Jurnal Ekonomi dan Pembangunan Vol. 32 No. 1 Tahun 2024
Journal Homepage: https://ejournal.brin.go.id/JEP
ISSN 0854-526x (print) | e-ISSN 2503-0272 (online)
DOI: 10.55981/jep.2024.671

The Impact of Financial Development on Carbon Emissions in ASEAN Countries

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Abstract

Financial development holds a significant role in reducing carbon emissions. However, the indirect impact of financial development can increase carbon emissions through several channels and shows an inconclusive result. Therefore, this study aims to examine whether financial development is also an important variable for reducing carbon emissions in ASEAN countries. This study utilizes a financial development index as a multidimensional indicator for financial development, using 27 years using balanced panel data from 1992 to 2018. The most important finding from this study is that the contribution of financial development in reducing carbon emissions is always less than the contribution of per capita GDP in increasing carbon emissions. This paper also finds that the inverted U-shaped curve of per capita GDP supports the EKC hypothesis in ASEAN.

Keywords: *financial development, carbon emissions, EKC hypothesis, ASEAN*
JEL Classification: O013, O016, O044

Abstrak

Perkembangan sektor keuangan (financial development) memegang peranan penting dalam mengurangi emisi karbon. Namun, pengaruh tidak langsung dari financial development dapat meningkatkan emisi karbon melalui beberapa saluran dan memberikan hasil yang meragukan. Oleh karena itu, tesis ini bertujuan untuk memeriksa apakah financial development juga merupakan faktor penting dalam mengurangi emisi karbon di negara-negara ASEAN. Tesis ini menggunakan indeks perkembangan sektor keuangan (financial development index) sebagai indikator multidimensi untuk financial development, menggunakan 27 tahun data panel mulai dari tahun 1992 sampai 2018. Temuan terpenting dari tesis ini adalah kontribusi dari financial development untuk mengurangi emisi karbon masih lebih kecil dibandingkan kontribusi PDB per kapita dalam menaikkan emisi karbon. Hasil tesis ini juga mendukung hipotesis Kurva Kuznet lingkungan (the Environmental Kuznet Curves) di ASEAN.

Kata kunci*: financial development, carbon emissions, EKC hypothesis, ASEAN*
Klasifikasi JEL*:* O013, O016, O044

Submitted : 04-02-2023
Revised : 23-12-2023
Accepted : 02-01-2024

INTRODUCTION

According to the World Meteorological Organization forum report (WMO, 2018), carbon dioxide emissions (CO2 emissions), as the major pollutant, can worsen global warming and negatively affect health and a major economy. It leads to the increase of the earth and sea surface temperature causing extreme climate change such as temperature anomalies, extreme rainfall, and natural disasters. As a result, a rise of 1 degree Celsius from its global temperature average will lower the economic growth by 0.9 % in emerging countries and 1.2 % in low-income developing countries (WMO, 2018, p. 33)

The urgency to respond the environmental problem brings the Association of Southeast Asian Nations (ASEAN) to launch an economic growth and environmental agenda considering that ASEAN members such as Indonesia, Lao and Myanmar has large forest coverage. While developing its economic development, ASEAN face some challenges towards environmental sustainability and it will impact on the loss of GDP per capita about 0.7-8.5 percent by 2100 (Kahn et al., 2021; Tan & Kamaruddin, 2019). In April 2020, ASEAN proposes sustainable finance as part of the ASEAN Socio-Cultural Community Blueprint 2025 agenda as the continuation of the Paris Agreement (ASEAN, 2020). There are four pillars to promote this agenda: policy, coordination, awareness and education, and demand-supply side. Coordination pillar s are about collaborating among stakeholders, starting with allocating finance to green investment, especially for climate action. It is noted that in 2018, the performance has been slowed down. Therefore, it is important to examine the influence of financial development on the environment in ASEAN.

A previous study confirms that green financial development in China can reduce carbon emissions through green technological information (Chen & Chen, 2021). On the other hand, a similar study in India shows that financial development is an important variable to increase carbon emissions. It also affects the long-run positive relationship, which means that the contribution of financial development to carbon emissions as a form of environmental degradation exists (M. Khan & Ozturk, 2021; Kwakwa, 2020). Moreover, a finding from Salahuddin et al. (2018) shows that financial development somewhat has no significant impact on carbon emissions. Despite the important role of financial development, empirical studies about financial development and carbon emissions mostly concentrate on China, India, and cross countries (K. Acheampong, 2019; Assi, Zhakanova Isiksal, & Tursoy, 2020; Munir, Lean, & Smyth, 2020)

It has been argued that variation in indicator used in the research will cause different results (Gök, 2020). There are many indicators to measure financial development. Svirydzenka (2016) states that financial development is a multidimensional concept, so it needs a more comprehensive measurement to capture the multidimensional nature of financial development. Moreover, the issue in the Environmental Kuznets Curves (EKC) hypothesis has not been solved yet. It posits that there is an inverted U-shaped curve relationship between growth and carbon emissions. At first, economic growth will cause an increase in carbon emissions, until it reaches a point where economic growth will help the environment by reducing carbon emissions.

Considering those facts, this study examines whether financial development in ASEAN countries can reduce or increase carbon emissions. Therefore, this study should answer two research questions: i) Does financial development have a negative effect on carbon emissions? ii) Does the EKC hypothesis exist in ASEAN?

Results from previous studies involve too many countries which have various natures of financial development (A. O. Acheampong, Amponsah, & Boateng, 2020). Since the study about financial development is no longer new research, this study aims to enrich more references about financial development effect on carbon emissions using financial development index including the data from 1992 to 2018. This study employs the financial development index (FD) which has been considered as the most comprehensive indicator for financial development, provided by IMF for ASEAN countries. It contrasts to previous studies that mostly use several proxies such as domestic credit as share to GDP and credit to the private sector. In addition, knowledge will affect decision-making. Therefore, this study employs interaction terms between financial development and human capital and examines the effect of the Paris Agreement towards financial development involvement in carbon emissions relation.

The findings of this study support the results from Acheampong et al. (2020) and Assi, Zhakanova Isiksal, & Tursoy (2021), in contrast with Haini (2021) in terms of the inverted U-shaped curve of financial development, which shows that the squared variable has a positive but insignificant effect on carbon emissions. In addition, the consistency of per capita GDP strengthens the findings of Saboori and Sulaiman (2013) for the EKC hypothesis. However, most results show that the effect of per capita GDP on carbon emissions after the turning point is insignificant. The possible reason is that per capita GDP is not the only factor causing an increase in carbon emissions in the long term.

This paper is divided into five chapters. The first chapter briefly explains the background and aim of the study. The second chapter is the literature review of conceptual theory and empirical findings. The third chapter shows the employed methodology and data sources. The fourth chapter presents the results and discussion, followed by conclusions in chapter five.

