The decline in carbon dioxide emissions between 1998 and

2010 due to the economic crisis was followed by a sharp spike in 2011. Indonesia's carbon dioxide emissions peaked at 637 megatons of carbon dioxide in 2012.

The consumption of fossil fuels contributes greatly to carbon dioxide emissions in Indonesia, in addition to other sectors, such as land use change, deforestation, and forest degradation (Solikin, 2015). Indonesia was one of the top ten countries producing carbon dioxide emissions from the combustion of oil, coal, and natural gas (CDIAC, 2019). According to data compiled by the World Bank (2014b), the power and heat-generating industry contributed 44% of all carbon dioxide emissions in 2014.

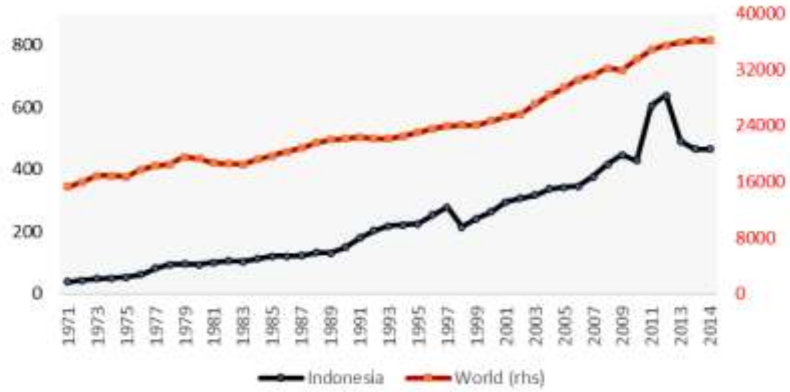

Figure 1. Carbon Dioxide Emissions in Indonesia and the World
Source: World Development Indicator dataset, World Bank

Environmental issues and climate change have become the subject of several studies analyzing the causes of carbon dioxide emissions. Namely, economic growth and energy reliance are among the most important causes of environmental degradation (Omri et al., 2015). However, researchers also try to associate other factors in analyzing environmental issues, one of which is the development of the financial sector (Imamoglu, 2019), since the development of the financial sector has turned into an essential component of the expansion of the economy (Zhang, 2011).

Several works of literature discussing the link between the financial industry and carbon dioxide emissions have been conducted, with varied results (Zhang, 2011). According to some research (Al-Mulali & Binti Che Sab, 2012; Fitriyah, 2019; Sadorsky, 2010; Zhang, 2011), a positive correlation between factors shows that the development of the financial industry has increased pollution levels. On the other hand, there are several studies (Jalil & Feridun, 2011; Shahbaz et al., 2013; Tamazian et al., 2009; Tamazian & Rao, 2010; Yuxiang & Chen, 2011) conclude that there is a negative relationship between the development of the financial sector and the environment. These studies indicate that improvements in the financial sector can reduce energy degradation and improve environmental quality.

In addition, research on the development of the financial industry and the emissions of carbon dioxide has been carried out in Indonesia, with contradictory findings. For example, Shahbaz et al. (2013) find that the expansion of Indonesia's financial industry has the potential to lower the country's overall level of carbon dioxide emissions; while Fitriyah (2019) finds the contrary. Understanding a complicated and dynamic link between financial development and carbon emissions is essential for establishing effective policies and strategies to accomplish sustainable development objectives and reduce climate change consequences. Considering the contradictory outcomes, this article seeks to add empirical evidence.

According to the description provided in the preceding section, this research will address two issues. First, what are the effects of the short- and long-term developments in the financial sector on carbon dioxide emissions in Indonesia? Second, is there a causal relationship between the development of the financial sector and carbon dioxide emissions in Indonesia?

