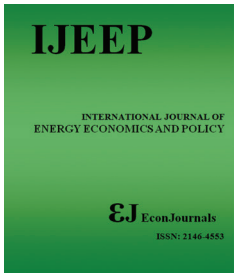

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Impacts of FDI and Environmental Pollution in ASEAN Countries: The Role of Institutions

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ABSTRACT

The study aims to examine the role of institutions in the relationship between foreign direct investment and environmental pollution in ASEAN countries from 2000 to 2019. With the General Moment method, the results show that foreign direct investment impacts increasing environmental pollution. At the same time, aspects of institutional quality such as the rule of law, government efficiency, political stability, quality regulations, and voice and accountability reduce environmental pollution. Furthermore, the study shows that institutional quality is essential in reducing the negative impact of foreign capital inflows on environmental pollution in ASEAN countries. From these results, the study recommends that ASEAN countries implement environmental protection plans when attracting foreign investment flows.

Keywords: FDI, Environmental Pollution, Institutions, ASEAN, GMM
JEL Classifications: D02, E02, G02, G21, G32

1. INTRODUCTION

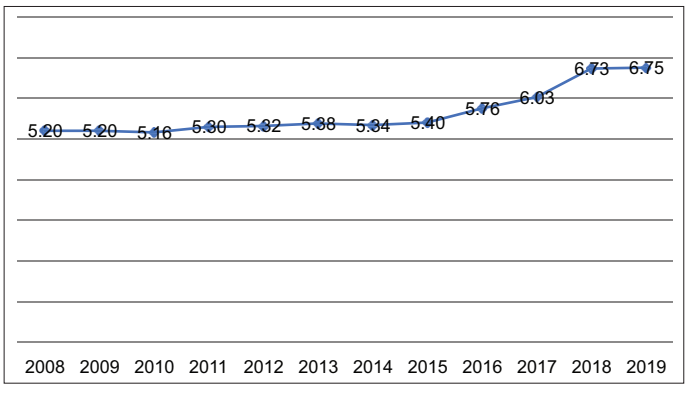
The problem of environmental pollution is currently very alarming (Abid et al., 2016; Hill, 2010; Victor, 2017). Environmental quality is getting worse and worse due to the increasing emissions of production and consumption activities, which affects the quality of life, and human health, causes global warming, seriously threatens human survival (Hill, 2010), and affects the economy. Notably, although the current environmental problem is alarming, the reality shows that many countries still focus only on economic growth, attracting foreign investment, and ignoring environmental harm (Cole et al., 2006; Lan et al., 2012; Solarin et al., 2017; Ulanowicz, 2012; Welford, 1995; Zhang and Zhou, 2016b). To promote growth and investment, these countries have limited application of policies and enforcement of regulations related to environmental protection (Cole et al., 2006; Lan et al., 2012; Solarin et al., 2017), leading to increasingly serious environmental problems. Many UN climate change conferences have been held, encouraging countries' governments to join hands to solve environmental problems. Many agreements have been signed, such as the 1997 Kyoto Protocol on emission reduction, The 2016 Paris Agreement on climate change… However, these efforts are insufficient to improve the current environmental situation (Kuiper and Van den Brink, 2012).

Theoretically, previous studies have tried to identify and analyze the impact of factors on environmental pollution, such as economic growth, urbanization, FDI, and institutions. (Cole et al., 2006; Damania et al., 2003; Hill, 2010; Ibrahim and Law, 2016; Victor, 2017; Wang and Chen, 2014; Wang et al., 2013). However, these factors' direction, level of impact, and transmission channels in theory and experimentally have not been elucidated and reached a consensus. In the current context, when countries are trying to find solutions to attract foreign investment, most studies show the positive impact of this factor on economic growth. FDI to environmental protection is still unclear and has not reached a consensus (Cole et al., 2006; Cole et al., 2017a; Grossman and Krueger, 1995). According to the "pollution halo hypothesis," FDI will help improve environmental problems (Antweiler et al.,

2001; Eskeland and Harrison, 2003; Zarsky, 1999). Meanwhile, the "pollution halo hypothesis" suggests that developing countries that attract more FDI inflows will gradually become "pollution havens" compared to other countries created by industrialization (Aliyu et al., 2005; Arrow et al., 1996; Wheeler, 2001). Furthermore, the review found that disagreement about the impact of FDI on environmental pollution is highly dependent on the role of government in each country (Cole et al., 2006; Damania et al., 2003; Gani and Scrimgeour, 2014; López and Palacios, 2014; Selden and Song, 1994; Wang and Chen, 2014). However, the studies are mainly carried out in the case of developed countries; Studies often evaluate the impact of factors individually, such as the impact of FDI on environmental protection, or examine the relationship between institutional quality and environmental protection. Therefore, the role of the government from an institutional perspective in the relationship between FDI and environmental protection has not been paid much attention.

