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Do Financial Development and Trade Liberalization Influence Environmental Quality in Indonesia? Evidence-based on ARDL Model

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ABSTRACT

The deepening of financial development and trade liberalization has been taking place in Indonesia since the Association of Southeast Asian Countries (ASEAN) formed in 1967. As a result, Indonesia experienced substantial growth in various economic sectors. However, this growth could also bring a negative externality such as environmental degradation to this country. This research paper investigated how financial development and trade liberalization could affect the country's environmental quality. This research utilized the time series approach, such as the Autoregressive Distributed Lag Model (ARDL), to test the determinant of environmental quality for Indonesia based on selected macroeconomic determinants with special emphasis on financial development and trade liberalization. The study used annual data from 1971 until 2020, which spans about 50 years. Based on the main outcomes, deepening financial development helps to improve environmental quality. However, at the same time, higher trade liberalization has caused greater environmental degradation. Therefore, the policymakers must ensure that more financial institutions in the country support their government in promoting sustainable growth by giving more loans to companies that promote using clean energy for development purposes. Besides, the country should monitor more closely any heavy industries such as chemicals production that operate to meet the demand for the oversea market by ensuring strict rules are enforced to avoid any negative externalities to the environment.

Keywords: Financial Development, Trade Liberalization, Environmental Quality, ARDL, Urbanization, Sustainable Energy
JEL Classification: G2, F18, O1

1. INTRODUCTION

Carbon dioxide (CO_2) emission is used as a proxy for environmental degradation as it is the primary greenhouse gas (GHG) (Udara et al., 2019). CO2 emissions were 22.15 Gt in 1990, skyrocketing to 36.14 Gt in 2014, which caused the average global temperature to rise. Due to human activity, the atmospheric CO_2 concentration has risen quickly since the Industrial Revolution and has reached a dangerous level. Indonesia is ranked the fifth-largest emitter of greenhouse gases (GHG) in the world, which are mostly caused due to landscape. With that, the consequences of recent climate and climate change issues garner much attention (Coca, 2018).

Besides, Indonesia emits 265-486 million tonnes of carbon dioxide between 2000 and 2017 due to plantations, agricultural activities, deforestation and forest fires (Vikniswari et al., 2021). Moreover, the rapid economic growth of Indonesia is linked to increasing CO_2 emissions (Adebayo et al., 2021), suggesting that the country is experiencing environmental degradation as it grows.

On the other hand, due to the negative effects on the environment, climate change has an adverse impact on people's health and the nation's development in Indonesia. Indonesia is already experiencing severe effects of climate change, including droughts, floods, heat and waves. Hence, if these conditions endure in Indonesia, this will cause a greater threat to the nation's ability to develop. In addition, according to Chaussard et al. (2019), almost half of the islands like Jakarta, which is below average sea level, were at the risk of sinking. Economic growth in Indonesia is linked to energy consumption, mostly achieved through burning fossil fuels that cause high releases of air pollutants like CO_2 (Adebayo et al., 2021). This economic growth model accompanied by environmental degradation has ultimately caused global warming (Choudhary et al., 2015). This process was sped up by the intense international competition, high growth, market liberalization, and globalization which has become more frequent every year (Gokmenoglu and Sadeghleh, 2019).

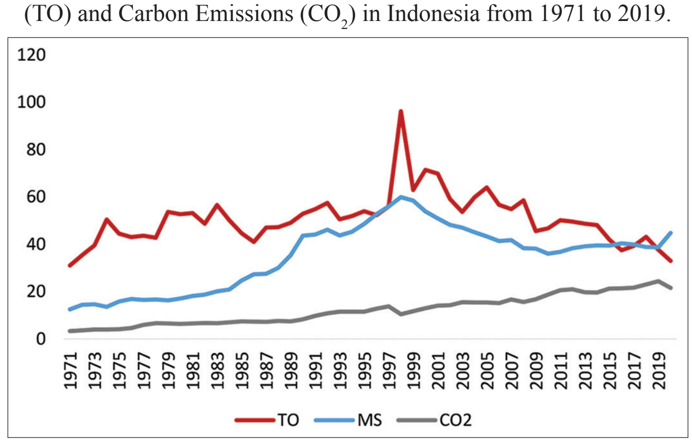
ASEAN nations are very concerned about the issues of climate change. Southeast Asia has produced the highest levels of greenhouse gas emissions during the past century. More specifically, the average temperature in Southeast Asia has risen over the past five decades from around 0.1 to 0.3°C (Ren et al., 2021). ASEAN countries include Malaysia, Thailand, Indonesia, Vietnam, Myanmar, the Philippines, and Cambodia, which were predicted to be most vulnerable to the effects of climate change. While, Thailand and Vietnam were among the top 10 nations in 2017 that were most impacted by extreme weather (Eckstein et al., 2019). This illustrates how seriously ASEAN nations are facing climate change. Extreme rainfall, increasing sea levels, a rise in heat waves and even droughts, floods, and tropical cyclones are just a few of the effects of climate change. Deforestation, particularly in Malaysia, Indonesia, and Cambodia, is the main factor that causes high CO_2 in ASEAN nations (Vikniswari et al., 2021). The greatest forests in the world are in these nations, and numerous trees have been felled for agricultural use.