Literature Review

As a financial intermediary, the financial sector plays an essential role in the economy. The financial sector can serve as the economy's brain by organizing the flow of excess funds from consumers and businesses to investors who lack funds but have profitable investment possibilities (Mishkin, 2015; Stiglitz, 1998). Successive advancements in the financial sector increase the amount, quality, and efficacy of intermediary financial organizations in an economy for all societal levels. This process involves numerous interactions, which in turn influence economic expansion (FitzGerald, 2006; Khan et al., 2015). Nevertheless, the rise of the financial industry may generate negative consequences as well. Manufacturing activities will consume available resources and energy to create commodities and services (Hanley et al., 2006). In addition to producing useful goods and services, these activities result in the dumping of waste into the environment, which harms the ecosystem. The adverse effects of waste emissions are external effects or negative externalities that occur apart from production and consumption. Hence, the market process becomes ineffective due to these external factors (Wiesmeth, 2022).

Three Facets of Financial Sector Development and Environment

The relationship between the development of the financial sector and the environment, as described by Yuxiang and Chen (2011) can be categorized into three elements. First, the rise of the financial sector allows investment in companies, which has a capitalizing influence on an organization's environmental performance. The development of the financial sector can have a positive effect on the environment by promoting the growth of businesses by removing their financing limitations. Therefore, environmental performance can be enhanced due to these enterprises' economies of scale, which allow them to utilize their resources more efficiently and reduce pollution as a result. On the other hand, the capitalization effect can have negative consequences if a rise in capitalization makes a firm dependent on the machine industry. As a result, capital expansions have the potential to generate pollution. The capitalization effect may therefore be positive or negative, according to theoretical predictions.

Second, the growth of the financial sector enables technological effects on the environment since it facilitates research and development activities and technological innovation. In theory, technological effects might impact the environment in two ways. On the one hand, the increase could spur the launch of new environmentally friendly technologies. However, technological advancements can raise the demand for energy and other natural resources. In theory, the impact of technology on the environment is likewise variable.

Third, the development of the financial sector influences the income effect because financial sector development influences growth (Christopoulos & Tsionas, 2004; King & Levine, 1993; Odedokun, 1996). The theory of the Environmental Kuznets Curve (EKC) (Grossman & Krueger, 1995; Suri & Chapman, 1998) states that in the early stages of economic development, pollution will increase, but in the long run, it will decrease and that the effect of income on the environment can be either positive or negative. According to the EKC, the link between pollutants and per capita income is U-shaped. As income rises, environmental deterioration grows to a certain degree; it then decreases. In other words, environmental harm increases at a greater rate than income in the early phases of economic development and at a slower rate as income levels rise.

Financial Sector Development and Emissions

Theoretically, the expansion of the financial sector can create environmental harm in the form of carbon dioxide emissions through multiple avenues (Al-Mulali & Binti Che Sab, 2012; Fitriyah, 2019; Sadorsky, 2010; Zhang, 2011). However, several literature studies also state that the development of the financial sector can play an important role in reducing the effects of environmental degradation (Jalil & Feridun, 2011; Shahbaz et al., 2013; Tamazian et al., 2009; Tamazian & Rao, 2010; Yuxiang & Chen, 2011). Addressing the complex and changing relationship between financial development and carbon emissions can help policymakers design good financial policies that can promote economic growth while reducing environmental degradation.

Many environmental studies have examined the relationship between economic growth and carbon dioxide emissions, particularly those on EKC (Soytas et al., 2007; Stern, 2004; Tamazian et al., 2009). The bulk of this research concluded that economic expansion is a significant contributor to rising carbon dioxide emissions, despite their divergent findings. Several researchers suggest associating various variables with the analysis of environmental issues, including the growth of the financial industry (Fitriyah, 2019). In reality, the rise of the financial sector is now a fundamental component of economic expansion (Zhang, 2011).

Several literature studies on the association between financial sector expansion and carbon dioxide emissions have been conducted, despite their scarcity, when compared with the research on the relationship between environmental and economic growth. For instance, Tamazian et al. (2009) examined the possible implications of economic, institutional, and financial variables on carbon dioxide emissions. Their research examines the effect of economic and financial sector growth on carbon dioxide emissions in Brazil, Russia, India, China, the United States, and Japan. Furthermore, Tamazian and Rao (2010) investigated the function of institutions in carbon dioxide emissions. According to the findings of their study, economic development, trade openness, and financial sector development have contributed to environmental damage mitigation.

