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The impact of factors on environmental pollution in asean countries: The role of institutional quality

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Abstract The impact of institutional quality on environmental pollution in ASEAN countries is analyzed in this study. The researcher collected 250 observations from the World Bank dataset using data from 1996 to 2020. The author applied principal component analysis (PCA) and autoregressive distributed lag (ARDL) techniques to estimate panel data. The evidence of this study suggests that institutional quality has a negative impact on environmental pollution in the short run and a positive impact in the long run. Other macro factors, such as economic growth, trade openness, financial development, FDI, and energy consumption, have varying degrees of impact on environmental pollution. To the best of the authors' knowledge, there is currently no research examining the impact of institutional quality on environmental pollution in ASEAN countries, with the institutional quality variable created from six indicators based on the WGI database by using the PCA technique.

Keywords: ARDL, ASEAN, environmental pollution, institutional quality, PCA

1. Introduction

Climate change is a phenomenon that has occurred throughout Earth's history, but in recent decades, climate change has become more urgent and worrying than ever because of its negative impacts on human health. During the first two decades of the 21st century (2001-2020), the Earth's surface temperature increased by 0.99°C, and from 2030 onward, it could reach 1.5°C compared to the 1850-1900 period, with a probability ranging from 40-60%, according to the Intergovernmental Panel on Climate Change (IPCC, 2023). The world records high temperatures; July 2023 is the hottest month recorded on earth (NOAA, 2023), and 2023 is predicted to become one of the 5 hottest years on record (NOAA, 2023). Regions on Earth are affected by these changes (Shaftel et al., 2022). Droughts and heat waves are increasing rapidly in many areas not only in frequency and intensity but also in the duration of occurrence (Pokhrel et al., 2021; Spinoni et al., 2018). According to many studies, the main cause of climate change is human activities that cause greenhouse gases, in which CO2 emissions are considered the main factor causing the greenhouse effect (Ritchie et al., 2020).

Government awareness of environmental issues is increasing, and governments are interested in addressing environmental issues and their socioeconomic impacts (Wang et al., 2018). In particular, the comprehensive governance and coordinated policies of countries are important keys to pollution control (Congleton, 1992). At the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), marking the birth of the Paris Agreement, countries agreed to cooperate internationally in solving environmental problems, as well as the commitment to Nationally Determined Contributions (NDCs) and the responsibilities of all participants. In November 2022, the theme of the COP27 conference in Egypt was "hands-on," continuing to emphasize international cooperation and commitment to adaptation and solving environmental problems. Countries make commitments by promulgating environment-related policies, but the results achieved between countries are uneven (Bryntesson, 2023). One of the main reasons for this difference is the institutional quality of countries (Ajiya, 2022; Tørstad et al., 2020).

Research on the impact of agents influencing environmental pollution has attracted much attention (Ahmed et al., 2017; Aye & Edoja, 2017; Hanif et al., 2019; Pata & Caglar, 2021; Usman et al., 2022; Zaidi et al., 2019). However, most research in this field has focused on economic growth, financial development, and energy consumption, with little attention given to institutional quality. Some studies have been conducted on the impact of institutions on school pollution, such as (Bernauer and Koubi 2009; Ali et al., 2019; Yameogo et al., 2021; Hoang 2021). However, research assessing the impact of institutional quality on environmental pollution in the ASEAN region is still very limited. Meanwhile, the ASEAN is considered a dynamic economic development region with a real GDP growth rate of 5.6% in 2022 and 4.8% expected to continue growing in 2024

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(OECD, 2023), and developments in nonagricultural sectors (Nations, 2021) have contributed to accelerating the urbanization process. Economies in the early stages of industrialization, with rapid economic development and urbanization, have more CO_2 emissions from fossil fuel use than do economies that rely heavily on services (Nations, 2021).

Therefore, this study provides evidence on the impact of institutional quality on environmental pollution in the ASEAN region. Policymakers can propose solutions to reduce CO_2 emissions without negatively impacting economic development.