LITERATURE REVIEW

2.1 Carbon emissions

Emissions refer to waste gas that is produced from the consumption or production cycle which Keohane and Olmstead (2016) state as an atmospheric concentration of trapped greenhouse gas. In the book Natural Resource and Environmental Economics, Perman et al. (2003) say that the use of fossil fuels and deforestation involving humans in the economy can produce massive emissions including carbon emissions which should naturally be absorbed by water, air, and soil. However, he states that the rise of emissions is influenced by other factors such as the population growth rate, rate of technological progress, energy efficiency, and policy implication of measures to handle environmental problems. As an environmental indicator, carbon dioxide emissions are a key driver for climate change. It is predicted that the impact of carbon emissions on economies is between 1 % to 1.5 % of GDP per year for developed countries, and 2 % to 9 % for developing countries (Perman, Ma, McGilvray, & Common, 2003, p. 329)

Several indicators measure carbon dioxide emissions such as carbon emissions per capita, total carbon emissions, concentrations, and carbon intensity (Munir et al., 2020; York, Rosa, & Dietz, 2003). Commonly, a study using cross countries data adopts carbon emissions per capita as the proxy of environmental degradation in their model (Sapkota & Bastola, 2017). However, the process of calculating is beyond this study.

2.2 Financial Development and Carbon Emissions

Financial development has a long history in economic research. Bagehot (1873) in Huang (2010) states that the well-organized capital market enhances resource allocation towards more productive investment. Subsequently, many researchers use those indicators separately to represent financial development and relate them to other factors such as carbon emissions (Ahmed, Asghar, Malik, & Nawaz, 2020; Bekhet, Matar, & Yasmin, 2017; Islam, Shahbaz, Ahmed, & Alam, 2013; Zhang, 2011)

Some studies shows that financial development gives uncertainty result for carbon emissions due to its complexity (Jiang & Ma, 2019).Previous studies indicate that financial development has an important role in carbon emissions which can be classified into three categories: negative, positive, and insignificant effects on carbon emissions. Shahbaz, Solarin, Mahmood, & Arouri (2013) find that real domestic credit to the private sector per capita can improve environmental quality in the long run. There are numerous commercial financial institutions in Malaysia, so loan schemes can be applied to households or firms. However, it has an insignificant effect in the short run. They also include the non-linearity variable of financial development which has an insignificant result.

On the other hand, many studies prove that financial development has a bad impact on the environment in accumulating more carbon emissions. Financial development through financial sectors tend to give kredit to industries on expanding scale production than focusing on green development in developing countries (Jiang & Ma, 2019). It boosts many projects and activities which needs more energi consumption that can lead to accumulate more carbon emissions. The result shows that the increase of carbon emissions due to financial development is less than 0.2 % (Phong, 2019). Many loans given by banks are not considering the effect on the environment and encourage people to consume more undurable goods which cause environmental problem (Shahbaz, Shahzad, Ahmad, & Alam, 2016). Furthermore, Parveen et al. (2023) claim that financial development can improve environmental quality in industrialized countries. They explain that the financial development gains high economic output by extending their finansial resources to the environmentally friendly input.

Another, study from Acheampong et al (2020) gives a complex result. In their study, the classification of 86 sample countries is based on Morgan Stanley Capital International (MSCI) index which divides them into four groups: developed, emerging, frontier, and stand-alone financial economies. It reveals that financial market depth and efficiency increase carbon emissions in frontier and stand-alone financial economies countries. Meanwhile, in the emerging and developed countries, the effect is negative. The reason is that financial development using technological innovation is a good promotion for gaining good governance and financial investment in environment-based projects. Their study gives more contribution regarding financial development and the carbon emissions relationship by adding a quadratic variable. This variable is beneficial in examining the extent impact of financial development across times. Then, study from Salahuddin, Alam, Ozturk, & Sohag (2018) shows the insignificant result of financial development on carbon emissions in Kuwait. They use electricity consumption, economic growth, financial development, and foreign direct investment. However, their results suggest that for financial developed in Kuwait, the effect on carbon emissions becomes insignificant.

When using a single country (Turkey), Shahbaz, Hye, Tiwari, & Leitão (2013) have not found a long-run relationship between domestic credit to the private sector and carbon emissions. He says that structural breaks in an economy are the causing factor of equilibrium conditions. Meanwhile, Shahzad, Kumar, Zakaria, & Hurr (2017) found unidirectional causalities with a positive impact on carbon emissions in Pakistan. Domestic credit as a percentage of GDP in this country leads to a 0.16 % increase in carbon emissions in the long run and less than 0.09 % in the short run.

In terms of regions, Munir et al. (2020) found that financial development measured by the increase of household loans in China and India leads to higher carbon emissions by 0.12 percent since households consume goods which needs energy requirement. Omri, Daly, Rault, & Chaibi (2015) find that bidirectional causalities exist between financial development, carbon emissions, trade, and economic growth in the Middle East and North Africa (MENA) countries and confirm the inverted U-shaped curve in the Environmental Kuznets Curves (EKC) hypothesis using GMM estimator. Carbon emissions is considered as the expense of economic growth. The greater trade openness and financial system development foster technological advancements by boosting investment in R&D, which leads to energy effeciency that can reduce emissions. It also supports finding from Sung, Song, & Park (2018) that domestic credit as a percentage of GDP has a positive impact of around 0.087 % in the short and long-run relationship with carbon emissions in emerging economies. They claimed that financial development plays an important role in the environment which is strongly affected by financial policy direction. However, in that study Sung does not control the policy strategies, though mostly GDP in china is driven by manufacturing sector. They suggest that further researcher can add more about industrial policy specifically considering China as the largest exporter in manufacture.

RESEARCH METHOD

This study uses 270 balanced panel data from 10 countries, namely Brunei Darussalam (BRN), Cambodia (KHM), Indonesia (IDN), Lao (LAO), Malaysia (MYS), Myanmar (MMR), the Philippines (PHL), Singapore (SGP), Thailand (THA), and Vietnam (VNM), range from 1992 to 2018. The dependent variable is carbon emissions, and the independent variables are financial development, per capita GDP, trade, Human Capital Index (HCI), Paris Agreement dummy variable (PA), and the interaction terms of FD with PA, per capita GDP, energy consumption, and human capital. Most data are obtained from world Development Indicator (WDI), while carbon emissions and energy use are obtained from ourworldindata (OWD). The financial development index (FDI) is obtained from IMF.

By utilizing panel regressions analysis, this study attempts to construct an economic model based on previous studies. First, most studies start from the basic relationship between economic growth and carbon emissions relation. This builds an empirical form of the EKC hypothesis (Ali, Gong, Ali, Wu, & Yao, 2021; Wang, Yang, & Li, 2023).

Then, some researchers include human capital as the contributor to the environmental problem (Z. Khan, Ali, Dong, & Li, 2021; Z. Khan, Hussain, Shahbaz, Yang, & Jiao, 2020). Subsequently, financial development becomes an interesting factor that experts include in the model. Shahbaz, Nasir, & Roubaud (2018) and Acheampong et al. (2020) add financial development by adding the squared variable to show the nature of financial development in extent time as well as the validity of the EKC hypothesis. Therefore, by considering the historical construction, this study attempts to construct a general form as is written in equation (1)

$$CO_{2it} = f(GDPC_{it}, TRADE_{it}, EU_{it}, FD_{it}, HCI_{it}) \quad (1)$$

where CO_{2it} is carbon emissions, FD_{it} is financial development, $GDPC_{it}$ is Gross Domestic Product (GDP) per capita, $TRADE_{it}$ is trade openness, EU_{it} is energy consumption per capita, and HCI_{it} is human capital.