Jalil and Feridun (2011) researched the association between the growth of the financial industry and environmental pollution as a proxy for carbon dioxide emissions. Their study utilizes Chinese economic data from 1953 to 2016. The findings of this study demonstrate that the development of the financial sector reduces carbon dioxide emissions through a considerable influence. Similar to the findings of Tamazian et al. (2009), this study

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demonstrates a negative relationship between the growth of the financial sector and environmental harm, indicating that an expansion of the financial sector can reduce carbon emissions.

The research conducted by Yuxiang and Chen (2011) using provincial panel data from 1999 to 2006 further strengthens studies on China. They say that the finance industry enables businesses to deploy cutting-edge technology that reduces carbon emissions. In addition, they assert that the expansion of the financial industry enhances capitalization and that financial regulation contributes to improving environmental quality. In contrast, Zhang's (2011) research, which was also done in China between 1980 and 2009, revealed that the rise of the financial industry boosted carbon dioxide emissions. Due to inefficiency in distributing financial resources to businesses, his research suggests that the growth of the financial sector increases carbon dioxide emissions. In addition, Ozturk and Acaravci (2013) investigate the relationship between the growth of the financial sector and energy consumption and environmental impact. This analysis examines economic statistics for Turkey from 1960 to 2007. The findings of this study demonstrate that the development of Turkey's financial industry has no major impact on the country's rate of environmental degradation.

Al-Mulali & Binti Che Sab (2012) analyze the dynamic link between energy use, income, financial sector development, and carbon dioxide emissions in a case study of sub-Saharan Africa. According to their findings, energy consumption boosts economic growth, increasing demand in the financial sector. In addition, Sadorsky (2010) research on developing nations also reached similar conclusions. Using a panel data model, he examines the effect of financial developments in 22 developing countries on energy consumption and concludes that, taken as a whole, financial changes in these nations considerably contribute to increases in energy consumption.

Fitriyah (2019) conducted a study on the relationship between the expansion of the financial industry and the state of the environment in Indonesia. This study examines the relationship between the growth of the financial sector, the use of energy, the expansion of the economy, and carbon dioxide emissions. According to this study, there is a considerable correlation between the growth of the financial industry and carbon dioxide emissions. The relationship shows that there is both a short-term and a long-term increase in carbon dioxide emissions connected with the growth of the financial industry. Nevertheless, a study conducted in Indonesia by Shahbaz et al., (2013) contradicted it. His research uses quarterly data on the Indonesian economy from 1975 to 2011 to demonstrate a connection between the expansion of the financial sector and the deterioration of the natural environment. According to the results of his study, there is a significant inverse relationship between economic growth and carbon emissions.

METHODS

Data and Variable Operationalisation

This research uses secondary data of Indonesia's annual time series data from 1971 to 2018. The World Bank's World Development Indicator (WDI) website is the primary source for information on the financial sector's domestic credit data, carbon dioxide emissions, energy consumption, exports, gross domestic product, and population density (World Bank, 2014a). However, WDI only provides data on carbon dioxide emissions from 1971 to 2014, while carbon dioxide emission variables from 2015 to 2018 were collected from the website globalcarbonatlas.org, which is based on data from the Carbon Dioxide Information Analysis Center (Global Carbon Atlas, 2018). The variables used in this study follow those used by Shahbaz et al. (2013). In addition, several other variables were added according to those suggested by Shahbaz et al. (2013) for further research as control variables. These variables and their definitions according to WDI are included.