2. Literature review

Some studies have shown that institutions play an important role in the environment. Studying the dynamic influence of renewable energy and institutions on the economic output and CO_2 emissions of 85 economies from 1991 to 2012, Bhattacharya et al. (2017) showed that institutions (determined through the economic freedom index) have a negative impact on CO_2 emissions, meaning that when institutions improve, CO_2 emissions decrease, contributing to improving the environment. This result is also found in the study of the role of institutions in the relationship between tourism, financial development, energy consumption and environmental performance in European Union countries by Musa et al. (2021). By combining six indicators of institutional quality published by the Worldwide Governance Indicators (WGI) using the principal component analysis (PCA) approach, Musa et al. (2021) emphasized the quality of institutions that stimulate environmental improvement. Additionally, via the PCA approach, Ali et al. (2020) created an institutional performance (IP) variable from five indicators of the ICRG dataset (socioeconomic conditions, government stability, law and order, corruption, and investment profile). Using the DCCE estimation method, Ali et al. (2020) found that institutional performance improves environmental quality in OIC countries. However, Arminen and Menegaki (2019) argue that in high-income and upper-middle-income countries, institutional improvements have a relatively ineffective impact on reducing emissions and improving the environment.

In addition, in developing countries, the impact of institutional quality on emissions is inconsistent (Mehmood et al., 2021). At approximately the same time, Wawrzyniak and Doryń (2020) argued for this distinction. For countries with high government efficiency, increased GDP will promote reductions in CO_2 emissions, and for countries with low government efficiency, an increase in GDP will lead to an increase in CO_2 emissions. Using three indicators to evaluate institutional quality based on the WGI dataset, Yameogo et al. (2021) explored the relationship between institutions and environmental quality in the context of globalization in 20 countries in sub-Saharan Africa (SSA) using the S-GMM approach. The results show a positive relationship between corruption control, government effectiveness and the environment; meanwhile, regulatory quality has a positive impact on environmental degradation. To assess environmental institutional quality in 66 developing countries, Azam et al. (2021) created the institutional quality variable using the PCA technique from six indicators based on the ICRG dataset. The results of the SYS-GMM estimation show that institutional quality increases CO_2 emissions, implying that the political environment in these countries is less concerned about public issues such as pollution from CO_2 emissions. Using this technique, Ha and Nguyen (2021) studied the role of institutions in the relationship between FDI and environmental pollution in 86 developing countries during the period 2008-2018. The results of the study revealed that regulatory quality, government effectiveness, voice and responsibility, political stability and the rule of law have positive relationships with the environment when FDI has a negative impact on the environment.

In the ASEAN region, much of the literature shows that different institutional elements play a heterogeneous role across countries (Ahmed & Bhattacharya, 2020). Ahmed and Bhattacharya (2020) explored the role of energy and institutions on CO_2 emissions for the ASEAN-8 during the period 1984-2014. Through the ARDL and FMOLS techniques, the authors show that institutions can help improve the environment by improving corruption; the results for each country are not consistent. Similarly, Rehman et al. (2023) also find evidence that institutional quality has a positive impact on the environment. Through technological innovation and improved institutional quality frameworks, countries can achieve environmentally sustainable development.

Previous literature has used many governance-related indicators to represent institutions, of which the corruption index is a commonly used measure to reflect the level of institutions. Many studies show that corruption has a negative impact on the environment, such as (Sabir et al., 2020; Apergis and Ozturk, 2015; Muhammad and Long, 2021). According to Biswas et al. (2012), corruption has an indirect impact on environmental quality. As the level of corruption increases, along with the positive impact of the shadow economy on CO_2 emissions, environmental quality decreases. Increasing levels of corruption will lead to less effective implementation of environmental policies as the economy grows (Arminen & Menegaki, 2019). However, past levels of corruption have a stronger impact than current levels of corruption on the implementation of climate change policies (Fredriksson & Neumayer, 2016). In addition to the corruption index, indicators of institutional quality (such as political stability, government efficiency, regulatory quality, and rule of law) play a positive role in improving environmental pollution (Apergis & Ozturk, 2015; Arminen & Menegaki, 2019; Muhammad & Long, 2021).