The Association of Southeast Asian Nations (ASEAN) was established in 1967 with five original members; by 1999, ASEAN had ten official members, including Brunei, Cambodia, Laos, Myanmar, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. ASEAN is one of the most dynamic economic growth blocs in the world. Specifically, in 2019, ASEAN became the world's fifth largest economic bloc after the United States, China, Japan, and Germany, with a total GDP of 3.23 trillion USD. ASEAN maintained an average economic growth rate of 5.7% from 2000 to 2019, with foreign direct investment inflows into ASEAN over the past decade increasing by 42% to US174 billion by 2021. This capital inflow not only makes up for the shortfall from domestic savings but also plays a more critical role, which is to help develop the economy through the spillover of technology and improve the management level of the country. Thanks to this capital inflow, the economic activities of ASEAN countries increased rapidly. However, Environmental quality in this area is also seriously affected and poses tremendous challenges (Figure 1). Therefore, studying foreign investment flows, environmental pollution, and institutions is attracting attention in countries around the world in general and ASEAN countries in particular because of the relationship between them in the analysis of policies and quality of national governance for sustainable economic development. The results of this study will provide helpful input for shaping environmental and FDI attraction policies in the national institutional context in ASEAN countries.

Figure 1: CO_2 emissions in ASEAN countries from 2008 to 2019



The study has some contributions as follows (1) first, the study examines the impact of FDI on environmental pollution; (2) research to add more evidence on institutional quality to environmental pollution, especially looking at each aspect of the institution separately; (3) assessing the influence of institutions on the impact of FDI on environmental pollution. This work is done on two aspects: The aggregate institutional index and each of its aspects, and (4) The above studies are carried out in different countries; each country's political and economic characteristics will not be the same and will not be like those of ASEAN, while research on this topic in ASEAN is still very much limited so that the results will have practical value applied to ASEAN, a country with a relatively fast development speed. However, the problem of environmental and institutional pollution is still inadequate.

The rest of the paper is structured as follows. Section 2 presents an overview of the document. Section 3 offers the data and methods, followed by Section 4 with the results. Finally, section 5 is the conclusion of the study.

2. THEORY AND EXPERIMENTAL STUDIES

2.1. Theoretical Basis of Institutions in the Relationship between FDI and Environmental Pollution

The impact of foreign direct investment (FDI) on the environment is also controversial, with two opposing hypotheses: the "improve pollution" hypothesis and the "pollution paradise" hypothesis. On the one hand, according to the hypothesis of "improving pollution," when applying international environmental standards, multinational corporations investing in FDI will tend to use and transfer production activities by new technology, greener and more environmentally friendly in the host country (Birdsall and Wheeler, 1993; Hübler, 2009; Mielnik and Goldemberg, 2002). From there, a spillover effect will appear, leading to FDI inflows of multinational companies that contribute significantly to the industrial output of the host country and help to improve the level of environmental pollution (Zarsky, 1999). Meanwhile, the "pollution paradise" hypothesis explains that developing countries with weak environmental regulations become places to attract foreign investment with harmful business activities for the environment (Jensen, 2002).

One of the reasons for the debate about the effects of FDI on the environment stems from the lack of a theoretical foundation, which makes reasoning difficult. The authors always try to find evidence to explain the difference. Recently, institutional factors have been argued in explaining the effects of FDI on climate change in emerging countries (Dunning and Lundan, 2008; Peng et al., 2008). Thus, the question of whether FDI generates negative environmental externalities and how they differ can be explained in terms of the institutional quality of a country.

Institutions are the foundation for the development of national economies. According to North (1990), institutions are defined as human-made constraints that are structured and interact in many ways, including political, economic, and social. The institution, therefore, refers to the "rules of the game in

society," including informal constraints (e.g., codes of conduct, conventions, traditions) and formal rules (e.g., constitutions, laws, and regulations) and the character of their implementation. Furthermore, formal criteria refer to the normative composition of organizations.