a. Carbon dioxide emissions per capita; Carbon dioxide emissions are emitted when fossil fuels are burned and cement is manufactured. These emissions consist of carbon dioxide produced by the combustion of solid, liquid, and gaseous fuels and by the consumption of solid, liquid, and gaseous fuels. Tons per capita are the unit of carbon dioxide emission utilized in this study.
b. Domestic credit provided by the financial sector per capita; is all domestic credit provided by the financial sector on a gross basis, excluding credit to the government. The data obtained from the WDI World Bank is in the form of a percentage of GDP which is then multiplied by nominal GDP and divided by the consumer price index to produce rupiah units and, in real terms, then divided by the population to produce per capita units.
c. Energy use per capita refers to the consumption of primary energy before transforming into various end-use fuels. The units used correspond to kilograms of oil per capita.
d. GDP per capita; GDP per capita is GDP divided by the midyear population. The GDP used is constant or real prices with the 2010 base year. The unit of GDP per capita is rupiah per population.
e. Export; the value of goods and services sold abroad. The export variable is calculated using a constant price, namely the 2010 base price. The unit of the export variable is in rupiah.
f. Population density; Population density is calculated by dividing the mid-year population by the total area, excluding the water area. The unit used is the population per square kilometer of area.

Using the three characteristics mentioned by Yuxiang and Chen (2011), the connection between the financial sector's expanding loan growth and carbon dioxide emissions may be established. Theoretically, all factors, including the effects of capitalization, technology, and money, can produce either a positive or negative association. The EKC theory explains the relationship between carbon dioxide emissions and economic growth. Initially, economic expansion will cause a rise in emissions, but this increase will diminish over time. Because most of the energy is derived from the combustion of fossil fuels, rising energy consumption will increase carbon dioxide emissions. Foreign trade activities (exports) will also boost resource consumption, increasing economic activity, carbon dioxide emissions, and environmental degradation. In addition, population expansion will boost economic activity, which can degrade the environment through land degradation and deforestation, for example.

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Estimation Strategy

This study used the Vector Auto Regression (VAR) or Vector Error Correction Model (VECM) approach. The VAR technique employs simultaneous equation modeling with several endogenous variables (Gujarati & Porter, 2009). The VAR/VECM methodology utilizes lags or historical values from itself and other endogenous variables in the model. Ajija et al. (2011) explain that the advantage of the VAR/VECM technique is that there is no need to determine the dependent and independent variables because all variables except control variables will be simulated as independent variables and as dependent variables. Therefore, this technique can be used to test models that do not yet have a basic theory. The model used in this study is transformed into a double-log form as follows.

$$\ln COE_t = \alpha_1 + \alpha_2 \ln CRD_t + \alpha_3 \ln ENR_t + \alpha_4 \ln GDP_t + \alpha_5 \ln EXP_t + \alpha_6 \ln PDS_t + \varepsilon_t \quad (1)$$

LnCOE is the log of per capita carbon dioxide emissions, InCRD is the log of domestic credit, InENR is the log of per capita energy consumption, InGDP is the log of per capita GDP, and InEXP is the log of per capita export values. Then another variable, the log population density, denoted by InPDS, is introduced.

Figure 2 explains the research implementation phase. Testing for stationarity is the initial step since the VAR/VECM method requires all variables to be stationary in the same order Ajija et al. (2011) According to Widarjono (2005), data is considered stationary when the mean and variance remain constant across time. Using Augmented Dickey-Fuller (ADF) is one approach to test the stationarity of the data (Gujarati & Porter, 2009).