3. Research method

3.1. Model specification

This study is based on the EKC theory (Grossman & Krueger, 1991) and the STIRPAT model (Dietz & Rosa, 1994). Then, inheriting previous empirical research (Essandoh et al., 2020; Muhammad & Long, 2021; Sabir et al., 2020), the authors develop an expanded model that includes additional factors, including institutional quality, financial development, and FDI. Thus, the general form of the empirical equation is modeled as follows:

$$CO2_{it} = f\left(IQ_{it,}X_{it}\right) \tag{1}$$

where i embodies cross sections (i = 1, 2 ..., 10) and t denotes the selected time. $CO2_{it}$ represents environmental pollution, measured by CO2 emissions, and IQ_{it} represents institutional quality in country i and year t. X_{it} represents the vector of control variables, where GDP_{it} is economic growth, TO_{it} is trade openness, FD_{it} is financial development, FDI_{it} is foreign direct investment, and EC_{it} is energy consumption. All variables in the research model (except IQ) are calculated as natural logarithms. The econometric form of the model can be explained in Eq. (2) as:

$$CO2_{it} = \alpha_0 + \beta_1 IQ_{it} + \beta_2 GDP_{it} + \beta_3 TO_{it} + \beta_4 FD_{it} + \beta_5 FDI_{it} + \beta_6 EC_{it} + \varepsilon_{it} \tag{2}$$

where α_0 is the intercept, ε_{it} is the random error term and $B_1 \rightarrow \beta_6$ are the coefficients of the regressors to be projected.

3.2. The data

The data used for this study were obtained from the World Bank. The data, namely, CO2 emissions (CO2), economic growth (GDP), financial development (FD), foreign direct investment (FDI), trade openness (TO) and energy consumption (Rafique et al.), are extracted from the World Development Indicators, and the institutional quality (IQ) data are taken from the Worldwide Governance Indicators (WGI).

The research topic focuses on 10 ASEAN countries from 1996 to 2020, with a research sample consisting of 10 countries and 25 observations per country, totaling 250 observations. The time scope of the research sample is based on the availability of data and ensures the continuity of the data in the model. The 10 ASEAN countries included Brunei, Cambodia, Laos, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam (Table 1).

Table 1 Variable descriptions.

Variables	Symbols	Measurement unit	Data-source
Carbon dioxide emissions	CO2	CO2 emissions (metric tons per capita)	WDI (2023)
Economic growth	GDP	Per capita real GDP (2015 US $)	
Financial development	FD	Domestic credit to private sector as a ratio of GDP (% of GDP)	
Foreign direct investment	FDI	Net inflow of total FDI (% of GDP)	
Trade openness	TO	Total exports and imports as a ratio of GDP (% of GDP)	
Energy consumption	EC	kg of oil equivalent per capita	
Institutional quality	IQ	Index constructed through PCA from governance indicators (scaled from -2.5 to 2.5)	WGI (2023)

3.3. Econometric strategy

3.3.1. Principal component analysis technique

According to Kaufmann et al. (2011), WGI indicators include institutional quality and core areas of governance. The importance of these indicators to environmental pollution has been determined by many studies (Apergis & Ozturk, 2015; Muhammad & Long, 2021; Wawrzyniak & Doryń, 2020). Although each index covers different aspects of institutional quality, these indicators are highly correlated (Kaufmann et al., 2011; Kuncic, 2012), leading to multicollinearity, so it would be difficult to use six indicators in a single regression equation. Therefore, according to the available literature (Ali et al., 2020; Azam et al., 2021; Musa et al., 2021; Samadi & Alipourian, 2021), this study uses principal component analysis (PCA) to construct a single composite index from all six indices, which can capture most of the features of all six WGI indices without the problem of multicollinearity. Thus, this study creates the institutional quality (IQ) variable using the PCA method as follows:

$$IQ_j = z_{j1}y_1 + z_{j2}y_2 + z_{j3}y_3 + \cdots + z_{jp}x_p \tag{3}$$

where IQ_j represents institutional quality; z_j is a parameter of an equation; x is an indicator; and p indicates that no variables exist.