Along with deforestation, ASEAN nations with rapid economic development and high urbanization have also caused the high CO_2 emission (Prakash, 2021; Adebayo et al., 2021). Due to poor planning in the development and construction, most of the major cities in the ASEAN region are extremely susceptible to flooding. The ASEAN countries' CO_2 emissions peaked in 2016, and the largest contributors to carbon emission releases are Indonesia, Thailand and Malaysia (Esquivias et al., 2022). Identifying the primary contributors to carbon dioxide emissions is important in light of the environment's degradation and the economy's growth. In this study, we hypothesized that from 1971 until 2020, CO_2 emissions in Indonesia are influenced by economic activity, energy consumption, liberalization of foreign direct investment and trade, urban growth, and financial development. FDI in Indonesia has attracted large capital inflows to primary activities (Narayan et al., 2022). In addition, trade liberalization has supported exports of natural resource-based products (Handoyo et al., 2021), which are more often linked to high environmental impacts. Moreover, a more rapid financial development can foster business expansion, increase land use demand, intensify energy use, foster consumption, and increase resource use (Kihombo et al., 2021). Still, larger FDI inflows, more open economies (trade), and deeper financial markets can favour environmental quality if linked to more efficient use of resources (Esquivias et al., 2022) and larger productivity that may reduce energy needs and lower CO_2 emissions.

From 2010 to 2017, most ASEAN countries experienced high debt ratios of around 20%. This shows that most of the private sectors in those nations tend to raise their financial leverage to expand their firms. When firms are financially stable, they will probably increase their expenditure on manufacturing or expanding their production line, which would cause high carbon emissions (Kumaran et al., 2021). The ASEAN nation's greater financial development and economic expansion have resulted in greater output and consumption to meet human requirements (Adeel-Farooq et al., 2022). This is because as the nation develops, there will be a greater need for land and higher demand for resources. This will significantly increase the country's CO_2 emissions. Sadorsky (2010) asserts that increased financial development would boost a nation's GDP. Therefore, financial development can encourage robust economic expansion, resulting in a rise in energy consumption (Kihombo et al., 2021). As a result, the nation's CO_2 emissions will increase. Furthermore, Ismail and Masih (2015) claimed that Indonesia's population increase is influenced by financial development. Therefore, long-term population growth is possible with the development of the financial sector.

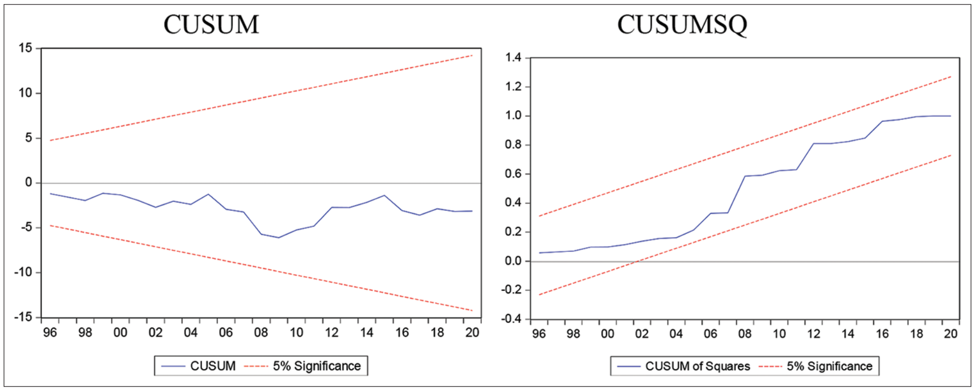
Figure 1 shows the CO_2 trend in Indonesia, which increased from 0.33 in 1971 to 2.16 in 2019. The high CO_2 emission was due to the high open burning of carbon-rich peatland and forests for agricultural purposes in Sumatra in 2013. The highest CO_2 emission was from 2015 to 2019. Rapid financial development and trade liberalization caused high CO_2 emissions in 1999. Hence, this shows that the fluctuating financial development and trade liberalization has caused CO_2 emission in Indonesia (Shoaib et al., 2020). As CO_2 climbed, so did the temperature.

Figure 1: Trend of Financial Development (FD), Trade Liberalisation (TO) and Carbon Emissions (CO_2) in Indonesia from 1971 to 2019.



Notes: We times CO_2 emission with 10 to get a clearer trend against trade openness (TO) and financial development (FD). Source of data from World Development Indicator 2022

Figure 2: CUSUM and CUSUM SQ



This study will contribute to the literature in several ways. First, previous studies on CO_2 emissions focus more on the cause of renewable energy consumption, population, economic growth, and foreign direct investment (Menyah and Wolde-Rufael, 2010; Burakov and Freidin, 2017). Second, earlier studies had included Indonesia as part of the sample countries (Esquivias et al., 2022; Handoyo et al., 2022) but had not provided specific insights for Indonesia. This study examines the nexus of financial development and trade liberalization in Indonesia, which would theoretically contribute to CO_2 emission (Kihombo et al., 2021; Adebayo et al., 2021). Third, this study employs 50 years of data which offers an important contribution to environmental policy in aspects connected to FDI, trade, urbanization, and financial deepening. While trade, investment, and financial deepening can positively impact environmental quality in high-income countries (Handoyo et al., 2022), middle and low-income countries often experience the opposite. As such, it suggests the need to examine Indonesia's case, a large developing country still in the middle-income level.