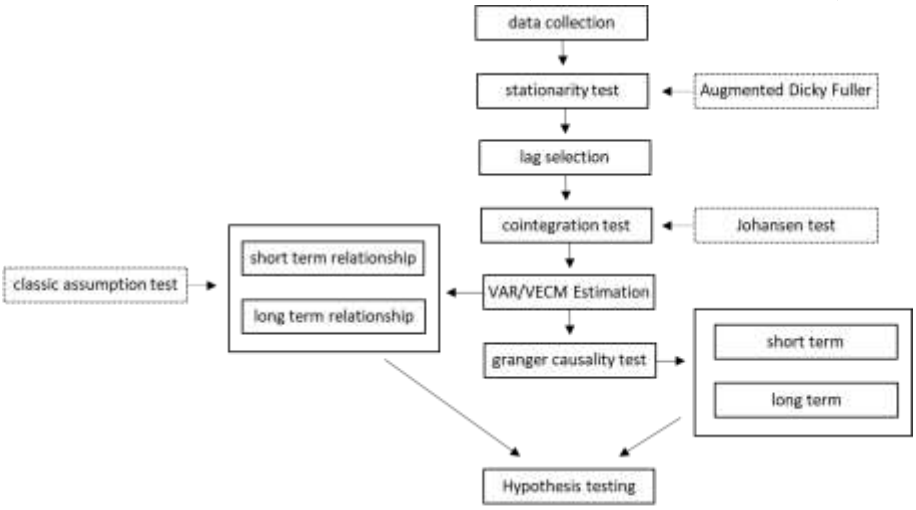

Figure 2. Research Implementation Phase
Source: edited by Authors

After the stationarity test, the optimal lag duration must be determined. Harris (1995) highlights the significance of choosing the optimal lag length because if the lag is too short, the model cannot predict the actual error since the residuals from the regression cannot exhibit the white noise process (derivative over time). Inversely, if the lag is too lengthy, it can increase the probability of receiving H_0 since adding too many parameters can diminish the degrees of freedom. Many criteria, including the Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan-Quinn Information Criterion (HQ), can be used to select the optimal lag from the collection of variables for use as a model.

Furthermore, to indicate the possibility of a long-term equilibrium relationship between several variables, the method used is the cointegration test (Brooks, 2008). One method that can be used to test cointegration is the Johansen method. If the model detects cointegration, the VAR/VECM model can be used to continue the analysis. VAR/VECM restricts short-term fluctuations between variables so they do not propagate over time. Widarjono (2005) explains that error correction gradually improves if there is a deviation with short-term partial adjustments.

Next, we perform the Granger causality test. Granger established the idea of causality, which gained widespread acceptance in econometric literature (Enders, 2016). Variable Y has causality concerning variable X if the value of X can be predicted more accurately with the historical values of X and Y than with the value of X alone. Using the Granger VECM, we conducted causality testing in this investigation. This test of causality evaluates whether a variable may predict other variables. With VECM, short-term and long-term causality, as well as a combination of long-term and short-term causality, can be differentiated (Belloumi, 2009).

RESULTS AND DISCUSSION

Stationary Data Testing and Lag Selection

This study tests the stationarity of the data using the Augment-Dickey Fuller (ADF) method. Static data has a constant mean, variance, and covariance over time. Data that is not stationary when used to perform regression equations can cause spurious regression. In order to prevent the problem of spurious regression that may originate from the regression of nonstationary time series data, the data must be transformed into stationary time series data (Gujarati & Porter, 2009). Differentiation is one technique for altering nonstationary time series data. The differentiation procedure is executed by subtracting data from one period (Y_t) from data from the preceding period (Y_{t-1}). Several iterations of the differentiation procedure can create static data.

Table 1 shows the stationarity test results for all variables. In testing the level or I(0), the absolute value of the t statistic is less than the level of significance for all variables. The result shows that every variable has a unit root or is not stationary at I(0). The data is transformed through a differentiation procedure into I(1) to address the issue of nonstationary data. The absolute value of the t statistic is greater than the significance level after data transformation hence it may be concluded that all variables are stationary on I(1) at a significance level of 1%.

Table 1. ADF Unit Root Test

Variables	I(0)		I(1)	
	T-stat.	Prob-Value	T-stat.	Prob-Value
COE	-2.66603	0.2548	-6.27175***	0.000***
CRD	-1.14221	0.9105	-6.29869***	0.000***
ENR	-1.10146	0.918	-6.94132***	0.000***
GDP	-2.64512	0.2633	-5.03201***	0.0009***
EXP	-2.79278	0.2071	-7.50459***	0.000***
PDS	-1.29344	0.8745	-4.30311***	0.0078***

Notes: The critical values at level (I0) and at the first difference (I1) for 1%, 5%, and 10% levels of significance are -4.165, -3.508, -3.184, and -4.171, -3.511, -3.185 respectively. ***, **, * are statistically significant at 1%, 5%, and 10%, respectively.

Source: data processed by authors.