3.3.2. Panel unit root tests

This study employed four-panel stationary tests such as LLC, HT, Breitung and IPS to determine the stationarity of the variables. The LLC test equation is specified as:

$$\Delta y_{it} = \phi y_{i,t-1} + z_{it}'\gamma_i + \sum_{j=1}^{p} \theta_{ij}\Delta y_{i,t-j} + u_{it} \qquad (4)$$

where p is the number of lags and $\phi, z_{it}', \theta_{ij}$ and u_{it} indicate the model's autoregression coefficients.

3.3.3. Cointegration test

It is necessary to test for cointegration among the selected variables before the estimation of long-run parameters. Nonstationary variables can lead to spurious regression results, meaning that there is no long-run equilibrium cointegration relationship. Therefore, to address problems of heterogeneity and cross-sectional dependence across units in panel data, this study uses the panel cointegration technique proposed by Kao (1999) and Pedroni (2004), which is based on the Engle and Granger (1987) approach. The expression is presented below with the null hypothesis of no cointegration and the alternative hypothesis of cointegration:

$$y_{it} = \alpha_i + \delta_y t + \beta_{1i}x_{1it} + \beta_{2i}x_{2it} + \cdots + \beta_{Ki}x_{Kit} + e_{it} \qquad (5)$$

where i represents countries, t represents time, and y_{it} is the tested variable. For each country, the covariance of x_{it} is stationary at $I(1)$, β_i is the cointegration vector, γ_i is the vector of coefficient z_{it}, and e_{it} is the error term.

3.3.4. ARDL methodology

To estimate the short-term and long-term relationships among the considered variables, this study applied the autoregressive distributed lag model (ARDL) proposed by Pesaran and Smith (1995). There are a few advantages to this technique over existing approaches. First, the ARDL model can use variables that are stationary at I(0), I(1) and mixed integration orders. Second, the ARDL model can estimate the short-run coefficients with long-run equilibrium without losing long-run information through the use of a correction error term. Third, with its flexibility, the ARDL model allows for different lags between variables (Pesaran et al., 2001).

The ARDL method consists of three main estimators, namely, MG, DFE, and PMG. The mean group (MG) technique is used to estimate regression coefficients for each country and the respective coefficient (Pesaran et al., 1999). It allows for heterogeneity in both short-run and long-run coefficients for each cross-section. The second estimator, the dynamic fixed effect (DFE) technique, limits the adjustment speed and the short-run coefficients for all countries to be the same. The DFE model also has restrictions on the slope coefficients of countries, and the error variances of countries must also be equal in the long run. The third estimator, the pooled mean group (PMG) technique, is a method that combines both the MG and DFE techniques. The PMG technique allows for heterogeneity in the intercept coefficient, short-run coefficients, the adjustment speed of short-run variables to long-run equilibrium, and heterogeneity of error variances across countries. At the same time, this method allows the long-run slope coefficient to be consistent across countries. The Hausman test was used to select between PMGs or MGs and PMGs or DFEs. As such, the null hypothesis of the Hausman test assumes no difference between the PMG and MG techniques. If the null hypothesis is accepted, the PMG is more efficient than the MG.
The ARDL model can be specified as follows in Eq. (6):

