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The Impact of Financial Development on Environmental Pollution in Asian Countries: Examining the Role of Corruption Control

Anh Dang*

Ho Chi Minh University of Banking, Ho Chi Minh, Vietnam. *Email: anhdtq@hub.edu.vn

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ABSTRACT

This study aims to assess the role of corruption control in the impact of financial development on environmental pollution in Asian countries from 2002 to 2022. Using the GMM model, the research results indicate that financial development has an inverse effect on environmental pollution, meaning that financial development contributes to improving environmental quality in the Asian region. Furthermore, the study also uncovers a non-linear relationship between these two variables, suggesting that the impact of financial development on the environment may change across different stages of development. Another important highlight of the study is the role of corruption control. The study employs the DID method to show that in countries with effective corruption control systems and high levels of comprehensive financial development, the positive impact of finance on the environment is more pronounced. This indicates that establishing a transparent and efficient business environment is crucial for maximizing the benefits of financial development in protecting the environment.

Keywords: Financial Development, Environmental Pollution, Corruption Control, GMM, DID Method
JEL Classifications: C32; F18; O44; Q56

1. INTRODUCTION

Environmental pollution is becoming an increasingly significant concern in many countries worldwide. This is also a topic that has garnered considerable attention from researchers who have conducted extensive studies. However, the factors influencing levels of environmental pollution remain unclear, and there is still much debate surrounding this issue. Therefore, understanding effecting factors and carbon emission models is crucial for developing appropriate and effective strategies (Dong et al., 2019). Studies worldwide generally agree that economic activities in countries are the main cause directly impacting global warming and climate change, especially in developing economies. Consequently, environmental pollution will be determined by their economic development strategies.

In the current context, common directions that strongly influence economic activities in each country, and subsequently affect the environment, include: economic growth, integration, and globalization, alongside the strategy for developing a robust financial system. In this study, we refer to financial development, a strategy strongly promoted by countries today. How is financial development related to environmental pollution? First, financial development can help countries attract foreign direct investment and higher levels of R&D investment to accelerate economic growth rates which influences environmental activity (Tamazian et al., 2009; Yuxiang and Chen, 2011). Second, financial development gives countries incentives and opportunities to adopt new technologies, enabling them to produce in a cleaner and more environmentally friendly manner, thus improving the global environment in general and enhancing the sustainability of regional development. However, financial development could also lead to increased industrial production activities, potentially resulting in greater environmental degradation (Shahbaz et al., 2013).

Moreover, the impact of financial development on environmental pollution depends on various external factors, such as the characteristics of the countries, including income levels and institutional quality (Nguyen et al., 2024). One of these factors is corruption. Corruption, a social ill, has severe consequences for a country's financial development. When corruption exists, public financial resources are often lost or diverted into the pockets of individuals and interest groups, reducing the effectiveness of public investment. This leads to deteriorating infrastructure and low-quality public services, hindering economic development. Furthermore, corruption distorts the market, creating an unhealthy business environment where legitimate businesses struggle to compete with those willing to engage in bribery. This diminishes business productivity and erodes investor confidence, causing foreign investment to hesitate. Additionally, corruption undermines the legal system, facilitating illegal activities, increasing social inequality, and diminishing public trust in the regime. Therefore, controlling corruption plays a vital role in ensuring that the financial development process does not negatively impact the environment. Without strict controls, corruption can lead businesses and individuals to exploit legal loopholes for profit, causing environmental pollution without accountability. This not only degrades the quality of the living environment but also hinders the sustainable development of the economy. Conversely, a clean and transparent business environment will encourage companies to invest in clean technology, promote sustainable production, and reduce pollution.

From the arguments above, we recognize that in the context of globalization and the increasing prevalence of environmental issues, researching the relationship between finance and environmental quality has become increasingly important, especially in Asian countries. Asia is one of the continents with the largest population in the world, alongside rapid urbanization and industrialization. Thus it faces significant challenges in balancing economic development with environmental protection. Therefore, studying the relationship between financial development, corruption control, and environmental pollution is not new in the research community. However, there is still a lack of studies examining the role of corruption control on the impact of financial development on the environment in Asian countries. Additionally, the conclusions regarding the direction of the effect of economic development on environmental pollution have not reached a consensus, which is addressed in this study.

In conducting this research, we make the following contributions: (1) The study provides evidence of the impact of financial development on environmental pollution in Asian countries using updated data. Therefore, the study's results will reflect timeliness; (2) The study offers evidence of the role of corruption control using a newer method compared to previous studies, specifically the DID method.