Table 2 displays the optimal recommended lag length to be selected. Available criteria include LR, Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criteria (SC), and Hannan Quinn Information Criteria (HQ). LR, FPE, AIC, and HQ indicate selection at lag 4, whereas SC indicates selection at lag 1. Lag 4 is used in this research to represent the majority of test results.

Table 2. Optimum Lag Length Selection

Lag	LR	FPE	AIC	SC	HQ
0	NA	0.033738	2.286595	2.369342	2.316925
1	208.4283	0.000195	-2.867245	-2.619006*	-2.776256
2	7.758356	0.000192	-2.886454	-2.472723	-2.734805
3	7.894952	0.000186	-2.921548	-2.342325	-2.709240
4	12.13944*	0.000157*	-3.098934*	-2.354218	-2.825966*
5	0.275797	0.000190	-2.917354	-2.007146	-2.583727

Notes: * in the lag indicates the suggested length of the lag to be selected based on the criteria contained in the header.

Source: data processed by authors.

Cointegration Test

A cointegration test is conducted to determine whether stationary variables have a long-term relationship. If stationary variables in I(1) are regressed and create stationary residuals in I(0), then the equation has cointegration (Gujarati & Porter, 2009). In this study, we conducted the cointegration test utilizing the Johansen Cointegration Test method for multivariable variables. The results of the Johansen cointegration test for Trace Statistics and Max-Eigen Statistics are displayed in Table 3. The first hypothesis, which claims that cointegration does not exist, is rejected when the probability is less than 5%. Both results for Trace Statistics and Max-Eigen Statistics are favorable. Thus, it can be stated that the data differentiation of the variables in the study has one cointegration, allowing it to move on to the VECM process to determine the dynamic relationship between variables.

Table 3. Cointegration Testing

Total Cointegration Hypothesis	Trace Statistic	0,05 Critical Value	Prob-Value
None	26.62666	25.87211	0.0402
at most 1	2.935786	12.51798	0.8841
Total Cointegration Hypothesis	Max-Eigen Statistic	0,05 Critical Value	Prob-Value
None	23.69087	19.38704	0.0111
at most 1	2.935786	12.51798	0.8841

Source: data processed by authors

VECM Model Estimation and Causality Analysis

The results of the VECM equation explain the relationship between the influence of the development of the financial sector and carbon dioxide emissions. The short-term association between the calculated VECM variables is displayed in Table 4. According to the VECM short-term estimation results, only a few variables have a substantial effect on carbon emission variables.

Table 4. Short-term VECM Estimation Results

Variable	Coeff.	T-stat.	Prob. Val.	Variable	Coeff.	T-stat.	Prob. Val.
COE_{-1}	0.074052	0.41504	0.6796	C	-22.14067	-2.87860	0.0056
COE_{-2}	-0.217951	-1.22440	0.2258	ENR	1.230572	3.31262***	0.0016***
COE_{-3}	-0.058327	-0.35287	0.7255	GDP	-0.045232	-0.16205	0.8718
COE_{-4}	-0.081016	-0.49497	0.6225	EXP	0.312125	2.23011	0.0296**
CRD_{-1}	0.054081	0.45338	0.652	PDS	0.919863	0.92961	0.3564
CRD_{-2}	0.176189	1.72951*	0.089*				
CRD_{-3}	0.06978	0.71178	0.4795				
CRD_{-4}	0.127506	1.23034	0.2235				

Notes: The critical values for 1%, 5%, and 10% significance level are 2.704, 2.011, and 1.679,, respectively. ***, **, * are statistically significant at 1%, 5%, and 10% respectively.

Source: data processed by authors.

Based on Table 4, the first through fourth COE lag variables do not significantly influence the value of carbon dioxide emissions. At a significance level of 10%, the CRD variable for the second lag considerably impacts the value of carbon dioxide emissions. A positive coefficient shows that the rise in credits from two years ago has led to an increase in carbon dioxide emissions.