$$\begin{aligned} \Delta CO2_{it} = \beta_0 &+ \sum_{j=1}^{n1}\beta_{1ij}\Delta CO2_{i,t-j} + \sum_{j=0}^{n2}\beta_{2ij}\Delta IQ_{i,t-j} + \sum_{j=0}^{n3}\beta_{3ij}\Delta GDP_{i,t-j} + \sum_{j=0}^{n4}\beta_{4ij}\Delta TO_{i,t-j} \\ &+ \sum_{j=0}^{n5}\beta_{5ij}\Delta FD_{i,t-j} + \sum_{j=0}^{n6}\beta_{6ij}\Delta FDI_{i,t-j} + \sum_{j=0}^{n7}\beta_{7ij}\Delta EC_{i,t-j} + \theta_0 CO2_{i,t-1} + \theta_1 IQ_{i,t-1} \\ &+ \theta_2 GDP_{i,t-1} + \theta_3 TO_{i,t-1} + \theta_4 FD_{i,t-1} + \theta_5 FDI_{i,t-1} + \theta_6 EC_{i,t-1} + \mu_i + \varepsilon_{it} \qquad (6) \end{aligned}$$

where Δ is the first difference operator, β_j are the coefficients of the terms that indicate short-term relationships, θ are the coefficients of the terms that indicate long-term relationships and represent fixed effects, and ε_{it} represents the error term for country i at time t.

This study uses the method of choosing the optimal lag length for the ARDL model of Kripfganz and Schneider (2023), which is an extension of the method of Pesaran et al. (2001) bounds testing approach. This method is based on implementing an ARDL regression model running the loop for each country separately and returning the optimal lag of each variable corresponding to each country. The lags of the variables in the general model are the optimal lags (most frequently occurring) of the variables in each country.

4. Results and discussion

4.1. Results of panel unit roots

Before checking the stationarity of the variables, this study used the Pesaran test (2004) to estimate cross-sectional dependence. The value of the cross-sectional independence test is -1.180, with $p > 10\%$.
To determine the stability of the variables, this study applied first-generation stationarity approaches. The outcomes of the test are depicted in Table 2. Table 2 shows that only FDI has no unit root at level, whereas CO2, IQ, GDP, TO, FD and EC are stationary at first difference. This means that all of the variables are not stationary in the same order. Therefore, only the ARDL model can be used.

Table 2 Panel unit root test results.

		Levin–Lin–Chu test	Harris-Tzavalis test	Breitung test	Im–Persaran–Shin test	Conclusion
Level	CO2	1.1523	1.0174	5.2581	3.7777	I(1)
	IQ	-1.3642*	0.8556	-0.2429	-0.1788	I(1)
	GDP	-2.696***	0.9873	8.1898	3.4154	I(1)
	TO	-0.5792	0.8241*	-0.3576	-0.3439	I(1)
	FD	-0.0084	0.9752	2.2476	2.0919	I(1)
	FDI	-2.7915***	0.3561***	-3.9934***	-4.8163***	I(0)
	EC	-0.9933	0.9819	5.2322	2.0632	I(1)
First Difference	CO2	-4.9435***	0.1434***	-7.4812***	-7.4633***	
	IQ	-4.5281***	0.0405***	-7.8029***	-7.3486***	
	GDP	-4.8801***	0.1765***	-4.735***	-4.1406***	
	TO	-7.8548***	0.0602***	-5.4211***	-6.9532***	
	FD	-3.465***	0.1751***	-5.8759***	-6.631***	
	FDI	-8.8692***	-0.4367***	-9.3332***	-9.4434***	
	EC	-4.7745***	0.0234***	-6.1542***	-7.1598***	

****, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.*

4.2. Results of panel cointegration tests

Table 3 reveals the findings of the cointegration test results by both the Kao (1999) and Pedroni (2004) approaches. All three statistics of the Pedroni test, the modified Phillips-Perron t test, the Phillips-Perron t test and the augmented Dickey-Fuller t test, are significant at the 1% level. The Kao test statistics are significant at the 1% and 5% levels. Therefore, there is a basis for rejecting the null hypothesis. This means that there are long-term relationships among variables in the 1996–2020 periodl.

Table 3 The cointegration test results.