We selected Indonesia as our highlight for this research instead of other ASEAN countries since Indonesia is the largest economy in the ASEAN region. It has experienced vast FDI and trading activities development, deepening its financial institution. FDI inflows in Indonesia expanded more than 90 times from 1980 to 2019, signalling a deep liberalization in investment and large openness to foreign capital (Sugiharti et al., 2022). Besides, by the end of 2021, Indonesia will have 42 bilateral free trade agreements and ratified 15 multilateral free trade agreements (Narayan et al., 2022). The rapid liberalization of trade in Indonesia supported the expansion of exports and economic activity (Purwono et al., 2022; Handoyo et al., 2021). However, as noted by Narayan et al. (2022), a large impact of liberalization of trade had supported FDI inflows into export-oriented activities related to the primary sector, with potentially large impacts on environmental quality. Notwithstanding, Indonesia is among the largest contributor to the releases of carbon emissions in the ASEAN, suggesting that the impressive economic development might have come with substantial environmental costs.

The structure of this paper is organized as follows: Section two explains the literature review, section three discusses methodology, section 4 highlights all the outcomes and discussion, and the last section focuses on conclusions and policy recommendations.

2. LITERATURE REVIEW

Numerous macroeconomic determinants are responsible for environmental degradation. Earlier studies found that economic growth and energy consumption are crucial determinants for various countries' environmental degradation. The rapid industrialization that utilizes natural resources could boost higher economic growth, especially in emerging countries like Indonesia. However, this development harms the environment as more energy is used through fossil burning, resulting in a higher release of carbon emissions (Ridzuan et al., 2017). Jafari et al. (2012), Jian et al. (2019), Afridi et al. (2019) and Al-Mulali and Sab (2012) are among researchers who proved that the heavy use of energy consumption could cause environmental degradation because of rapid industrialization. Ridzuan et al. (2020) used the ARDL model to test the link between economic growth and energy consumption towards environmental pollution in Indonesia. Using annual time series data from 1980 to 2014, the authors found a positive relationship between these variables, indicating that higher economic development and fossil fuel energy usage has caused environmental degradation in this country. However, Jafari et al. (2012) found no relationship between economic growth, CO_2 emissions and energy consumption in Indonesia, except that there is a causality effect run from urban population to energy consumption. The authors used the Today Yamamoto procedure, using annual data from 1971 to 2007.

A rapid economic growth in Indonesia also enhanced the country's financial institutions and international trade. Katircioglu (2012) highlighted that financial development might be one of the major catalysts of economic growth. However, it may also lead to ecological implications. Studies such as Jian et al. (2019) and Pata (2018) have included financial development in their econometric models to examine its potential impact on environmental degradation. Zhang (2011) claimed that two main channels could justify the nexus between financial development and energy consumption. According to the first channel, the financial development attracted higher foreign investment inflows. It generated economic growth, which consequently led to higher demand for energy. Higher energy consumption generated mostly from fossil fuel combustion will lead to environmental degradation. Higher economic growth resulting from financial development can lead to additional energy demand and investment in the energy sector which then affects the environment (Cetin and Ecevit, 2017). Similarly, Tadesse (2005) recognized that improving the financial system triggers technological innovations that stimulate higher productivity and economic growth through risk sharing and easing capital mobilization.

The level of environmental degradation or quality also depends on the practice of trade liberalization in the country. Copeland and Taylor (2004) described that the impact of international trade on environmental degradation depends on the scale, the composition, and the production technologies employed. Liobikiene and Butkus (2019) found that the scale effect has led to a massive increase in the production of goods and services, thus increasing input usage, resulting in higher pollution levels. Meanwhile, the composition effect occurred when the country's economic structure changed in favor of reduced polluting activities. Finally, as Ramos et al. (2017) mentioned, the production technologies effect refers to adopting new, cleaner technologies that can alter the expected emission levels. However, empirical research indicates a diverse relationship between trade openness and CO_2 emissions. For example, Halicioglu (2009) provide empirical evidence about the positive influence of trade on environmental degradation in the Turkish economy. Tachie et al. (2020), on the other hand, acknowledge that trade positively impacts environmental degradation through the scale and composition effects, and the production technologies effect has a negative impact. Recent empirical studies such as Nguyen et al. (2021) and Nasir et al. (2021) showed that trade causes environmental degradation. In contrast, other studies, such as Afridi et al. (2019), showed that trade negatively influences environmental degradation in emerging economies.

Past research is scarce on financial development and trade openness towards environmental quality, especially in Indonesia. To address this research gap, this research aimed to investigate the impact of macroeconomic determinants on carbon emission in Indonesia by highlighting both financial development and trade openness using recent datasets. The findings would provide policymakers with more comprehensive and useful information for developing a strategic plan for reducing emissions.