Meanwhile, the control variable has a different short-term effect on the COE variable. The statistical t values for the two control variables ENR and EXP surpass the critical values for 1% and 5% level of significance, respectively, indicating that these factors have a substantial effect on the COE variable. Both the ENR and EXP coefficients are positive, indicating that an increase in energy consumption and exports will increase carbon dioxide emissions. Based on the findings of the VECM estimation, the following short-term equation can be derived:

$$\ln COE = -22{,}14067 + 0{,}176189 \ln CRD_{-2} + 1{,}230572 \ln ENR + 0{,}312125 \ln EXP \quad (2)$$

In the short term, the value of credits in the previous two years will affect the current value of carbon dioxide emissions. With a positive coefficient value of 0.176, it explains that a 1% increase in credit in the previous two years will increase 0.176% of current carbon dioxide emissions. Credit has a considerable effect on carbon dioxide emissions over the long term. With a positive available credit coefficient of 0.528, it suggests that a 1% increase in credit disbursements will result in a 0.528% increase in carbon dioxide emissions. The relationship can be explained by examining Table 5. The long-term effects of CRD factors on carbon dioxide emissions are significant. The significance is demonstrated by the value of the t statistic exceeding the t table at a 1% significance level. The t value of CRD statistics is 3.14042. The value of the coefficient indicates the direction of CRD's influence on COE over the long term. As illustrated by the positive coefficient value of 0.528352, the COE value will rise as the CRD increases.

Table 5. Long-term VECM Estimation Results

Variable	*Coefficient*	*t-stat.*
COE_{-1}	*1*	

Variable	Coefficient	t-stat.
CRD_{-1}	0.528352	3.14042*
C		-9.353037

Notes: ***, **, * are statistically significant at 1%, 5%, and 10% respectively
Source: data processed by authors.

As for the causation component, we utilized multivariate VECM Granger causality in this study. This causality test evaluates whether a variable can predict other variables. Variable Y has causality concerning variable X if the value of X can be predicted more accurately with the historical values of X and Y than with the value of X alone. Through VECM, causality can be distinguished into long-term and short-term causality, as well as combined short-term and long-term causality (Belloumi, 2009). Short-term causality can be seen through the combined significance of the independent variable λ using $\chi 2$ – Wald meanwhile, long-term causality can be seen through the significance of η (ECT coefficient).

Table 6 displays the VEC Granger Causality results to see short-term and long-term causality in the VECM equation. When the COE variable is utilized as the dependent variable, there is no short-term causation between the CRD variable and carbon dioxide emissions. The lack of causation is indicated by the chi-square probability value of 0.281, which surpasses the significance threshold. Similarly, when CRD is utilized as the dependent variable, lnCOE does not have short-term causality with CRD.

As for long-term causality, the probability value is 0.0046 when COE is the dependent variable. This value is less than the significance level, showing a long-term causal relationship between the CRD variable and COE. Similarly, the probability value equals 0.0114 when lnCRD is the dependent variable. This data indicates a long-term causal relationship between COE and CRD. It can be argued from these studies that carbon dioxide emissions and credits have bidirectional long-term causality. The relationship demonstrates that over the long term, in Indonesia, the value of carbon dioxide emissions is determined by the value of historical credits and vice versa.

Table 6. Long-term VECM Estimation Results

Dependent Variables	Short-term		Long-term	
	Chi-sq	Prob. Value	T-stat.	Prob. Value
COE	5.062417	0.2810	-2.94977	0.0046***
CRD	6.029385	0.1970	-2.611867	0.0114**

Notes: ***, **, * are statistically significant at 1%, 5%, and 10% respectively
Source: data processed by authors.

Discussion

The results of the study show that there is a causality between credit in the financial sector and carbon dioxide emissions following research conducted by Zhang (2011). The study was conducted in China utilizing data from 1980 to 2009 using the VECM Granger Causality method. Zhang (2011) shows that the development of the financial sector is a significant influence on the rise of carbon dioxide emissions because it is inefficient at distributing financial resources to businesses.

Similar results stating that there is a positive influence of financial sector developments on carbon dioxide emissions are also supported by Fitriyah's research (2019). Fitriyah (2019) discovered a correlation between the growth of the financial industry and rising carbon dioxide emissions. Fitriyah (2019) argues that it is a result of the immature growth of the financial sector in Indonesia so financial sector improvements have not created incentives for the utilization of environmentally friendly energy.