Individualsh overview shows that institutions play an essential role in the market economy: Good institutional quality effectively supports the activities of the market mechanism, and businesses and individuals can participate in the market economy, making market transactions without incurring unnecessary costs or risks (Meyer et al., 2009; North, 1990). The development of institutional quality in the host country will help reduce the negative impact of FDI on the environment. When the institutional quality is good, the environmental protection management system is transparent, consistent, and tight. The high cost of violations prevents companies from taking actions that harm the environment. Therefore, in the face of high environmental standards, multinational companies must adopt strict environmental policies, invest in more environmentally friendly technologies and act more responsibly in waste generation, management, and disposal (Christmann, 2004). Furthermore, domestic firms enjoy less government protection in a country with good institutional quality, exposing them to increasingly stiff competition from foreign investors in the host country. As a result, this motivates them to find ways to improve productivity and innovate technology. In these cases, the competitive process will force inefficient domestic firms to change. Moreover, high institutional quality also supports the process of economic restructuring, gradually creating a higher share of the service industries in the host country. Accordingly, along with domestic investment, foreign investment also invests more in clean service industries and less in energy-consuming industries (Wang and Chen, 2014). According to this argument, when institutional quality improves, foreign direct investment (FDI) can positively impact environmental problems in the host country.

Conversely, if the market malfunctions, the weakness of market-supporting institutions will distort the healthy competition of foreign investors and domestic enterprises. Some companies can take advantage of their advantage (advantage due to institutional constraints) to survive with outdated technology and high waste generation. Such inefficient market competition can exacerbate the negative environmental impact of FDI. In addition, a weak and inconsistent management system related to environmental protection can also create loopholes for companies, including domestic companies and multinational companies, to commit illegal acts harmful to the environment.

In short, foreign capital flows into places with loose environmental protection regulations, creating negative environmental impacts. Weak and inconsistent environmental regulations, coupled with high local economic growth and competitive inefficiencies, may combine to explain the negative externalities generated by FDI. For the locality where the investment is received, more developed institutions and strong environmental management capacity will force foreign companies to adopt global environmental standards, and the overall environmental quality of the nation will be affected. In contrast, where institutions are poorly developed, for-profit firms can initiate a "race to the bottom," polluting practices as weak local institutions receive investment, leading to serious environmental problems. Based on the above analysis, the study put forward the following hypotheses:

H_1: Institutions reduce the negative impact of FDI on environmental pollution in ASEAN countries.

2.2. Previous Experimental Studies

Regarding the impact of FDI on environmental pollution, studies by (Li et al., 2019), (Gong et al., 2021), (Abdo et al., 2020), (Wang et al., 2020) (Raihan, 2023)… all support the "pollution paradise" hypothesis when arguing that FDI is one of the causes of environmental quality deterioration in the host country. Most recently, Gong et al. (2021) used data from countries along the "One Belt, One Road" as the sample and discovered that developing countries such as South Africa and Malaysia are still "polluted paradise." Qamruzzaman et al. (2019) used an interprovincial panel to analyze the impact of foreign trade and FDI on the transfer of pollution intensive industries and pointed out that the more FDI was attracted by China's provincial administrative regions, the more significant the transfer of pollution-intensive industries; thus, China is still a "pollution paradise" for FDI. Wang et al. (2020) investigates the interaction effect between corruption and foreign direct investment on environmental pollution by applying the spatial econometric model to the panel data of China's 29 provinces from 1994 to 2015 and analyzes the differences between China's eastern, central, and western regions. Results show that FDI inflow deteriorates the environmental quality, validating the pollution haven hypothesis; (b) by weakening the environmental standards, corruption enables the inflow of low-quality FDI, weakens the spillover effect of FDI and indirectly causes further environmental pollution. Deng et al. (2022) examines the impacts of social globalization, foreign direct investment inflows, and financial development on environmental pollution in the context of a globally representative sample of 107 countries. Especially concerning foreign direct investment inflows, Deng et al. (2022) find that for in the entire panel and the upper-middle-income and low-income sub-panels, foreign direct investment reduces and increases air pollution before and after the threshold level. In lower-middle-income countries, foreign direct investment inflows cause increased environmental pollution before and after the threshold. Abdo et al. (2020) apply the spatial lag model, the spatial error model, and the spatial Durbin model (SDM) to achieve the study objectives. Data are analyzed by using the SDM since the results of the Wald and likelihood ratio tests. The results of the lag model and global and local Moran's I test confirm the existence of SAR. The SDM results reveal that a slight increase in CO_2 is an influence of the FDI on environmental pollution. Findings support the existence of pollution haven hypothesis in the Arab countries. The direct effect of the FDI is increased CO_2 and environmental degradation, and the spatial spillover effects are statistically insignificant. Huynh and Hoang (2019) using a panel data for 19 developing Asian countries over the period of 2002-2015. Result shows that FDI inflows initially increase air pollution in Asia, and the institutional quality improvement helps reduce this effect until the institutional quality achieves a threshold, then beyond this threshold, FDI reduces air pollution. The findings