Pedroni (2004) cointegration		
	Statistic	p value
Modified Phillips-Perron t	2.461	0.007
Phillips-Perron t	-2.612	0.005
Augmented Dickey-Fuller t	-11.349	0.000
Kao (1999) cointegration		
	Statistic	p value
Modified Dickey-Fuller t	-2.288	0.011
Dickey-Fuller t	-2.454	0.007
Augmented Dickey-Fuller t	-2.053	0.020
Unadjusted modified Dickey-Fuller t	-3.379	0.000
Unadjusted Dickey-Fuller t	-2.899	0.002

4.3. Results of ARDL regression

The panel ARDL (1,1,0,0,1,0,0) results for the three approaches (PMG, MG, DFE) are displayed in Table 4. According to the Hausman test, PMG is a more effective technique than MG and DFE in this study. Therefore, this study only focuses on the PMG estimator results, despite the MG, DFE, and PMG results being reported.

The short-run coefficients adjust by approximately 37.15% to approach long-run equilibrium. This corresponds to 2.69 years needed for the short run to return to long-run equilibrium. Institutional quality (IQ) has a positive and significant impact on CO2 emissions at the 1% significance level. However, in the short run, there is a change in the impact from institutional quality to environmental pollution. In other words, institutional quality has a positive impact on the environment. This can be explained by the fact that at the beginning of a new incumbency, politicians often fulfill some of their promises about providing public issues to ensure the trust of voters who have supported them (Grossmann & Hopkins, 2016; Keefer, 2007). The environment is a topic that politicians often commit to as well as an issue that the public cares about (Grossmann & Hopkins, 2016). Thus, in the first stage, they impress voters by implementing strong institutions for environmental protection. Therefore, in the short run, institutional quality plays an important role in reducing environmental pollution. This is in accordance with the empirical evidence of this study. However, this period is not too long. After gaining people's trust, the government gradually shifted its focus to economic development because in the long run, there is a priority for economic growth over sustainable resource use (Eisenmenger et al., 2020). The economies of the ASEAN region are mostly developing economies, with a large proportion of industry. This makes improvements in institutional quality promote economic development, leading to a long-term increase in CO2 emissions.

Table 4 Results of ARDL regression.

Variables	PMG	DFE	MG
Long-run			
IQ	0.1943***	0.1297	0.4793
	(0.0425)	(0.1243)	(0.3546)
GDP	0.0004	-0.2281*	0.0529
	(0.0683)	(0.1299)	(0.2833)
TO	0.0941**	0.0578	-0.0504
	(0.0439)	(0.122)	(0.2843)
FD	0.0436	0.1845**	-0.0293
	(0.0269)	(0.0769)	(0.0599)
FDI	0.0012	0.0273	-0.0306
	(0.0073)	(0.0462)	(0.0351)
EC	0.9649***	1.0634***	0.8476***
	(0.0526)	(0.1104)	(0.1866)
Short-run			
EC_{-1}	-0.3715***	-0.2242***	-0.9465***
	(0.1282)	(0.0379)	(0.1362)
$CO2_{-1}$	0.1035	0.1161**	0.1750*
	(0.0718)	(0.0565)	(0.1001)
IQ	-0.0965**	-0.0137	-0.0348
	(0.0484)	(0.0448)	(0.0465)
GDP	0.1438	0.3860**	0.1322
	(0.2503)	(0.165)	(0.3691)
TO	-0.1122	-0.0200	-0.2650***
	(0.0704)	(0.0421)	(0.0788)
FD	0.1013**	0.1182***	0.0644
	(0.0421)	(0.032)	(0.063)
FDI	0.0099**	0.0062	0.0050
	(0.0049)	(0.0082)	(0.0204)
EC	0.2155	0.3026***	-0.2192
	(0.1351)	(0.065)	(0.1383)
Cons	-3.2175***	-1.8742***	-7.8990***
	(1.083)	(0.3627)	(2.3023)
Hausman test	$\chi^2_6 = 5.59\ (p = 0.4285)$	$\chi^2_6 = -107.66$	

Standard errors are in parentheses. ****, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.*