3. METHODOLOGY

In this research paper, we have identified several macroeconomic determinants that able to influence the level of environmental quality in Indonesia. Our special attention is given to foreign direct investment (FDI) and trade liberalization (TO) as what we have emphasized in introduction. The econometric model can be viewed in Equation 1 below:

$$CO2_t = f(GDP_t, ENY_t, FDI_t, TO_t, URB_t, FD_t, DI_t) \quad (1.0)$$

Where
CO_{2t} represents environmental quality,
GDP_t represents economic growth,
ENY_t represents energy used,
FDI_t represents foreign direct investments inflows,
TO_t represents trade openness,
URB_t represents urban population,
FD_t represents financial development,
DI_t represents domestic investment

All of the variables are transformed into log-linear forms (LN). The log version of the variables will indicate the short-run and long-run elasticity of the tested variables. It can also reduce the sharpness of the time series data so that we can have a consistent and reliable estimation (Shahbaz, 2010). The log version of the model derived from Equation 1.0 can be seen as follows:

$$LNCO2_t = \delta_0 + \alpha_1 LNGDP_t + \beta_2 LNENY_t + \sigma_3 LNFDI_t + \phi_4 LNTO_t + \lambda_5 LNURB_t + \nu_6 LNFD_t + \tau_7 LNDI_t + \mu_t \quad (2.0)$$

Higher economic development (LNGDP) is expected to increase environmental degradation ($LNCO_2$) in developing countries such as Indonesia. Thus, it exhibits a positive relationship between these two variables. Similar to LNGDP, energy used also exhibits a positive relationship with $LNCO_2$. Higher energy from fossil fuels will lead to a greater release of carbon emissions in the country. Next, LNFDI is expected to have either a positive or negative relationship with $LNCO_2$ for Indonesia. If the outcome posits positive outcomes, this portrays the existence of the Pollution Haven Hypothesis. In contrast, if the outcome is negative, it validates the Pollution Halo Hypothesis. The pollution Haven Hypothesis indicates that foreign investors have more interest in investing their money in a country with less stringent environmental policies, especially in developing countries such as Indonesia. Pollution Halo Hypothesis, on the other hand, indicates that there are strict environmental rules that foreign investors who have committed to bringing cleaner technology into production and reducing emissions must be fulfilled. The urban population (URB) is also expected to have a positive relationship with $LNCO_2$ for Indonesia. Higher urbanization indicated massive development of new housing or business area, thus increasing energy use, leading to a greater emission release in the countries.

Trade openness is predicted to positively or negatively impact CO_2 emissions. According to Shahbaz et al. (2012), international trade benefits the environment by promoting the efficient use of scarce resources due to competition among countries. On the other hand, other researchers such as Copeland and Taylor (2004) and Jalil and Mahmud (2009) found a positive association between trade openness and CO_2 emissions. They recommend that international trade causes an increase in CO_2 emissions due to the depletion of natural resources.

Next, financial development (LNFD) is expected to have either a positive or negative relationship with $LNCO_2$. According to Jansen (1996), the development of the financial sector may stimulate technological progress in the energy sector designed to reduce emissions. Conversely, the financial sector also promotes CO_2 emissions by aiding manufacturing activities. Financial development (LNFD) could enhance research and development (R&D) activities and consecutively improve economic activities, hence, affecting environmental quality (Frankel and Romer, 1999). This scenario could fit the Indonesian economy, which has been progressing rapidly compared to other ASEAN countries. Therefore, excluding financial development in the growth-emissions nexus may lead to omitting an important variable in the regression. Hence, in the present study, we consider financial development as another likely contributing factor to environmental performance in the Indonesian case.

Lastly, domestic investment (LNDI) is expected to have a positive relationship with $LNCO_2$, where a higher number of local industries leads to higher economic activities, thus contributing to the release of carbon emissions.

The ARDL model based on the Unrestricted Error Correction Model (UECM) is stated below:

$$\begin{aligned}\Delta LNCO2_t &= \beta_1 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \\ &\theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \\ &\theta_5 LNURB_{t-1} + \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \\ &\sum_{i=1}^{a}\beta_i \Delta LNCO2_{t-i} + \sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} \\ &+ \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} + \sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} + \\ &+ \sum_{i=0}^{g}\tau_i \Delta LNUFD_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (3.0)$$

$$\begin{aligned}\Delta LNGDP_t &= \beta_2 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \\ &\theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \\ &\theta_5 LNURB_{t-1} + \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \\ &\sum_{i=1}^{a}\beta_i \Delta LNGDP_{t-i} + \sum_{i=0}^{b}\gamma_i \Delta LNCO2_{t-i} \\ &+ \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} + \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} + \\ &\sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} + \\ &+ \sum_{i=0}^{g}\tau_i \Delta LNUFD_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (4.0)$$

$$\begin{aligned}\Delta LNENY_t &= \beta_3 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \\ &\theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \theta_5 LNURB_{t-1} + \\ &\theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \sum_{i=1}^{a}\beta_i \Delta LNENY_{t-i} + \\ &\sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNCO2_{t-i} + \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} \\ &+ \sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} + + \sum_{i=0}^{g}\tau_i \Delta LNUFD_{t-i} \\ &+ \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (5.0)$$

$$\begin{aligned}\Delta LNFDI_t &= \beta_4 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} \\ &+ \theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \\ &\theta_5 LNURB_{t-1} + \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \\ &\sum_{i=1}^{a}\beta_i \Delta LNFDI_{t-i} + \sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} \\ &+ \sum_{i=0}^{d}\lambda_i \Delta LNCO2_{t-i} + \sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} \\ &+ + \sum_{i=0}^{g}\tau_i \Delta LNUFD_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (6.0)$$