indicate that the pollution haven hypothesis and the pollution halo hypothesis are not contradictory when the institutional quality is taken into consideration. Raihan (2023) using the most up-to-date annual data between 1990 and 2019, this study investigated the evidence of the Environmental Kuznets Curve and the Pollution Haven Hypothesis in Bangladesh. To assess the effects of economic growth, foreign direct investment, energy use, and trade on carbon dioxide emissions, this research employed the autoregressive distributed lag method. The empirical results indicated that the country has an inverted U-shaped Environmental Kuznets Curve and the adverse impact of foreign direct investment on the environment confirmed the validity of the Pollution Haven Hypothesis in Bangladesh.

In contrast, there exists the "pollution halo" hypothesis. According to this theory, FDI can bring the host country clean production technology, advanced environmental standards, and efficient environmental performance management capabilities, which are conducive to the improvement of environmental quality. Demena and Afesorgbor (2020) conduct a meta-analysis of the effect of FDI on environmental emissions using 65 primary studies that produce 1006 elasticities. Results show that the underlying effect of FDI on environmental emissions is close to zero, however, after accounting for heterogeneity in the studies, FDI significantly reduces environmental emissions. Results remain robust after disaggregating the effect for countries at different levels of development as well as for different pollutants. Omri and Hadj (2020) examines how good governance and technological innovation complement foreign direct investment to mitigate carbon emissions in twenty-three emerging economies for the period 1996-2014. Based on the Generalized Method of Moments approach, result shows that FDI inflows have positive effects on the four indicators of carbon emissions. Bhujabal et al. (2021) examines the effect of ICT and FDI on environmental pollution in major Asia Pacific countries during the year 1990-2018 by using Pooled Mean Group (PMG) and Dumitrescu-Hurlin Panel Causality for the estimation of the results. The results suggest that ICT and FDI affect carbon emissions or environmental pollution negatively. This implies that with the rise in ICT infrastructure and FDI inflows, environmental pollution decreases significantly in the long run.

Furthermore, the impact of FDI on the environment in the existing research has not yet been clarified, and some scholars have proposed that the impact of FDI on the environment is nonlinear. Ji et al. (2015) empirically tested the impact of FDI on pollutant emissions across China and in subregions through the three-stage ordinary least squares (OLS) method and found that FDI has an inverted U-shaped relationship with environmental pollution in China. Liu et al. (2018) revealed that there exists spatial development relationship with the "Ntype" between the degree of environmental pollution and FDI through the results of a spatial autoregressive model (SAR) and spatial error model (SEM). Gu et al. (2020) found that the environmental effect of FDI is U-shaped, that is, the environmental pollution first decreases and then increases with the inflow of FDI. In this study An et al. (2021) based on the spatial correlation of environmental situation between adjacent regions, spatial autoregressive models are constructed to examine the impacts of foreign direct investment (FDI) on environmental pollution in China. An et al. (2021) find an inverted U-shaped relationship between FDI and environmental situation.