Thus, this study applies logarithm form and modifies some variables to answer the research question whether financial development have a negative impact on the environment. This study hypothesizes that the effect of financial development on carbon emissions depends on the value of human capital and the shock that occurred during the timeline. Therefore, considering the environmental agenda as a shock, this study attempts to examine the role of this shock in reducing carbon emissions by adding dummy variables and its interactive variable with financial development. The interaction terms in the model are meant to assess how GDPC, EU, and HCI affect carbon emissions at a particular state of financial development (FD). The squared variable of economic growth also is meant to answer the second research question whether the EKC hypothesis exist in ASEAN. Thus, the overall equation can be written as (2):

$$lnCO_{2it} = \beta_0 + \alpha_1 lnFD_{it} + \alpha_2 lnFD2_{it} + \alpha_3 lnGDPC_{it} + \alpha_4 lnGDPC2_{it} + \alpha_5 lnTRADE_{it} + \alpha_6 lnEU_{it} + \alpha_7 lnHCI_{it} + \alpha_8 PA_t + \alpha_9 PA_{it}\_lnFD_{it} + \alpha_{10} lnFD_{it}\_lnGDPC_{it} + \alpha_{11} lnFD_{it}\_lnEU_{it} + \alpha_{12} lnFD_{it}\_lnHCI_{it} + u_i + \varepsilon_{it} \quad (2)$$

where $i = 1, \ldots, N$ for country and t = 1, …, T for time-period; $lnCO_{2it}$ is the natural logarithm of carbon emissions of country *i* in time *t;* $lnFD_{it}$ is the natural logarithm of financial development index of country *i* in time *t;* $lnFD2_{it}$ is the square of the natural logarithm of financial development of country *i* in time *t;* $lnGDPC$ is the natural logarithm of per capita GDP in constant 2010 US dollars of country *i* in time *t;* $lnGDPC2_{it}$ is square of the natural logarithm of per capita GDP in constant 2010 US dollars of country i in time t; PA_t is a dummy variable for the Paris Agreement, where the dummy for the Paris Agreement in 2015 has a value of 1 for the year after 2015 and 0 for the year before 2015, and others are control variables of country i in time t including $lnTRADE_{it}$, $lnEU_{it}$, $lnHCI_{it}$, and interaction variables; u_i is the unobserved time-invariant heterogeneity for country i that may be correlated with explanatory variables; ε_{it} is the error term of country i in time t. Since the presence of time-invariant unobserved heterogeneity is inevitable in panel data, it should be examined whether regressor and time-invariant factors correlate with each other. If so, the factor can be treated as a composite error by using the fixed-effect model Wooldridge (2016). Various tests are employed for robustness purposes using different panel unit root tests and different proxies. The procedure for the best fitting and robust model can be seen in Appendix B.

To obtain the turning point of the EKC in the model, this study follows strategies from Thompson (2012). Model without moderating variable can obtain the turning value of the EKC using this formula:

$$Turning\ point\ of\ EKC\ (Basic\ model) = exp(-\frac{\alpha_3}{2\alpha_4}) \quad (3)$$

where α_1 is the coefficient of linear term and α_2 is the coefficient of non-linear term. Then, the results will be multiplied by 1000 to obtain value in per capita \$US.

Meanwhile, *Model 5* with moderating variable of lnFD_lnGDPC, will use this formula:

$$Turning\ point\ of\ EKC(with\ moderating\ variable) = exp(-\frac{(\alpha_3+\alpha_{10}FD^*)}{2\alpha_4}) \quad (4)$$

RESULTS AND DISCUSSION

Table 1 shows that the total number of observations in this study is 270, except for energy consumption per capita (EU) which only has 262 observations since data for the years 2017 and 2018 are unavailable. The variables are per capita CO_2 emissions (total carbon emissions in a year per capita in gigaton), finansial development is proxied by the Financial Development Index (FD) which is a relative ranking of countries on depth, access, and efficiency of their financial institutions and financial markets in a squared form. It is an aggregate of the financial institution's index and the financial market index. It is represented by a range number from 0 to 1, where 0 means a country has worse financial development and 1 means a country has the best financial development, per capita GDP (constant 2010 US\$) to measures economic growth, trade opennes as a percentage of total export and import to GDP, energi consumption per capita (kg of oil equivalent), human capital index (index point) that can describe the influence of knowledge, and Paris Agreement Dummy *(PA)* is included to capture the significant phenomenon in the time, especially the environmental agenda such as Paris Agreement.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	270	4.36	5.82	.11	24.23
FD	270	.32	.172	0.00	.75
GDPC	270	9.72	14.84	0.21	59.07
TRADE	270	1.23	.90	.04	4.42
EU	262	30.69	44.48	0.21	174.63
HCI	270	2.27	.5	1.41	4.15
PA	270	.15	.36	0	1

Source: OWD (Author's calculation)

Notes: The lowest index from Cambodia with 0.00007. In the IMF data from Svirydzenka (2016), it is written as zero due to missing data. However, it also said that missing data does not mean the financial activity is non-existent.

The overall summary for each country can be seen in Appendix A. On average, *Carbon emissions per capita (CO_2)* range from 0.11 to 24.23 metric tons per capita, with a mean of 4.36 metric tons per capita and a standard deviation of 5.82 metric tons per capita. *The Financial Development Index (FD)* ranges from 0.0007 to 0.75 with a mean of 0.32 and deviates from its mean by 0.172. *Per capita GDP* (*GDPC)* in thousand $US ranges from US$ 0.21 to US$ 59.07 with a mean of US$ 9.72 and deviates from its mean by 14.84 US$. *Trade openness (TRADE)* ranges from 0.04 to 4.42 with a mean of 1.23 and a standard deviation of 0.90. *Energy consumption per capita (EU)* ranges from 0.21 MWH to 174.63 MWH averaging 30.69 MWH and deviates from its mean by 44.48 MWH. *The human capital index (HCI)* ranges from 1.41 to 4.15 averaging 2.27 with a standard deviation of 0.5. *Paris Agreement dummy (PA)* ranges from 0 to 1 averaging 0.148 with a standard deviation of 0.356. Among variables, GDPC and EU have the highest number with a very wide range. Therefore, a natural logarithm transformation is needed.

Brunei Darussalam was the highest contributor of carbon emissions in the last 27 years, averaging carbon emissions of 17.573 gigatons (GT) per capita, followed by Singapore with 11.472 GT per capita. Meanwhile, the lowest contributor is Myanmar averaging around 0.2 GT per capita. In addition, the highest level of financial development is for Malaysia with 0.582, while the lowest is for Cambodia with 0.095. It means that financial development in Malaysia is better than in Cambodia. Meanwhile, the highest level of per capita GDP is Brunei (35.644) and the lowest is Cambodia (0.644). ASEAN is one of the country groups which has a unique country composition. Based on the World Bank classification, only

Singapore and Brunei Darussalam are categorized as high-income countries, while others are upper-middle-income countries (Indonesia, Malaysia, Thailand) and lower-middle-income countries (Cambodia, Lao, the Philippines, Vietnam, Myanmar). This hints at the different behavior of financial development in ASEAN countries in reducing carbon emissions. According to the Sustainable Finance Report (World Wildlife Fund, 2019), less than 10 % of the banks in Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam has joined the Network for Greening the Financial System (NFGS) as part of Environmental, Social, and Governance (ESG) policy. There is no deforestation commitment found in most banks, even though tropical forests in ASEAN countries are beneficial for saving the world's global carbon stock.