$$\begin{aligned}\Delta LNTO_t &= \beta_5 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} \\ &+ \theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \\ &\theta_5 LNURB_{t-1} + \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \\ &\sum_{i=1}^{a}\beta_i \Delta LNTO_{t-i} + \sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} \\ &+ \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} + \sum_{i=0}^{e}\vartheta_i \Delta LNCO2_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} \\ &+ + \sum_{i=0}^{g}\tau_i \Delta LNUFD_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (7.0)$$

$$\begin{aligned}\Delta LNURB_t &= \beta_6 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \\ &\theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \theta_5 LNURB_{t-1} \\ &+ \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \sum_{i=1}^{a}\beta_i \Delta LNURB_{t-i} + \\ &\sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} + \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} \\ &+ \sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNCO2_{t-i} + \\ &+ \sum_{i=0}^{g}\tau_i \Delta LNUFD_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (8.0)$$

$$\begin{aligned}\Delta LNFD_t &= \beta_7 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \\ &\theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \theta_5 LNURB_{t-1} \\ &+ \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \sum_{i=1}^{a}\beta_i \Delta LNFD_{t-i} + \\ &\sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} + \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} + \\ &\sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} + \\ &+ \sum_{i=0}^{g}\tau_i \Delta LNCO2_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNDI_{t-i} + \upsilon_t\end{aligned} \quad (9.0)$$

$$\Delta LNDI_t = \beta_8 + \theta_0 LNCO2_{t-1} + \theta_1 LNGDP_{t-1} + \theta_2 LNENY_{t-1} + \theta_3 LNFDI_{t-1} + \theta_4 LNTO_{t-1} + \theta_5 LNURB_{t-1} + \theta_6 LNFD_{t-1} + \theta_7 LNDI_{t-1} + \sum_{i=1}^{a}\beta_i \Delta LNDI_{t-i} + \sum_{i=0}^{b}\gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c}\delta_i \Delta LNENY_{t-i} + \sum_{i=0}^{d}\lambda_i \Delta LNFDI_{t-i} + \sum_{i=0}^{e}\vartheta_i \Delta LNTO_{t-i} + \sum_{i=0}^{f}\psi_i \Delta LNURB_{t-i} + + \sum_{i=0}^{g}\tau_i \Delta LNFD_{t-i} + \sum_{i=0}^{h}\vartheta_i \Delta LNCO2_{t-i} + \upsilon_t \quad (10)$$

Where Δ is the first difference operator, and u_t is the white-noise disturbance term. Residuals for the UECM should be serially uncorrelated, and the model should be stable. The final model represented in Equation 3.0 until Equation 10 above can also be viewed as an ARDL of order (a b c d e f g h). The model indicates that level of environmental degradation ($LNCO_2$) can be influenced and explained by its past values. Hence, it involves other disturbances or shocks. From the estimation of UECM, the long-run elasticity is the coefficient of the one lagged explanatory variable (multiplied by a negative sign) divided by the coefficient of the one lagged dependent variable.

The short-run effects are captured by the coefficients of the first differenced variables. The null of no co-integration in the long-run relationship is defined by:

H_0: $\theta_0=\theta_1=\theta_2=\theta_3=\theta_4=\theta_5= \theta_5=\theta_6=0$ (there is no long-run relationship),

is tested against the alternative of

H_1: $\theta_0\neq\theta_1\neq\theta_2\neq \theta_3\neq\theta_4\neq\theta_5\neq\theta_6\neq\theta_7\neq 0$ (there is a long-run relationship exists),

by means of the familiar F-test. Suppose the computed F-statistic is less than the lower bound critical value. In that case, we do not reject the null hypothesis of no co-integration. However, suppose the computed F-statistics is greater than the upper bound critical value of at least the 10% significant level. In that case, we reject the null hypothesis of no co-integration.

This study uses annual data ranging from 1971 up to 2020 (50 years) as a sample period. A summary of the data and its sources are shown in Table 1:

4. RESULTS AND DISCUSSION

The ADF and PP unit root tests are used to examine the stationarity of all the variables. The results are disclosed in Table 2. Based on the ADF unit root, it is found that most of the variables are not significant at level except for LNFDI, LNTO and LNDI. In contrast, the PP unit root test showed that LNFDI, LNTO, LNURB and LNDI are significant at mixed degrees of significant levels. Furthermore, all the variables are found to be stationary at a 1% significant level at the first difference for both ADF and PP unit root test. Therefore, based on the overall unit roots tests, we concluded that there is mixed stationery of data. Thus, the outcomes of unit root tests allowed us to proceed with the cointegration analysis using ARDL estimation.

Next, the ARDL cointegration test based on F stat is run to confirm the presence of a long-run relationship in the ARDL model. Based on the outcomes revealed in Table 3, the F-statistic for the bound test for our main equation (Equation 3.0) is 6.865, which is significant at 1% level, thus confirming the existence of the long-run relationship in the model. Hence, the null hypothesis is rejected, and the alternative hypothesis for the bound test is accepted. The rest equations (Equation 4.0 until Equation 10.0) also confirming the presence of long run relationship among its variables, indicating that the all the variables used in this research are well connected among each other's. This could potentially be recommended for future studies. The following outcomes will be based solely on our main model (Equation 3).