Empirical evidence also shows the impact of trade openness, financial development, foreign direct investment, and energy consumption on environmental pollution. However, this study found no evidence of the impact of GDP on CO2 emissions. This result does not support the EKC hypothesis. Trade openness (TO) has a positive impact on CO2 emissions with a significance level of 5% in the long run and a negative impact in the short run. This finding is consistent with the research of Wang and Zhang (2021), Muhammad and Long (2021), and Leitão and Lorente (2020). Studying BRI countries, Muhammad and Long (2021) also found that trade openness contributes to increased emissions in LM and UM countries because trade accelerates their economic growth, and the composition effect is supported in LI and HI countries, where trade openness reduces CO2 emissions. In addition, Wang and Zhang (2021) also argue that trade openness is highly correlated with economic development and is a byproduct of the industrial process.

CO2 emissions are significantly affected by the financial development (FD) variable in the short run at the 5% significance level but have an insignificant positive impact in the long run. This finding is different from those of studies by Shahbaz et al. (2013) and Abid et al. (2022) but consistent with those of studies by Zakaria and Bibi (2019) and Boutabba (2014). Zakaria and Bibi (2019) argue that this is the result of capital effects overwhelming technology effects. The companies that were provided with credit did not invest in environmentally friendly projects; in other words, the financial sector does not have enough resources to allocate credit to green projects and energy-saving technologies (Boutabba, 2014).

However, foreign direct investment (FDI) has a short-term positive impact on CO2 emissions in ASEAN countries at the 5% significance level. Aydin (2023) showed that FDI has a positive impact on emissions in the UK and the US. Contrary to this result, FDI has a positive and significant role in improving the environment in LM countries in the long run. The impact of FDI on CO2 emissions in LM countries changes direction. In the short run, these countries need to focus on economic development, with weaker institutional quality to attract more FDI related to polluting industries as well as a lack of capital sources for investment in environmentally friendly technology (Khan et al., 2022). Thus, the research results also support the pollution haven hypothesis. Through trade and foreign direct investment, developed countries tend to transfer the social costs of environmental pollution and the exports of "dirty" industries to developing countries in the preindustrial period.

Energy consumption has a positive impact on CO2 emissions in both the long run and the short run, with a 1% significance level in the long run. This result is also consistent with the findings of Aye and Edoja (2017) who studied 31 developing countries and Rafique et al. (2020) who studied BRICS countries. The energy source in the ASEAN region is mainly fossil fuels, with coal, oil and natural gas (IEA, 2023). The consumption of fossil fuel energy has a positive impact on environmental pollution (Wawrzyniak & Doryń, 2020). Khan et al. (2022) also shows a positive impact of energy use on CO2 emissions because economic activities use fossil fuels in the production process and in highly polluting industries.

5. Conclusions

This study focuses on clarifying the impact of institutional quality and macro variables such as economic growth, trade openness, financial development, foreign direct investment, and energy consumption on pollution. environment in the ASEAN region during the period of 1996-2020. This study uses the ARDL model to study the relationships between variables in the short and long term.

The results obtained from the ARDL model indicate a U-shaped relationship between institutional quality and environmental pollution. That is, institutional quality has a negative impact on CO2 emissions in the short run and a positive impact in the long run. In addition, trade openness, financial development, foreign direct investment, and energy consumption have positive impacts on environmental pollution in ASEAN countries in both the short and long run.

The findings of this study have several policy implications for the governments of the selected countries. First, the empirical findings show that, at least temporarily, increasing institutional quality helps to promote a better environment. Therefore, to reduce CO2 emissions, governments must continue bolstering their institutions, enhancing the quality of their regulations, and increasing their anticorruption efforts. Second, governments should increase the effectiveness of monitoring the implementation of environmental regulations by private organizations. People's voice and awareness of environmental issues should be increased at the same time. Third, governments should continue to cooperate, exchange technology, and implement international commitments to energy and climate change. Ultimately, the primary goal of many countries is economic growth. Therefore, countries should have a roadmap for energy conversion and integrate environmental goals with economic growth goals to both reduce CO2 emissions and develop the economy.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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