A prior step for choosing the best fit model can be seen in Appendix B and C. **Table 2** presents the estimation results of all models under Fixed Effect robust estimation. There is a small deduction in sample observations due to the unavailability of data for years 2017 and 2018. However, models 1 to 7 show a determination coefficient of more than 70 %, which means that most variables included in this model can explain the variation on the dependent variable. Since all variables are in natural logarithmic form, the interpretation can be explained as elasticity to carbon emissions as a percentage. the diagnostic test shows some econometrical issues such as heteroscedasticity and autocorrelation. The fixed effect robust estimator can solve this problem.

In general, GDPC and GDPC2 have the expected sign which supports the EKC hypothesis. Meanwhile, FD and FD2 show positive signs in both terms, linear and non-linear. However, the variables should be interpreted carefully since the squared and interaction variables are included in the models. Wooldridge (2016) suggested using some interesting values, for example, an average of each variable would give a more reasonable explanation. Therefore, instead of only examining the sign and affect partially, we need to calculate the average partial effect of the independent variable on a dependent variable. The result is summarized in **Table 3**.

Table 2. Estimation Results

Dep. Var: $lnCO_2$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
lnGDPC	0.331***	0.270***	0.291***	0.256***	0.318***	0.312***	0.329***
	(0.088)	(0.087)	(0.086)	(0.086)	(0.101)	(0.088)	(0.089)
lnGDPC2	-	-	-	-	-	-	-0.078***

	0.065***	0.075***	0.070***	0.068***	0.074***	0.070***	
	(0.024)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
lnTRADE	0.064	0.134**	0.148***	0.131**	0.141**	0.151***	0.151***
	(0.050)	(0.054)	(0.053)	(0.053)	(0.054)	(0.054)	(0.054)
lnEU	0.567***	0.574***	0.545***	0.559***	0.569***	0.613***	0.564***
	(0.053)	(0.053)	(0.054)	(0.053)	(0.054)	(0.055)	(0.053)
lnHCI	-0.577	-0.692**	-0.802**	-0.612*	-0.762**	-0.895**	-0.555
	(0.353)	(0.345)	(0.344)	(0.344)	(0.353)	(0.353)	(0.345)
PA		0.166***	0.159***	-0.003	0.162***	0.157***	0.153***
		(0.045)	(0.045)	(0.088)	(0.046)	(0.045)	(0.045)
lnFD		-0.034**	0.152*	-0.033**	-0.025	0.006	-0.150***
		(0.017)	(0.079)	(0.016)	(0.019)	(0.024)	(0.049)
lnFD2			0.010**				
			(0.004)				
PA_lnFD				-0.160**			
				(0.072)			
lnFD_lnGDPC					0.017		
					(0.019)		
lnFD_lnEU						0.030**	
						(0.013)	
lnFD_lnHCI							0.299**
							(0.120)
Constant	-0.575***	-0.461***	-0.127	-0.497***	-0.422**	-0.325*	-0.477***
	(0.151)	(0.157)	(0.209)	(0.157)	(0.163)	(0.167)	(0.156)
Observations	262	262	262	262	262	262	262
R-squared	0.742	0.759	0.764	0.764	0.759	0.764	0.765
Number of id	10	10	10	10	10	10	10
Adj. R-sq	0.728	0.743	0.748	0.747	0.743	0.747	0.748
F test	142.3	110	98.85	98.47	96.29	98.64	99.06
Prob>F	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Average Partial Effect

Dep. Var: $lnCO_2$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
lnGDPC	0.185	0.101	0.134	0.102	0.126	0.153	0.153
	(0.119)	(0.118)	(0.118)	(0.117)	(0.121)	(0.119)	(0.119)
lnTRADE	0.064	0.134**	0.148***	0.131**	0.141***	0.151***	0.151***
	(0.050)	(0.054)	(0.053)	(0.053)	(0.054)	(0.054)	(0.054)
lnEU	0.567***	0.574***	0.545***	0.559***	0.569***	0.572***	0.564***
	(0.053)	(0.053)	(0.054)	(0.053)	(0.054)	(0.053)	(0.053)
lnHCI	-0.577	-0.692**	-0.802**	-0.612*	-0.762**	-0.895**	-0.962***
	(0.353)	(0.345)	(0.344)	(0.344)	(0.353)	(0.353)	(0.358)
PA		0.166***	0.159***	0.215***	0.162***	0.157***	0.153***
		(0.045)	(0.045)	(0.050)	(0.046)	(0.045)	(0.045)
lnFD		-0.034**	0.123*	-0.052***	-0.006	0.077	0.088*
		(0.017)	(0.067)	(0.018)	(0.035)	(0.050)	(0.052)
Observations	262	262	262	262	262	262	262

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This research finds that financial development boost environmental quality by reducing carbon emissions. The non-linear model without interaction terms in **column (2)** in **Table 2** shows that the estimated coefficient of the financial development is negative and significant at the 1 % significance level. It means that financial development can directly reduce carbon emissions by 0.034 %. The finding is consistent with Acheampong (2019) and Assi et al. (2020) that show how financial market development helps the emerging countries to boost the environmental quality by good governance. It is believed that financial policy among ASEAN members support the result. The regulation pertaining to sustainable banking in ASEAN members has been issued since 2015. For example, promoting Green Credit Growth and E&S Risks Management in Credit Granting Activities in State Bank of Vietnam (SBV) and the Financial Services Authority (OJK) in Indonesia which issued the regulation No. 51/POJK.03/2017 on the Application of

Sustainable Finance. **Column (3)** shows that financial development has a U-shaped curved. It is consistent with findings from Shahbaz, Ozturk, Afza, & Ali (2013) which found that the U-shaped curve of financial development in Indonesia resulted in the suggestion of redirecting investment with loans to environmentally friendly investment ventures so the environment can be saved.

The interaction term of financial development can be interpreted by using the results of the average partial effect in **Table 3.** It shows the size of the partial effect on average. About 3 out of 7 models of financial development give a positive and significant average partial effect on carbon emissions. **Column (3)** indicates that in the presence of FD2, the average partial effect on carbon emissions is about 0.123 % at the 10 % significance level. It means that a percentage point increase in financial development increases carbon emissions by 0.123 %. Nevertheless, **Columns (4)** show a negative and significant partial effect on carbon emissions. The influence of *financial development* on carbon emissions following only on Paris Agreement can moderate the reduction of carbon emissions by 5.2 %. It means that Paris Agreement effectively reduces carbon emissions during the time. It is similar to previous findings that the Paris Agreement raises the sensitivity of lenders to become aware of the strong commitment taken by policymakers (Palea & Drogo, 2020).