Next, several diagnostic tests were performed to ensure that the model's output produces non-spurious results. Table 4 confirm that the proposed model has no evidence of serial correlation and no heteroscedasticity effect in disturbances. Furthermore, the model's specifications are well specified, given that the P value of all tests is greater than the 10% significant level. On the other hand, the normality test indicated that the model is not normally distributed. This scenario is normal for ARDL based model and considered an optional test.

To ensure the goodness of the model, CUSUM and CUSUM of Square (CUSUMSQ) are performed to confirm the parameter constancy of the model (Figure 2). The following graphs confirm that the model is structurally stable at a 5% significance level, given that the blue line lies between the two dotted red lines. From the confirmation of diagnostic tests, it is believed that the model proposed in this study can produce reliable and robust outcomes for policymakers.

The results of short-and long-run elasticities are presented in Table 5. Short-run elasticities' outcomes are being emphasized based on its present coefficient value only (without lag). Based on the first independent variable, it is found that economic growth (LNGDP) has a positive and significant at both short-run and long-run elasticities. Thus, it can influence the level of environmental degradation (LNCO2) in the country. For example, a 1% increase in LNGDP leads to a 1.33% increase in the short run and a 0.59%

Table 1: Sources of data

Variables	Description	Sources
CO2	CO2 emissions (metric tons per capita)	WDI
GDP	GDP per capita (constant 2015 US$)	WDI
ENY	Energy use (kg of oil equivalent per capita)	WDI
FDI	Foreign direct investment, net inflows (% of GDP)	WDI
TO	Trade (% of GDP)	WDI
URB	Urban population growth (annual %)	WDI
FD	Broad money (% of GDP)	WDI
DI	Gross fixed capital formation (annual % growth)	WDI

WDI: World Development Indicator 2022

Table 2: Testing ADF and PP Unit Root Test

Level I (0)	ADF unit root		PP unit root	
	Intercept	Intercept and trend	Intercept	Intercept and trend
LNGDP	−1.129 (0)	−2.732 (1)	−1.129 (0)	−2.307 (1)
LNENY	−1.117 (0)	−1.260 (0)	−1.179 (4)	−1.257 (1)
LNFDI	−2.846 (0)*	−2.897 (0)	−2.995 (3)**	−3.009 (3)
LNTO	−2.902 (0)*	−2.677 (0)	−2.825 (3)*	−2.425 (2)
LNURB	0.770 (0)	−3.714 (0)**	0.770 (0)	−3.643 (1)**
LNFD	−1.483 (1)	−1.094 (1)	−2.133 (3)	−1.142 (3)
LNDI	−4.637 (0)***	−4.865 (0)***	−4.378 (5)***	−4.541 (6)***
First difference I (1)	**ADF unit root**		**PP unit root**	
	Intercept	**Intercept and trend**	**Intercept**	**Intercept and trend**
LNGDP	−4.951 (0)***	−4.962 (0)***	−4.906 (2)***	−4.921 (2)***
LNENY	−7.027 (0)***	−7.102 (0)***	−7.036 (2)***	−7.151 (4)***
LNFDI	−7.732 (0)***	−7.696 (0)***	−7.727 (2)***	−7.693 (1)***
LNTO	−8.887 (0)***	−9.300 (0)***	−9.269 (3)***	−11.934 (7)***
LNURB	−7.091 (0)***	−7.204 (0)***	−7.145 (1)***	−7.332 (3)***
LNFD	−4.639 (0)***	−4.644 (0)***	−4.639 (0)***	−4.644 (0)***
LNDI	−7.651 (1)***	−7.554 (1)***	−16.551 (47)***	−17.714 (47)***

***, ** and * are 1%, 5% and 10% of significant levels, respectively. The optimal lag length is selected automatically using the Schwarz Info Criteria (SIC) for the ADF test, and the bandwidth was selected by using the Newey–West method for PP.

Table 3: Detecting the presence of long-run cointegration based on F statistics

Model	Lag order	F statistics
LNCO2=f(LNGDP,LNENY,LNFDI,LNTO,LNURB,LNFD,LNDI)	(4,1,1,1,1,4,0,1)	6.865***
LNGDP=f(LNCO2,LNENY,LNFDI,LNTO,LNURB,LNFD,LNDI)	(4,2,3,0,1,2,2,4)	10.268***
LNENY=f(LNGDP,LNCO2,LNFDI,LNTO,LNURB,LNFD,LNDI)	(4,4,4,4,4,4,3,4)	8.298***
LNFDI=f(LNGDP,LNENY,LNCO2,LNTO,LNURB,LNFD,LNDI)	(4,0,4,4,0,0,0,0)	6.212***
LNTO=f(LNGDP,LNENY,LNFDI,LNCO2,LNURB,LNFD,LNDI)	(1,4,3,0,2,2,3,4)	8.055***
LNURB=f(LNGDP,LNENY,LNFDI,LNTO,LNCO2,LNFD,LNDI)	(4,4,4,1,4,4,2,2)	7.484***
LNFD=f(LNGDP,LNENY,LNFDI,LNTO,LNURB,LNCO2,LNDI)	(1,0,1,4,4,4,4,1)	12.158***
LNDI=f(LNGDP,LNENY,LNFDI,LNTO,LNURB,LNFD,LNCO2)	(4,4,3,4,1,3,2,3)	12.676***
Critical values for F statistics	**Lower I(0)**	**Upper (1)**
10%	2.03	3.13
5%	2.32	3.5
1%	2.96	4.26

The critical values are based on Pesaran et al. (2001), case III: unrestricted intercept and no trend. k is a number of variables, and it is equivalent to 7. *** represent 1% levels of significance, respectively. The maximum lag set for all model is (4,4).