In addition, when considering whether this influence is influenced by other external factors such as institutions, the study finds that this issue has not received much attention. The studies only stop at assessing the personal impact of institutional quality on environmental pollution but have not considered the institutional factor as an intermediary factor affecting the impact of FDI on environmental pollution. For example, Azam et al. (2021) examine the role of institutional quality on environment and energy consumption for 66 developing countries by using data from 1991 to 2017. System generalized method of moments results reveal that institutional quality has a positive impact on most of the environmental indicators such as CO_2 emissions, CH4 emissions, and forest area. Hussain and Dogan (2021) using data from 1992 to 2016, long-and short-term relationships are estimated through a cross-section augmented autoregressive distributive lag model, augmented mean group estimator, and common correlated effects mean group. The second-generation econometric tools indicate that institutions quality reduction in environmental degradation. Wang et al. (2022) applies the method of the fully modified ordinary least squares method and the vector error correction model to explore the institutional quality and environmental quality in oil-producing and non-oil-producing African countries from 1999 to 2017. The FMOLS findings demonstrate that institutional quality significantly improved environmental quality in all countries. In addition, a few studies examine aspects of institutional quality such as corruption, political stability, government efficiency, etc. to environmental pollution. For example, Shaari et al. (2022) examined the short-run and long-run relationships between economic growth, energy consumption, foreign direct investment, trade openness, financial development, corruption, urban population, and carbon dioxide (CO_2) emissions in three developing countries of ASEAN, i.e., Malaysia, Indonesia, and the Philippines (ASEAN-3), with data from 1970 to 2017. Long-run elasticity results have proven that the higher level of corruption in these three ASEAN countries has caused more environmental pollution. Ganda (2020) analyses the impact of corruption on environmental sustainability in all 16 countries in the Southern region of Africa from 2010 to 2017. Using two econometric methods, namely, the Dumitrescu and Hurlin (2012) Granger causality test and the Generalised Method of Moments (GMM) techniques this study found largely congruent results in the short-run corruption was also found to worsen environmental sustainability. For the political stability, Kirikkaleli and Osmanlı (2023) investigates the effect of political stability on environmental quality, considering the critical role of economic growth, environmental regulation, patents in environmental technologies, and renewable energy consumption in Turkey from 1990 to 2019. Using nonlinear autoregressive distributed lag (NARDL) and dynamic ordinary least square (DOLS) models, the result shows that political stability in Turkey reduces environmental deregulation by declining CO_2 emissions. Muhammad and Long (2021) compares different effects of political stability, corruption control and rule of law on CO_2 emissions across 65 belt and road initiative countries from 2000 to 2016 on utilize across low income (LI), lower middle, upper middle-and

high-income countries. The results show that institutional factors such as political stability, corruption control and rule of law are highly important in lowering carbon emissions and improving environmental quality.

3. DATA AND METHODOLOGY

3.1. Research Sample

To accomplish the research objective, we estimate three models in turn. Model 1, the study examines the impact of FDI inflows on the level of environmental pollution. Model 2 to assess the effect of institutional quality on environmental pollution. From model 2, the study, in turn, adds the institutional variable and the interaction variable between the two factors FDI and the institution, into the empirical model to assess the degree of institutional influence in the relationship between FDI and environmental pollution.

$$lnco_{2it} = \alpha_{it} + \beta_1 lnco_{2it-1} + \beta_2 fdi_{it} + \beta_3 X_{it} + +\eta_i + \xi_{it} \quad (1)$$

$$lnco_{2it} = \alpha_{it} + \beta_1 lnco_{2it-1} + \beta_2 fdi_{it} + \beta_3 ins_{ijt} + \beta_4 X_{it} + \eta_i + \xi_{it} \quad (2)$$

$$lnco_{2it} = \alpha_{it} + \beta_1 lnco_{2it-1} + \beta_2 fdi_{it} + \beta_3 ins_{ijt} + \beta_4 insxfdi_{it} + \beta_5 X_{it} + \eta_i + \xi_{it} \quad (3)$$

Where i and t are country and time, respectively, CO_2 is CO_2 emissions per capita (tons/person), INS is a representative variable for countries' institutions, FDI is a direct investment in foreign countries, and X is the vector of control variables, including GDP per capita, urbanization, industrial level, domestic investment, trade openness, energy consumption, and Infrastructure.

3.2. Data

All data for the study were collected from the World Bank Development Index (WDI). The study collects data from 10 ASEAN countries, including Brunei, Cambodia, Indonesia, Laos, Philippines, Singapore, Thailand, and Vietnam, with an annual frequency from 2000 to 2019. Countries and study periods were selected based on available data to ensure the continuity and balance of data in the regression model.

3.3. Description of Variables

The research model includes the dependent variable CO_2 reflecting the level of environmental pollution; the independent variables are foreign direct investment (FDI) and institutional quality (INS). In addition, other control variables in the model include:

Environmental pollution can be measured through air pollution and soil and water pollution. NO_2 emissions, SO_2 dust, and noise levels are used to measure air pollution… For water pollution, the measured indicators include pH, DO (dissolved oxygen in water), COD (chemical oxygen demand), and BOD (biochemical oxygen demand). For the soil environment, environmental pollution measures are more complex, including soil fertility, soil porosity, erosion level, etc. (Johnson et al., 1997). Due to the difficulty of collecting time series data and ensuring uniformity for comparison across countries, previous studies have mainly exploited air pollution (Arouri et al., 2012; Azam et al., 2021; Bastola and Sapkota, 2015; Beghin et al., 2002). Therefore, this study uses an environmental pollutant measure, which is CO_2 emissions.