Studies on the impact of the development of the financial industry on the environment in developing nations offer comparable conclusions. Sadorsky (2010) investigated the impact of financial sector changes on energy consumption in 22 developing countries using data from 1990 to 2006. The analysis shows that the expansion of the financial industry in these nations has substantially increased their energy usage. Considering the influence of large financial sector developments, Sadorsky (2010) proposes taking the financial sector into account when planning energy consumption, as it is expected that the financial industry will continue to expand in developing countries. However, the research reveals that bank deposit asset characteristics have no substantial impact on energy consumption growth due to the inaccessibility of credit non developing nations, such that bank deposit assets cannot boost consumption, investment, or economic growth (Sadorsky, 2010). Ozturk and Acaravci (2013) in Turkey concluded, using data from 1960 to 2007, that the growth of the financial sector had no long-term impact on carbon dioxide emissions. In addition, Ozturk and Acaravci (2013) highlight the significance of financial sector expansion in energy consumption and carbon dioxide emissions because there is a short-term causal relationship between financial sector development and energy consumption.

In the case of Indonesia, the growth of the banking sector can support industrial expansion, particularly among small and medium-sized businesses. The capitalization effect permits environmental deterioration to occur since these enterprises lack economies of scale and effective pollution prevention resources. The number of small and medium enterprises in Indonesia reached 64 million in 2019; this represents a year-over-year growth (Kementerian Koperasi & UKM, 2019). The growth suggests that the capitalization effect of developing the financial industry in Indonesia tends to exacerbate pollution.

When evaluated from the perspective of technological consequences, the growth of the financial sector permits an increase in research and development activities, hence boosting environmentally friendly technologies. In Indonesia, the financial sector development is still in its infancy (Fitriyah, 2019). The early stage suggests that the rise of the financial industry has not created research and development incentives for environmentally friendly solutions. The same can also be observed via the income impact. Initially, the rise of the financial sector will influence economic growth, increasing pollution.

In addition, there is no regulation with a good environmental protection framework for the supply of financial services in Indonesia. The existence of healthy regulations tends to strengthen the effect of environmental policies, such as regulation of requirements for banks that are required to consider environmental issues when assessing loan applications or provisions for prioritizing projects that take environmental concerns into account.

CONCLUSION

One of the greatest challenges we face today is mitigating the adverse effects of global climate change, and one of the key efforts is reducing carbon emissions. This study explores the causal relationship between financial development and carbon dioxide emissions in Indonesia. Changes in the financial industry have both a short- and long-term effects on carbon dioxide emissions. The development of the financial sector, as measured by the value of credit in the preceding two years, has a positive effect on current carbon dioxide emissions. Long-term financial sector development has a positive effect on economic growth, which then increases carbon dioxide emissions. According to the results of the VEC Granger Causality test, there is no short-term causal relationship between the development of the financial industry and carbon dioxide emissions. In the long term, the development of the financial sector and carbon dioxide emissions in Indonesia have bidirectional causality. Given two-way causation, initiatives to limit carbon emissions and financial sector advances will have long-term adverse effects. Thus, the Indonesian government should evaluate the long-term effects of economic growth on carbon dioxide emissions and take steps to reduce them. The government can, for instance, strengthen environmental norms and standards for financial transactions and monitor their compliance. The government can also impose carbon taxes or emission caps on high-polluting sectors and use the revenue to fund renewable energy sources and energy efficiency programs. Also, the government should consider the environmental implications of financial development and introduce policies that incentivize financial actors to promote green finance and low-carbon technologies and support green initiatives. In addition, the government can develop a culture of environmental responsibility among financial actors and customers. Lastly, this study has a research limitation where the data utilized is annual data. Hence, observations are limited. The more time series data available, the better it is to discern causality and long-term correlations between variables. In addition, the data presented solely uses domestic financial sector credit as a proxy for financial sector development. Considering the vast extent of the Indonesian financial sector from various perspectives, it is hoped that by expanding the research on financial sector variables, more comprehensive results can be reached.

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