Table 4: Diagnostic tests

(A) Serial correlation (*P*)	(B) Functional form (*P*)	(C) Normality (*P*)	(D) Heteroscedasticity (*P*)
2.139 (0.140)	2.149 (0.155)	7.577** (0.022)	0.565 (0.901)

**5% significant levels. The diagnostic test is performed as follows A. Lagrange multiplier test for residual serial correlation; B. Ramsey's RESET test using the square of the fitted values; C. Based on a test of skewness kurtosis of residuals; D. Based on the regression of squared fitted values

increase in the long run, respectively. Therefore, reducing carbon emissions releases, in the long run, indicates an improvement of the Indonesian government to ensure reduced carbon emission releases by following sustainable development goals more closely. This result complies with earlier studies for emerging economies that also found a significant nexus between GDP and environmental degradation; i.e., Esquivias et al., (2022) for emerging Asian countries, Adebayo et al., (2021a) and Raihan et al. (2022) for Indonesia, Adebayo et al., (2021b) for Brazil, Handoyo et al. (2022) for middle-income economies, and Rafique et al. (2019) for BRIC countries.

Next, it is found that there is a positive and significant relationship between energy used (LNENY) and LNCO2 for both in the short run and long run. In brief, a 1% increase in LNENY increases LNCO2 by 0.726% in the short run and 1.316% in the long run. These outcomes indicated that the country uses more fossil fuels as cheaper energy sources to generate electricity, realizing higher carbon emissions in the long run. Furthermore, the positive relationship between energy use and CO_2 emissions is in tally with previous studies such as Raihan et al. (2022) and Adebayo et al. (2021a). They addressed that Indonesia still relies heavily on cheaper energy sources such as coal, natural gas, and oil, leading to increased CO_2 emissions and environmental degradation. This outcome is clear given that Indonesia's national energy policy promotes using fossil fuels to generate economic development. As a result, industrial and residential activities could harm the environment. Similarly, the results support previous outcomes in cases like Brazil (Adebayo et al., 2021b), South Asia (Afridi et al., 2019), and ASEAN (Adeel-Farooq et al., 2022), and Turkey (Gokmenoglu and Sadeghleh, 2019).

Regarding FDI, the results indicate that FDI has a significant positive relationship with $LNCO_2$ in the long run. For example, a

Table 5: Short run and long run elasticities

Short run elasticities		Long run elasticities	
Variables	**Coefficient**	**Variables**	**Coefficient**
$\Delta LNCO2_{(-1)}$	0.365***	LNGDP	0.593***
$\Delta LNCO2_{(-2)}$	0.213*	LNENY	1.316***
$\Delta LNCO2_{(-3)}$	−0.418***	LNFDI	0.055**
ΔLNGDP	1.337***	LNTO	0.199**
ΔLNENY	0.726***	LNURB	0.555***
ΔLNFDI	0.028	LNFD	−0.463***
ΔLNTO	0.040	LNDI	−0.032***
ΔLNURB	0.211	C	−12.691***
$\Delta LNURB_{(-1)}$	0.219		
$\Delta LNURB_{(-2)}$	−0.349*		
$\Delta LNURB_{(-3)}$	−0.472***		
ΔLNFD	−0.451***		
ΔLNDI	−0.002		
ECT	−0.974***		

***,** and * are 1%, 5% and 10% of significant levels, respectively. Δ refer to difference

1% increase in FDI inflows contributes to an increase in carbon dioxide emissions by 0.055% in the long run. The results are in accordance with earlier studies for G6 countries (Nguyen et al., 2021) and Asian countries (Handoyo et al., 2022). Nevertheless, the nexus between FDI and CO2 in Indonesia differs from the relationship that FDI-CO2 holds in BRICs economies (Rafique et al. 2019), where FDI supports environmental quality.

Next, financial development (LNFD) has a significant and negative relationship with $LNCO_2$ in both the short and long run. A 1% increase in financial deepening (LNFD) leads to a decrease in carbon emissions by 0.451% in the short run and 0.463% in the long run. This outcome is in tally with the outcome conducted by Shahbaz et al. (2013) for Indonesia, Kihombo et al. (2021) for West Asia and the Middle East, emerging Asian economies (Esquivias et al., 2022), BRICs economies (Rafique et al. 2019), and ASEAN (Adeel-Farooq et al., 2022). This reveals that financial development contributes to condensing CO_2 emissions by instructing banks to provide loans to firms for those investment projects which are environmentally friendly. Contrary to cases like Turkey (Gokmenoglu and Sadeghieh, 2019), where financial development worsens environmental quality, Indonesia can foster green growth by deepening access to finance. Besides LNFD, domestic investment (LNDI) was also found to have a negative relationship with carbon emission ($LNCO_2$), indicating that a 1% increase in LNDI reduces environmental degradation by 0.032%. Domestic investment involves the development of small cities in the country, and the development follows environmental rules carefully.