The study uses a set of global governance indicators (WGI) collected from the World Bank Development Index (WDI) database to reflect institutional quality. The WGI institutional quality indicators range from −2.5 to 2.5. These indicators capture various aspects of a country's institutional and governance characteristics, such as control of corruption (CC), government effectiveness (GE), voice, and accountability (VA), regulatory quality (RQ), political stability (PS), and the rule of law (RL).

The control variables in the model include urbanization (URB) and level of industry (IND), Domestic Investment (DIN), Trade Openness (OPEN), Energy Consumption (ENE), and infrastructure (INFR). GDP per capita (GDP), based on previous studies (Narayan and Narayan, 2010; Ozturk and Acaravci 2013; Ozturk and Acaravci, 2013).

The variables in the model are summarized and described in Table 1.

3.4. Estimation Method

The study uses the two-step GMM estimation method (Arellano and Bond, 1991; Holtz-Eakin et al., 1988; Roodman, 2006) proposed by (Roodman, 2006) for the following reasons:

Firstly, the empirical model in the study is dynamic, so it is necessary to take the difference first to eliminate the effects that are fixed with country characteristics. Then, the model variables in the differential form are used as instrumental variables with different lags, assuming that the original models' time-varying errors are not correlated (Judson and Owen, 1999). This approach, known as the Arellano-Bond disparity GMM estimation method, can deal with the problem of bias in estimates due to endogeneity.

Second, compared with one-step GMM estimators, two-step GMM estimators are more efficient (almost asymptotic). Therefore, the Arellano-Bond two-step GMM estimation method (S-GMM) is recommended to ensure the lowest possible bias and higher efficiency.

Accordingly, the study uses S-GMM for all estimation models based on the above characteristics. Therefore, the discussion is also mainly based on experimental results from this method. In addition, to test the reliability of the test results from the GMM method, the Hansen/Sargan test on the instrumental variable and the quadratic correlation AR (2) are also used.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Before interpreting the empirical results in more detail in the next section, the statistical summaries of the variables are presented in Table 2.

Table 2 records that the average CO_2 emissions per capita in the 10 ASEAN countries in the period 2000-2019 were 1.19 tons/year;

Table 1: Descriptive variables in the model

Variable	Explain	Measure	Source
CO_2	Environnement pollution	The amount of CO_2 gas per capita	WDI
$CO_{2\,(1)}$	Environnement pollution in previous year	The amount of CO_2 gas per capita	WDI
INS	Institutional quality	PCA method from 6 indicators: Voice and Accountability, Political Stability, Government Efficiency, Regulatory Quality, Rule of Law, Control of Corruption.	WGI
FDI	Foreign direct investment	FDI has been constructed as the year wise FDI inflows to different destination countries, in US $ million.	WDI
GDP	GDP per capita growth	Ratio of gross domestic product to total population	WDI
URB	U rbanization	Ratio of urban population to total population	WDI
IND	Industrial	Industrial Value (% GDP)	WDI
DIV	Domestic investment	Domestic investment as a percentage of GDP	WDI
OPEN	Trade open	Total import and export to GDP	WDI
INFR	Infrastructure	Number of telephone subscribers per 100 inhabitants	WDI
ENE	Energy consumption	Energy usage (% of total)	WDI

Source: The authors. FDI: Foreign direct investment, URB: Urbanization, IND: Industry, OPEN: Openness, INFR: Infrastructure, ENE: Energy consumption

The standard deviation is also relatively high at 1.15, indicating a significant disparity between these countries regarding CO_2 emissions.

Similarly, the net FDI attracted is also unevenly distributed among ASEAN countries. During 2000-2019, ASEAN countries attracted an average amount of FDI capital of 6.01% of GDP. In some countries, the amount of net FDI capital has a negative value, showing that the amount of FDI inflows is much lower than the amount of FDI brought into investment.

Regarding the institutional factor, ASEAN countries have a low level of institutions, the average body quality index is below 0 (neutral scale of institutional quality), and the standard deviation is low. This proves that the institutional quality of ASEAN countries is not too different, except for Singapore. Singapore is a country that is assessed to have a much higher institutional quality. However, the quality of institutions in other countries has recently improved.