In **column (7)**, financial development influences carbon emissions positively depending on the level of human capital with the average partial effect of 0.088 % at the 10 % significance level. This result supports Haini's finding (2021) which found that human capital positively contributes to carbon emissions since it can lead to a higher economic activity that demands more energy consumption. The finding is consistent with Phong (2019) by using ASEAN-5 that financial development can boost energy consumption due to new projects and activity promotion which adds more carbon emissions.

In terms of *per capita GDP*, all models in **Table 2** show that the sign of per capita GDP (GDPC) and its square (GDPC2) consistently follows the EKC hypothesis. It is consistent with Saboori and Sulaiman's (2013) results in the case of Thailand, the Philippines, and Singapore. This supports findings from the previous result that the EKC hypothesis does exist in some cross countries' cases such as the United Arab Emirates (Voumik, Nafi, & Bekun, 2023), MENA countries (Gorus & Aslan, 2019), and ASEAN-5 (Phong, 2019). However, **Table 3** shows that the average partial effect of per capita GDP is not significant in all models. This finding further strengthens the findings of Acheampong (2019) that show an insignificant result of per capita GDP. It also supports that per capita GDP is not the only source contributing to carbon emissions.

Since this study uses ASEAN data as one region, the turning point of the EKC hypothesis counts as the overall turning point. This study uses equations (3) and (4) to obtain the value. The results for all basic models, except Model 5 is as follow: $US 12,758 (Model 1), $US 6,050 (Model 2), $US 7,993 (Model 3), $US 6,568 (Model 4), $US 9,286 (Model 6), $US 8,239 (Model 7). In equation (4), the calculation is done using the average value of financial development and the result for Model 5 is $US 8,894. These results show that on average, the EKC turning point in ASEAN countries is around $US 8,541 per capita, which supports the statement of Phrakhruopatnontakitti, Watthanabut, & Jermsittiparsert (2020) that most countries have the average EKC turning point around $US 8000 per capita. It indicates that carbon dioxide emissions are increasing in per capita GDP. However, the interaction terms of FD and GDPC in Model 5 are positive and insignificant, though it has an inverted U-shaped curve. It implies that financial development is not the only variable that can moderate per capita GDP to increase carbon emissions.

Trade (TRADE) shows a positive and significant result in **Tables 2 and 3** at a 1 % significance level. The average partial effect from **Table 3** shows that trade in all models can increase carbon emissions by 0.20 %. It supports the previous findings from Haini (2021) in the case of ASEAN but in contrast with Quang & Tao (2022) where trade can reduce carbon emissions in ASEAN and Zhu, Duan, Guo, & Yu (2016) for the case of ASEAN 5. One explanation for this is because this study uses different sample periods and countries which contain different influences from shocks such as oil price shocks, economic crisis, and environmental agreement.

Energy consumption (EU) shows the positive and significant results in **Tables 2 and 3** at the 1 % significance level. The average partial effect from **Table 4.3** shows that energy consumption contributes to carbon emissions from 0.55 % to 0.81 %. This is slightly lower than a previous result from Phong (2019) in which a 1 % increase in energy consumption can increase carbon emissions by around 1.133 %. This result is also in line with findings from Fatima, Mentel, Doğan, & Hashim (2022) in Gulf Cooperation Council (GCC) and Ozturk & Acaravci (2013) in the case of Tunisia. Both studies emphasize the importance of energy efficiency to reduce the negative externalities that can increase carbon emissions.

Human capital (HCI) mostly shows the negative and significant results in **Tables 2 and 3**. The average partial effect from **Table 3** indicates that human capital has an important role in reducing carbon emissions. The average partial effect shows that the percentage change of carbon emissions reduction due to human capital is around 0.7 % to 1.5 %. The result is consistent with Haini (2021) which emphasizes the role of Research and Development (R&D) to find renewable and more efficient energy in manufacturing sectors.

Meanwhile, *Paris Agreement* (PA) mostly shows positive and significant results in **Tables 2 and 3**. The average partial effect from **Table 3** shows that the average partial effect of the Paris Agreement contributes to the increase of carbon emissions by less than 0.3 % at the 1 % significance level. It indicates that in this study, even after the Paris Agreement, the increase of carbon emissions is still higher as the other factors also contribute to carbon emissions.

The interesting finding from the estimation result is that financial development can reduce carbon emissions through a direct effect but also can increase carbon emissions through an indirect effect. Results in **Table 3** demonstrate that financial development is best in collaborating with other sectors in achieving the optimum performance in reducing carbon emissions. The robust estimation also strengthens findings that the impact magnitude of financial development depends on other channels such as trade, energy consumption, and human capital is higher than the direct impact of financial development to reduce carbon emissions.

Furthermore, ASEAN countries have different launch time programs regarding green financing. For example, Vietnam launched green credit growth and environmental-social risk management in 2015, while Indonesia forced this implementation in 2017. Singapore, as the biggest trading country in ASEAN, launched its responsible financing guidelines in 2015, while the remaining countries implemented this rule in 2019 (WWF, 2019, p. 8). During 1992-2018, ASEAN top commodity groups for exports and imports were electrical machinery and equipment, sound recorders and reproducers, and television image and reproducers with a share of around 24 % of total ASEAN trade. It implies that the demand for electrical equipment is high in ASEAN, which has a spill-over effect on energy consumption. Therefore, electrical consumption in ASEAN also increases over the years. Therefore, it also affects the performance of each country in implementing environmental protection programs. The most important thing is about energy consumption in ASEAN. Nearly 90 % of electricity consumption is attributed to several countries namely Indonesia, Vietnam, Thailand, and Malaysia, where the power plant is powered by diesel and coal (International Energy Agency, 2020).

The other interesting finding comes from the Paris Agreement dummy. The result shows that even after the Paris Agreement was launched, an increase in carbon emissions was inevitable. It indicates that the environmental agenda in ASEAN is still far from achieving its target. This may be caused by several factors such as the content of the Paris Agreement. As an international agreement, the Paris Agreement urges its members to commit to their pledges. The mitigation and reduction plan for reducing emissions before 2030 is handled by individual members. The specific goal in each sector for reducing carbon emissions is not published. Therefore, it also ignores the reality of international trade that involves aviation and shipping.

4.2 Robustness Check

This study instead uses the financial institution index which is part of the financial development composite index. According to IMF (2022), the financial institution index is an aggregate of the Financial Institution Depth index (FID), Financial Institution Access index (FIA), and Financial Institution Efficiency Index (FIE). FID compiles data on bank credit to the private sector in percent of GDP, pension fund assets to GDP, mutual fund assets to GDP, and insurance premiums, life and non-life to GDP. FIA compiles data on bank branches per 100,000 adults and ATMs per 100,000 adults. FIE compiles data on the banking sector's net interest margin, lending-deposits spread, non-interest income to total income, overhead costs to total assets, return on assets, and return on equity.

The finding obtained in **Appendix E.** The results are almost consistent with the findings in **Table 2** which use the financial development index as a proxy. It does not confirm an inverted U-shaped curve of financial development but confirms the EKC curve in all models.