Urban population (LNURB) only has a significant relationship with carbon emissions ($LNCO_2$) in the long run. For example, a 1% increase in LNURB increases emissions by 0.555%. Ridzuan et al. (2019), on the other hand, found that LNURB has a negative effect on $LNCO_2$ in Malaysia. According to them, in developed cities, the urbanized population prefers to use energy-efficient appliances to reduce energy usage costs. As for Indonesia, the population are far greater than Malaysia and the country has massive amounts of fossil fuel and coal for energy generation to meet expected demand. With higher populations in urban areas, this will cause higher energy consumption usage, thus causing greater environmental degradation. A positive nexus between urban growth and CO_2 was also found in cases like South Asia (Afridi et al., 2019), emerging Asian economies (Esquivias et al., 2022), and ASEAN countries (Adeel-Farooq et al., 2022), BRICs economies (Rafique et al. 2019), and West Asia and Middle East (Kihombo et al., 2021).

Trade openness (LNTO) has a significant relationship with carbon emissions (LNCO2) in the long run. A 1% increase in LNTO increases the emissions release by 0.1999%. The outcome for Indonesia indicates that trade openness contributes to the depletion of resources and deterioration of the environment rather than to improvements in the use of resources. The findings are similar to Ali et al. (2017) outcome for Malaysia, Australia (Nasir et al., 2021), and Nguyen et al. (2021) for G6 countries. The impact of international trade (LNTO) activities, such as the transfer of goods and services between Indonesia and its trading partners worldwide, cause increasing emissions in other parts of the globe. These outcomes are contrary to the findings of Afrindi et al. (2019) for the South Asian region, Liobikiene and Butkus (2019), and Shahbaz et al. (2013) for Indonesia, where trade openness has supported environmental quality. As noted in Narayan et al. (2022), Handoyo et al. (2021), and Purwono et al. (2022), liberalization of trade has mainly supported exports of natural resource-based industries suggesting that pursuing free trade in Indonesia has worsened the environmental quality of the country. Indonesia's trade expansion has been more intense in the last decade (Purwono et al., 2022), possibly indicating why the results differ from Shahbaz et al. (2013), whose data for Indonesia only covers to 2011.

Lastly, the long-run relationship of the model was supported by the negative and significant value of the error correction term (ECT). ECT reflects the model's speed of adjustment, and the negative value means that the variables in the model will converge in the long run. The recorded speed of adjustment for the proposed model is 0.974. Approximately 97% of disequilibria from the previous year's shock converge to the current year's long-run equilibrium.

5. CONCLUSIONS AND POLICY IMPLICATIONS

This study investigated the impact of financial development and trade liberalization on environmental degradation in Indonesia. The ARDL approach analyses data on various variables, particularly CO_2 emissions, economic growth, energy use, FDI inflows, trade openness, the urban population, financial development and domestic investment, from 1971 to 2020. The findings disclose that higher economic growth and energy use can be harmful to the environment not only in the short run but also in the long run. On the other hand, urban population growth and FDI growth can positively impact the environment. Therefore, domestic investment can potentially result in lower environmental degradation. The main findings of this study show that trade liberalization can increase environmental degradation, but financial development can conserve the environment.

These findings are indispensable to shedding light on formulating the right policies. It is imperative to invest in green technology through financial development in a bid to achieve sustainability. Energy efficiency by consuming more green energy, such as hydro and solar, can also conserve the environment. Close monitoring of factories or plants with high CO_2 emissions is mandatory to ensure that the effort to conserve the environment will fall into place. This is because the absence of enforcement from the authority might contribute to the failure of our policy, and thus environmental degradation continues to escalate.

The findings suggest that rapid economic growth, larger FDI inflows, increasing participation in global trade, and fast urbanization have come at the expense of environmental quality in Indonesia. Policymakers in Indonesia need to assess how to break the energy-growth model that the country has been following for the last 50 years. Policies are needed to improve energy efficiency, encourage energy conservation, and cleanse economic activities. Despite the impressive increase in economic per capita in Indonesia, the country continues to be in the stage where environmental degradation comes at the expense of growth. The negative impacts of economic activities on the environment are also reflected in the nexus between FDI and CO_2, Trade Openness and CO_2, and urbanization and CO_2. Besides, Indonesia likely needs to revitalize urban development by encouraging green-transportation systems, environmentally friendly buildings, and more sustainable energy consumption in urban areas.

As Indonesia actively seeks larger FDI inflows and continues to sign new trade agreements, it is advisable that the country target cleaner activities, provide incentives to direct FDI and trade within more sustainable activities and revise the economic policy more thoroughly and regulations. It is then vital to explore new policies which have sustainability at its core, ensuring that trade-offs derived from FDI, trade, and economic growth can be mitigated by higher use of renewable sources, efficiency in the use of energy, conservation, and higher technology in production that may help to reduce CO_2 emissions. Switching to renewable energy sources, giving incentives to higher tech sectors, and limiting extraction-use of natural resources are potential sources of environmental improvements for the country, as noted in earlier studies.

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