4.2. Regression Analysis

4.2.1. Consider the impact of FDI on environmental pollution

First, the study examines the impact of FDI on environmental pollution according to model 1; The test results are presented in Table 3.

The test results show that FDI has a positive impact on CO_2 emissions in the case of ASEAN countries. This result is like previous studies such as (Li et al., 2019), (Gong et al., 2021), (Abdo et al., 2020), (Wang et al., 2020) (Raihan, 2023). In the context of fast economic growth, environmental problems are becoming more and more acute in ASEAN countries, so this result also warns ASEAN countries about the harmful effects of FDI inflows, first, the risk of of the trend of shifting dirty industries from other countries Nation. Along with FDI inflows, multinationals in heavy-polluting manufacturing industries will shift operations to branches in developing countries (Cole et al., 2006; Williamson et al., 2006). This shows that ASEAN countries have become the destination of FDI inflows with outdated production and management technology and polluting production activities. This transformation led to a restructuring of production and a change in trade patterns between countries (Cole and Elliott, 2003; Cole et al., 2017b).

Table 2: Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
CO_2	1.1968	1.1562	−1.8972	3.0544
FDI	6.0158	6.1264	−1.3200	28.6
INS	−1.830	0.7941	−1.7516	1.6354
GDP	0.3752	0.2910	−0.0378	0.1251
DIN	3.3051	0.2223	2.6026	3.9219
OPEN	4.5086	1.1786	−1.7872	6.0806
INFR	1.9319	1.2167	−1.2697	3.6707
ENE	144.7097	200.2889	5.4298	663.286
URB	3.8271	0.4623	2.9741	4.6051
IND	3.3899	0.3251	2.3938	3.8724

FDI: Foreign direct investment, URB: Urbanization, IND: Industry, OPEN: Openness, INFR: Infrastructure, ENE: Energy consumption

Table 3: Impact of FDI on environmental pollution in ASEAN countries

Change	
$CO_{2\,(1)}$	0.9481***
FDI	0.0097***
GDP	0.1058***
DIN	0.0108***
OPEN	0.0005
INFR	0.0140***
ENE	0.0016***
URB	0.0086***
IND	0.0059***
hansen	0.4516
Sargan	0.5304
AR (2)	0.9139

*P<0.1; **P<0.05; ***P<0.01; Solid standard deviation for the alternative variance in parentheses. FDI: Foreign direct investment, URB: Urbanization, IND: Industry, OPEN: Openness, INFR: Infrastructure, ENE: Energy consumption

4.2.2. Consider the impact of institutional aspects on environmental pollution

FDI policies into ASEAN countries need to be carefully considered. On the one hand, FDI weakens economic development (Adeleke, 2014; Dixit, 2012). Environmentalhand, increased FDI makes environmental problems worse (Baek and Koo, 2008; Chan and Yao, 2008; Zhang and Zhou, 2016a). Accordingly, the government has a decisive role in attracting and effectively managing FDI inflows. From this argument, the study examines the role of government in both institutional aspects of the relationship between FDI and environmental protection. To understand the

Table 4: Impact of institutional aspects on environmental pollution in ASEAN countries

Change	CC	GE	PS
$CO_{2\,(1)}$	0.9492***	0.9451***	0.9614***
FDI	0.0114***	0.0097***	0.0081***
GDP	0.1593***	0.2068***	0.0885*
DIN	0.0113***	0.0124***	0.0081***
OPEN	0.0005***	0.0051**	0.0005**
INFR	0.0097***	0.0113***	0.0086***
ENE	0.0108***	0.0005***	0.0006***
URB	0.0037*	0.0054**	0.0021
IND	0.0027***	0.0027**	0.0054***
CC	−0.1155***		
GE		−0.1231***	
PS			−0.0518***
Hansen	0.4420	0.4375	0.3596
Sargan	0.5060	0.5233	0.4473
AR(2)	0.9283	0.9051	0.8766
Variable	RG	RL	VA
$CO_{2\,(1)}$	0.9593***	0.9496***	0.9639***
FDI	0.0097***	0.0092***	0.0091***
GDP	0.1042**	0.2084***	0.0140
DIN	0.0070***	0.0108***	0.0064***
OPEN	0.0010***	0.0005***	0.0011***
INFR	0.0097***	0.0081***	0.0108***
ENE	0.0005***	0.0005***	0.0020***
URB	0.0048**	0.0027	0.0059***
IND	0.0027**	0.0016**	0.0048***
RQ	−0.1155***		
RL		−0.1431***	
VA			−0.0302
Hansen_	0.4120	0.4112	0.4407
Sargan	0.5334	0.5084	0.5206
AR(2)	0.8942	0.8931	0.8876

*P<0.1; **P<0.05; ***P<0.01; Solid standard deviation for the alternative variance in parentheses. FDI: Foreign direct investment, URB: Urbanization, IND: Industry, OPEN: Openness, INFR: Infrastructure, ENE: Energy consumption

role of institutions in the environment, the study introduces the operational model of indicators measuring aspects of institutions as described in the model (2). The test results are briefly presented in Table 4.