CONCLUSION AND RECOMMENDATION

This research implications investigates the impact of financial development on carbon emissions by considering other variables such as economic growth, trade openness, energy consumption, human capital, and interaction variable between financial development-economic growth, financialdevelopment-energy consumption, financial development-human capital, and the effect of the Paris Agreement-financial development on carbon emissions.

There are several main findings from the results. First, based on the significance of independent variables, this study found that financial development has mixing nature and affected by the including variables in the model. It might have affected by the unique composition of ASEAN member that has various level of economic development and financial system. The study also can validate the existence of EKC Kuznet curves. The economic growth demands more environmental degradation due to higher demand in population's need. Therefore, it will need more production output, The improvement in technology effeciency to be more environmental friendly is unevitable by involving green financing. The green financing encourages people or institution to import more environmental-friendly tools or using energy domestic product.

This research also find that financial development can reduce carbon emissions, although it is not a major role. The direct impact of financial development in reducing carbon emissions has not exceeded the indirect impact through trade, energy consumption, and human capital in increasing carbon emissions. However, it does not mean financial development can be ignored because financial development can help the environment directly but in a small portion, at least, in the ASEAN case. Some of ASEAN members still face difficulty to accelerate the application of renewable energy and environmental regulation. The financial institution should run a comprehensive assessment before giving credits and considering the impact on environment. The integration between green financial regulation, green technology adoption and renewable energy can help ASEAN members to gain the aim of environmental improvement.

The indirect effect of the Paris Agreement in reconstructing financial development to reduce carbon emissions has not worked effectively. It indicates that ASEAN countries should reevaluate their commitment and set a clear target for each sector. The involvement of financial development in trade shows its importance as a push factor in carbon emissions, showing that trade in ASEAN should be more considerate towards environmental issues. Fortunately, financial development helps people to be more engaged in the environment, resulting in responsibility towards sustainability.

Finally, trade and energy consumption exerts some cautious notes about energy efficiency. The study result indicates that trade and energy consumption in ASEAN is still dominated by non-environmentally friendly products. We argue that many financial institution has not joined the Network for Greening the Financial System (NFGS) as part of Environmental, Social, and Governance (ESG) policy so it encourages people to consume more goods which are environmentally unfriendly.

Based on several findings in this study, the policy recommendation formula cannot be made as one-way action. The improvement of environmental quality by reducing carbon emissions requires a strong commitment from all. Government can impose some rules related to financial development without neglecting the profit maximization philosophy for some institutional finance. Training in green investment and green financing for all vital stakeholders such as financial institutions is needed. Therefore, financial institutions such as banks can be more selective to distribute their fund. Besides that, the result of human capital shows the significant and negative effect on carbon emissions. Hence, environmental education should be included as the primary content in basic education both in formal and informal schools.

ACKNOWLEDGMENTS

The author would like to thank the editor’s and anonymous reviewer’s reviews and comments. The usual disclaimers apply.

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Appendices

Appendix A: Summary per country

Country: BRN

	N	mean	sd	min	max
CO2pc	27	17.573	4.022	11.666	24.225
GDPC	27	35.644	1.884	31.437	37.848
TRADE	27	.913	.077	.799	1.109
EU	25	88.236	31.387	50.811	148.258
HCI	27	2.652	.079	2.491	2.786
PA	27	.148	.362	0	1
FD	27	.305	.084	.08	.39

IDN

CO2pc	27	1.565	.355	1.05	2.172
GDPC	27	2.796	.729	1.879	4.285
TRADE	27	.529	.107	.374	.885
EU	27	6.308	1.412	3.879	8.536
HCI	27	2.241	.143	1.95	2.417
PA	27	.148	.362	0	1
FD	27	.326	.037	.26	.4

KHM

CO2pc	27	.297	.201	.135	.953
GDPC	27	.664	.269	.321	1.203
TRADE	27	1.066	.327	.124	1.446
EU	25	1.078	.665	.211	2.933
HCI	27	1.646	.147	1.454	1.932
PA	27	.148	.362	0	1

FD	27	.095	.038	0	.16
LAO					
CO2pc	27	.634	.984	.132	4.569
GDPC	27	.965	.404	.481	1.786
TRADE	27	.737	.15	.441	.991
EU	25	3.904	3.364	.772	12.009
HCI	27	1.747	.108	1.552	1.927
PA	27	.148	.362	0	1
FD	27	.13	.029	.07	.19
MMR					
CO2pc	27	.245	.103	.114	.486
GDPC	27	.711	.449	.206	1.573
TRADE	27	.46	.135	.036	.674
EU	25	19.788	10.458	9.289	33.586
HCI	27	1.616	.14	1.406	1.83
PA	27	.148	.362	0	1
FD	27	.117	.011	.1	.14
MYS					
CO2pc	27	6.478	1.292	3.839	8.073
GDPC	27	8.245	1.953	5.135	12.131
TRADE	27	1.745	.295	1.288	2.204
EU	27	29.414	6.738	17.729	38.157
HCI	27	2.722	.224	2.3	3.056
PA	27	.148	.362	0	1
FD	27	.582	.076	.41	.67
PHIL					
CO2pc	27	.915	.146	.735	1.303
GDPC	27	2.046	.501	1.501	3.191
TRADE	27	.797	.166	.554	1.047
EU	27	3.812	.476	3.151	5.095
HCI	27	2.509	.128	2.268	2.701
PA	27	.148	.362	0	1
FD	27	.358	.031	.32	.42
SGP					
CO2pc	27	11.472	3.158	5.751	18.139
GDPC	27	40.618	10.443	24.221	59.073
TRADE	27	3.567	.386	3.053	4.416
EU	27	133.483	25.493	93.277	174.634
HCI	27	2.924	.529	2.178	4.154
PA	27	.148	.362	0	1
FD	27	.357	.031	.317	.419
THA					
CO2pc	27	3.291	.69	1.835	4.212
GDPC	27	4.429	1.041	2.874	6.37
TRADE	27	1.159	.202	.758	1.404

EU	27	15.424	4.44	7.605	22.405
HCI	27	2.405	.219	2.083	2.774
PA	27	.148	.362	0	1
FD	27	.566	.107	.34	.75

VNM					
CO2pc	27	1.114	.585	.301	2.216
GDPC	27	1.084	.442	.478	1.964
TRADE	27	1.323	.398	.662	2.083
EU	27	4.69	2.837	1.186	10.818
HCI	27	2.221	.34	1.745	2.816
PA	27	.148	.362	0	1
FD	27	.36	.053	.27	.47

Appendix B. Panel Unit Root and Cointegration Test

Panel Unit Root Test Results

Variables	statistics			
	Terms	LLC	IPS	Fisher
Levels				
lnCO2	constant and trend	0.0955	-0.9889	33.2352***
lnGDPC	constant and trend	-3.7528***	-1.2085	0.1525
lnTRADE	constant and trend	0.0338	-4.2942***	149.83***
lnEU	constant and trend	NA	-1.7982***	19.8134
lnHCI	constant and trend	-1.3565	0.0932	118.5440***
lnFD	constant and trend	9.7753	-5.3189***	109.5776***
First Difference				
lnCO2	constant	-7.6417***	-7.5999***	189.6885***
lnGDPC	constant	-12.2388***	-5.8088***	113.4333***
lnTRADE	constant	-3.3477***	-9.0294***	343.2434***
lnEU	constant	NA	-7.1998***	168.7271***
lnHCI	constant	-4.1973***	-1.1211	29.1082
lnFD	constant	5.5809	-10.0376***	53.8083***

Panel Cointegration Test

Models	Kao		Pedroni	
	Mod. DF	DF	Philip-Perron	Aug. DF
Model 1	-3.6452***	-2.0492***	-3.9933***	-5.1168***
Model 2	-4.4951***	-2.7337***	-4.9053***	-5.8348***
Model 3	-4.5726***	-2.6411***	NA	NA
Model 4	-4.6121***	-2.9534***	NA	NA
Model 5	-4.4646***	-2.7030***	NA	NA
Model 6	-4.5813***	-2.7600***	NA	NA
Model 7	-4.6409***	-2.7873***	NA	NA

Appendix C. Choose Best Fit Model

FEM Results Without Robust Estimator

Dep. Var: $lnCO_2$ VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7
lnGDPC	0.33***	0.27***	0.29***	0.26***	0.32***	0.31***	0.33***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.10)	(0.09)	(0.09)
lnGDPC2	-0.06***	-0.07***	-0.07***	-0.07***	-0.07***	-0.07***	-0.08***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
lnTRADE	0.06	0.13**	0.15***	0.13**	0.14**	0.15***	0.15***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
lnEU	0.57***	0.57***	0.55***	0.56***	0.57***	0.61***	0.56***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)
lnHCI	-0.58	-0.69**	-0.80**	-0.61*	-0.76**	-0.90**	-0.55
	(0.35)	(0.34)	(0.34)	(0.34)	(0.35)	(0.35)	(0.35)
PA		0.17***	0.16***	-0.00	0.16***	0.16***	0.15***
		(0.05)	(0.05)	(0.09)	(0.05)	(0.05)	(0.05)
lnFD		-0.03**	0.15*	-0.03**	-0.03	0.01	-0.15***
		(0.02)	(0.08)	(0.02)	(0.02)	(0.02)	(0.05)
lnFD2			0.01**				
			(0.00)				
PA_lnFD				-0.16**			
				(0.07)			
lnFD_lnGDPC					0.02		
					(0.02)		
lnFD_lnEU						0.03**	
						(0.01)	
lnFD_lnHCI							0.30**
							(0.12)
Constant	-0.57***	-0.46***	-0.13	-0.50***	-0.42**	-0.32*	-0.48***
	(0.15)	(0.16)	(0.21)	(0.16)	(0.16)	(0.17)	(0.16)
Observations	262	262	262	262	262	262	262
R-squared	0.742	0.76	0.76	0.76	0.759	0.764	0.765
R-squared	0.74	0.759	0.764	0.764	0.76	0.76	0.76
Number of id	10	10	10	10	10	10	10

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

REM Results Without Robust Estimator

Dep. Var: $lnCO_2$ VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7
lnGDPC	0.50***	0.44***	0.51***	0.44***	0.58***	0.61***	0.58***
	(0.08)	(0.08)	(0.07)	(0.08)	(0.09)	(0.07)	(0.08)
lnGDPC2	-0.04**	-0.04**	-0.03**	-0.04**	-0.04**	-0.04***	-0.04***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)
lnTRADE	0.11**	0.17***	0.20***	0.17***	0.19***	0.20***	0.20***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
lnEU	0.51***	0.53***	0.46***	0.51***	0.49***	0.52***	0.48***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
lnHCI	-0.90***	-1.06***	-1.25***	-0.99***	-1.18***	-1.28***	-0.87***
	(0.27)	(0.28)	(0.27)	(0.28)	(0.27)	(0.26)	(0.27)
PA		0.14***	0.12**	-0.03	0.12**	0.10**	0.11**
		(0.05)	(0.05)	(0.09)	(0.05)	(0.05)	(0.05)

lnFD		-0.03*	0.27***	-0.03	-0.01	0.05**	-0.18***
		(0.02)	(0.08)	(0.02)	(0.02)	(0.03)	(0.05)
lnFD2			0.02***				
			(0.00)				
PA_lnFD				-0.16**			
				(0.07)			
lnFD_lnGDPC					0.03*		
					(0.02)		
lnFD_lnEU						0.05***	
						(0.01)	
lnFD_lnHCI							0.40***
							(0.13)
Constant	-0.47**	-0.38*	0.17	-0.41*	-0.29	-0.12	-0.38**
	(0.20)	(0.22)	(0.24)	(0.21)	(0.20)	(0.19)	(0.19)
Observations	262	262	262	262	262	262	262
R-squared	0.738	0.754	0.756	0.758	0.751	0.748	0.755
Number of id	10	10	10	10	10	10	10

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Most panel data analysis uses fixed effect and random effect models. However, both have different philosophies. The random effect model emphasizes the homogeneity between unobserved heterogeneity in residuals and the explanatory variables, which is rarely accomplished. Thus, a study should conduct the Hausman test to avoid hesitation in choosing the best fit model between FEM and REM. The important thing in the Hausman test is the covariance matrix from vector difference $[\hat{\beta} - \widehat{\beta_{GLS}}]$. In advance, the variance of $[\hat{\beta} - \widehat{\beta_{GLS}}]$

is:

Var $[\hat{\beta} - \widehat{\beta_{GLS}}]$=$var$ $[\hat{\beta}]$var$[\widehat{\beta_{GLS}}]$-cov 2$[\hat{\beta}, \widehat{\beta_{GLS}}]$

The difference of covariance between the efficient and inefficient estimator $[\hat{\beta}, \widehat{\beta_{GLS}}]$ should be 0, thus

$cov\ [\hat{\beta} - \widehat{\beta_{GLS}}, \widehat{\beta_{GLS}}]$=cov$[\hat{\beta} - \widehat{\beta_{GLS}}, \widehat{\beta_{GLS}}] - var[\widehat{\beta_{GLS}}]$==0

cov$[\hat{\beta} - \widehat{\beta_{GLS}}, \widehat{\beta_{GLS}}] = var[\widehat{\beta_{GLS}}]$

The statistics value follows *chi-square* distribution as follow:

$$W = \chi^2[K] = [\hat{\beta} - \widehat{\beta_{GLS}}]\,\hat{\Sigma}^{-1}[\hat{\beta} - \widehat{\beta_{GLS}}] \quad (4)$$

Where K is the total of the independent variable. If the statistics are bigger than a critical value of Chi-square, then the null hypothesis is rejected. It means that FEM is preferable to REM.

Fixed Effect and Random Effect

The results of FEM and REM in Appendix C show two estimation models, using Fixed Effect. The Fixed Effect Model (FEM) assumes that each country has different behavior in contributing to carbon emissions, which is represented by the intercept. Meanwhile, the Random Effect Model (REM) assumes the intercept is random or stochastic. There are 7 models in Table 4. Models 1 to 4 show the model with the squared variable of GDPC, while models 5 to 7 show the model with the squared variable of FD. The interaction terms are submitted subsequently from models 1 to 4, and then applied from models 5 to 7. Table 7 reveals the results of REM with the same strategies from models 1 to 7.