Table 4 shows that all aspects of institutions have a significant negative impact on CO_2 emissions in ASEAN countries; this result is like the study of (Gani and Scrimgeour 2014; Ibrahim and Law, 2016; Lau et al., 2014; Solarin et al., 2017). Thus, improving institutional quality is one of the critical factors to help limit environmental pollution in these countries.

4.2.3. Consider the role of institutions in the relationship between FDI and environmental pollution

To test the level of institutional influence in the relationship between FDI and environmental pollution, the study uses the interaction variable between institutions and FDI in model 3. In this step, the study will first use the variable that interacts with the institutional variable as a composite variable (built from the PCA primary component analysis method). Then, to test the certainty of the model, the study runs with individual aspects of the institution in turn. The results will serve as a basis for research to propose more specific and clear policy implications. The study results are presented in Tables 5 and 6, respectively.

Table 5: Role of institutions-look at the composite index

Change	INS	INS×FDI
$CO_{2\,(1)}$	0.9611***	0.9734***
FDI	0.0092***	−0.0934**
GDP	0.0756	0.2149***
DIN	0.0081***	0.0005
OPEN	0.0011***	0.0081
INFR	0.0092***	0.0038***
ENE	0.0070***	0.0011**
URB	0.0037*	0.0016
IND	0.0052***	0.0113***
INS	−0.0842***	0.0162***
FDI*INS		−0.0043*
hansen	0.4134	0.5495
Sargan	0.5037	0.5464
$AR_{(2)}$	0.8872	0.7669

Table 6: Institutional roles-considered aspects

Variable	CO_2
CCFDI	−0.0027***
PSFDI	−0.0205**
RLFDI	−0.0001***
RQ FDI	−0.0005***
GEFDI	−0.0149*
VAFDI	−0.0010*

Table 5 shows that the composite institutional variable impacts reducing CO_2 emissions, demonstrating the critical role of institutional quality improvement in environmental protection policies. Moreover, Tables 5 and 6 show that the interaction variable between FDI and institutions (in both the aggregate index and the individual index aspect) has a negative sign implying that improving institutions' quality will reduce the impact adverse effects of FDI on the environment (Bissoon, 2012). Improving institutional quality and reducing CO_2 emissions directly reduces CO_2 indirectly through the effect on FDI inflows. As the institutional quality increases, the government policies and regulations related to attracting FDI inflows become stricter towards high-quality FDI inflows, with modern management and production technology, with more appropriate and efficient post-production waste treatment technology. Therefore, the interaction between FDI and institutional quality helps to improve environmental quality and reduce CO_2 emissions in developing countries (Neequaye and Oladi, 2015). On the contrary, weak institutions create loopholes for companies, including multinational ones, to commit acts that are harmful to the environment. (Damania et al., 2003) pointed out that corruption seriously undermines the implementation of environmental policies. Cadres and civil servants often "ignore" regulations on environmental protection for the sake of their interests. Thereby creating opportunities for companies instead of spending a lot of money to improve technology and management skills to carry out production activities that are harmful to the environment instead of spending a lot of money to improve management skills.

5. CONCLUSION

Environmental pollution is a topical issue that countries worldwide are particularly concerned about. Attracting foreign direct

investment brings many benefits to the development of nations. But besides that, this activity will affect the environment. Using the GMM method, the study using data from ASEAN countries in the period 2008-2019 shows that foreign direct investment has an influence, increasing the level of environmental pollution. However, this power level will improve in an environment of good institutional quality.

With the obtained results, the study recommends that ASEAN countries be cautious in designing, promulgating, and implementing policies related to institutions and attracting FDI flows because institutions directly affect the quality of FDI. Therefore, the governments of ASEAN countries need to carry out more important institutional reforms to create an environment to effectively attract high-quality FDI with advanced and environmentally friendly production and management technology.

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