The preferable model is decided using the Hausman test. It indicates that the Fixed Effect Model is better than the Random Effect Model because all P-values are less than 5 % of the significance level.

Hausman test (1978)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Chi-square test value	24.80	25.21	32.11	29.34	38.31	50.38	40.70
P-value	0	0	0	0	0	0	0
Best Model	FEM	FEM	FEM	FEM	FEM	FEM	FEM

Appendix D. Diagnostic Test

The next step is to examine whether heteroscedasticity and panel autocorrelation exist in the model since the FEM requires testing for assumptions such as homoscedasticity, no autocorrelation, and no multicollinearity. The results from Table 9 columns (1) and (2) show that models 1 and 4 have a heteroscedasticity issue. Meanwhile, the autocorrelation test shows that all series have a serial correlation. According to Alejo, J. et.al. (2018), the correlation among data set in panel data should be independent. Therefore, the result shows the correlation

Wald test and Cross-Dependency test by using Pesaran (2006) and Hoechle (2007), respectively. Based on column (7), only Models 1, 3, 4, and 7 have independent cross-sectional panel data. However, the heteroscedasticity and autocorrelation test hint at a violation assumption. The result shows that residuals have autocorrelation series, and the variance is not homoscedastic across variables. Thus, the fixed-effect model becomes inefficient due to violated assumptions. Some treatment to handle this problem has been applied by using robust standard error. The results are shown in Table 5.

1. Diagnostic Test of Homoscedasticity, Autocorrelation, and Cross-Dependence

Model	Diagnostics Test						H_0: Homoscedastic	H_0: No Autocorrelation	H_0: Cross-Sectional Independence
	LM test	P-value	Wald test	P-value	Pesaran-abs	P-value			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Model 1	15.72	0.00	21.53	0.00	1.85	0.06	NO	NO	YES
Model 2	11.92	0.02	24.94	0.00	1.63	0.10	NO	NO	YES
Model 3	8.74	0.07	24.84	0.00	0.90	0.37	YES	NO	YES
Model 4	11.49	0.03	35.08	0.00	1.70	0.09	YES	NO	YES
Model 5	3.80	0.43	25.38	0.00	1.52	0.13	YES	NO	YES
Model 6	3.25	0.52	24.98	0.00	1.24	0.34	YES	NO	YES
Model 7	1.27	0.87	25.15	0.00	1.15	0.25	YES	NO	YES

2. VIF Result

	(1) lnCO2pc	(2) lnCO2pc	(3) lnCO2pc	(4) lnCO2pc	(5) lnCO2pc	(6) lnCO2pc	(7) lnCO2pc
lnGDPC	10.36	14.39	25.63	14.39	20.43	27.90	14.67
lnGDPC2	8.60	11.68	15.68	11.78	11.81	13.31	24.36
lnTRADE	1.49	1.72	1.76	1.72	1.80	1.88	1.76
lnEU	12.34	12.58	12.96	12.95	12.62	27.90	13.02
lnHCI	6.34	10.51	17.60	10.95	10.53	10.52	17.84
PA		1.22	1.24	5.30	1.23	1.23	1.22
lnFD		3.27	16.09	3.39	3.91	4.48	24.36
lnFD2			5.73				

PA_lnFD				4.96			
lnFD_lnGDPC					6.92		
lnFD_lnEU						6.61	
lnFD_lnHCI							47.65
Mean VIF	7.83	7.91	12.09	8.18	8.66	10.81	16.58

Appendix E. Robustness Check using Financial Institution Index

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7
lnGDPC	0.331***	0.226**	0.149*	0.138	0.062	0.197**	0.165*
	(0.088)	(0.087)	(0.086)	(0.084)	(0.096)	(0.087)	(0.087)
lnGDPC2	-0.065***	-0.078***	-0.096***	-0.073***	-0.065***	-0.073***	-0.049**
	(0.024)	(0.023)	(0.023)	(0.022)	(0.023)	(0.023)	(0.024)
lnTRADE	0.064	0.137**	0.111**	0.116**	0.120**	0.123**	0.115**
	(0.050)	(0.053)	(0.052)	(0.051)	(0.052)	(0.053)	(0.053)
lnEU	0.567***	0.591***	0.587***	0.534***	0.558***	0.472***	0.539***
	(0.053)	(0.053)	(0.051)	(0.051)	(0.052)	(0.072)	(0.054)
lnHCI	-0.577	-0.600*	-0.678**	-0.019	-0.606*	-0.505	-1.120***
	(0.353)	(0.345)	(0.333)	(0.343)	(0.336)	(0.344)	(0.369)
PA		0.170***	0.136***	-0.245***	0.153***	0.162***	0.175***
		(0.045)	(0.044)	(0.087)	(0.044)	(0.045)	(0.044)
lnFII		-0.026**	0.496***	-0.025**	0.316***	0.233**	0.670***
		(0.011)	(0.118)	(0.010)	(0.092)	(0.108)	(0.199)
lnFII2			0.042***				
			(0.009)				
PA_lnFII				-0.501***			
				(0.092)			
lnFII_lnGDPC					-0.095***		
					(0.025)		
lnFII_lnEU						-0.065**	
						(0.027)	
lnFII_lnHCI							-0.753***
							(0.216)
Constant	-0.575***	-0.499***	0.228	-0.741***	0.032	-0.127	0.176
	(0.151)	(0.159)	(0.225)	(0.157)	(0.210)	(0.221)	(0.248)
Observations	262	261	261	261	261	261	261
R-squared	0.742	0.765	0.782	0.790	0.777	0.770	0.776
Number of id	10	10	10	10	10	10	10
Adj. R-sq	0.728	0.749	0.767	0.776	0.762	0.754	0.760
F test	142.3	113.2	109.1	114.5	106.1	101.7	105.1
Prob>F	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The average partial Effect using FII

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7
lnGDPC	0.185	0.048	-0.070	-0.028	0.028	0.032	0.054
	(0.119)	(0.119)	(0.118)	(0.114)	(0.116)	(0.118)	(0.117)
lnTRADE	0.064	0.137**	0.111**	0.116**	0.120**	0.123**	0.115**
	(0.050)	(0.053)	(0.052)	(0.051)	(0.052)	(0.053)	(0.053)
lnEU	0.567***	0.591***	0.587***	0.534***	0.558***	0.549***	0.539***
	(0.053)	(0.053)	(0.051)	(0.051)	(0.052)	(0.055)	(0.054)
lnHCI	-0.577	-0.600*	-0.678**	-0.019	-0.606*	-0.505	-0.223
	(0.353)	(0.345)	(0.333)	(0.343)	(0.336)	(0.344)	(0.354)
PA		0.170***	0.136***	0.351***	0.153***	0.162***	0.175***
		(0.045)	(0.044)	(0.054)	(0.044)	(0.045)	(0.044)
lnFII		-0.026**	0.396***	-0.087***	0.208***	0.079*	0.069**
		(0.011)	(0.096)	(0.015)	(0.063)	(0.045)	(0.029)
Observations	262	261	261	261	261	261	261