The paper is structured into five sections. Following the introduction is a literature review to identify research gaps. Section 3 will describe the methodology, data, and model construction to address the objectives. The results of the research will be discussed in Section 4, while Section 5 will present conclusions, outline some policy implications, and finally highlight the limitations of the study

2. THEORETICAL AND LITERATURE REVIEW

2.1. Theoretical

Environmental quality changes due to many factors, among which changes in population and scarcity of natural resources are believed to have a significant impact. There are two different perspectives on this issue (Shi, 2003). First, according to Malthus's viewpoint, he argued that environmental degradation occurs due to the pressure of population on resources (Malthus, 1986). In contrast, Boserup (1981) posits that population growth will stimulate the emergence of technological innovations, reducing the negative impact on the environment. Specifically, Boserup considers high population density a prerequisite for technological progress in human activities, especially agriculture. Thus, Malthusian scholars predict that the impact of population on greenhouse gases will be more than proportional, while Boserupian scholars assert that this relationship does not exist or if it does, it is negatively elastic. Ehrlich and Holdren (1971) were the first to use the IPAT equation to describe how increasing population contributes to our environment, both positively and negatively. This takes the form of an equation combining environmental impact (I) with population size (P), affluence (A, per capita consumption or production), and technology's environmental impact (T, impact per unit of consumption or production), referred to as I = PAT. Chertow (2000) revisited the history of the IPAT equation and its variations. This equation is a widely recognized formula for analyzing the impact of population on the environment (Harrison and Pearce, 2000), and continues to be used to analyze the drivers of environmental change (York et al., 2002). Waggoner and Ausubel (2002) revised this model by separating T into consumption per unit of GDP (C) and impact per unit of consumption (T), resulting in I = PACT and renaming it ImPACT. The main purpose of the ImPACT model is to identify key factors that can be modified to mitigate environmental change and to determine some factors that influence those factors (York et al., 2003). There has been some debate regarding I =PAT. Schulze (2002) proposed adding behavior (B) to I = PAT, creating I = PBAT. He argued that people have many effective behavioral styles, such as changing their behavior, reducing affluence, or adopting more efficient technologies to lessen environmental impact. However, Schulze's approach has faced some criticism. Diesendorf (2002) argued that some aspects of behavior are implicitly related to each factor on the right side of the I = PAT equation. Therefore, B can only include those behavioral aspects not already encompassed in P, A, and T, making B difficult to define.

Nevertheless, whether using the I = PAT, I = PBAT, or I = PACT models, we can assess the corresponding impact of environmental change by altering one factor while holding the others constant.

To overcome the limitations of these models, York et al. (2003) transformed the IPAT model into a stochastic model, as STIRPAT (for Stochastic Impacts by Regression on Population, Affluence, and Technology), to analyze the asymmetric impact of population on the environment. The specifications of the STIRPAT model are as follows:

$$I_i = aP_i^b A_i^c T_i^d e_i \quad (1)$$

The model retains the multiplicative logic of the I = PAT equation, treating population (P), affluence (A), and technology (T) as determinants of environmental change (I). After taking the logarithm, the model takes the following form:

$$lnI_{it} = a + b(lnP_{it}) + c(lnA_{it}) + d(lnT_{it}) + e_i \quad (2)$$

The subscript i indicates that these quantities (I, P, A, and T) vary across observational units; t denotes the year; b, c, and d are the exponents of P, A, and T; *e* is the error term, and *a* is the constant. Equation (2.2) presents the linear relationship between population, affluence, and technology.

The determinants of P and A (Dietz and Rosa, 1994) as well as (York et al., 2003) are disaggregated. This paper modifies equation (2) by incorporating the percentage of the population living in urban areas (urbanization), resulting in equation (3). Equation (4) is based on equation (2.3) but adds the percentage of the population aged 15-64. Here U refers to urbanization and L refers to the percentage of the population aged 15-64.

$$lnI_t = a + b_1(lnP_t) + b_2(lnU_t) + c(lnA_t) + d(lnT_t) + e_i \quad (3)$$

$$lnI_t = a + b_1 (lnP_t) + b_2 (lnU_t) + b_3 (lnL_t) + c (lnA_t) + d (lnT_t) + e_i \quad (4)$$

Since both the dependent variable and the predictor factors are logarithmic, the coefficients should be understood as changes in percentage terms. Furthermore, (York et al., 2003) introduced the concept of ecological elasticity to analyze environmental issues further. Ecological elasticity (EE) refers to the responsiveness or sensitivity of environmental impacts to changes in any driving factor. Therefore, we can calculate the EE of any leading factor. The term population elasticity of impact (EEIP) refers to the degree of response of environmental impact to changes in population size. The term elasticity of impact for affluence (EEIA) refers to the responsiveness of environmental impact to changes in economic measures of affluence (e.g., per capita GDP or GNP). The coefficients b*b* and c*c* in model (2) represent EEIP and EEIA, respectively. York et al. (2003) did not discuss the elasticity of impact regarding technology, as ecological elasticity does not apply to technology and there is no uncontroversial single measure of T.

In summary, we use the STIRPAT model as a basis for incorporating variables such as income, energy consumption levels, urbanization rates, etc., into the research model in the following section (Canh et al., 2019; Lin et al., 2017; Liu et al., 2017; McGee et al., 2015).

2.2. Literature Review

Financial development can have both favorable and unfavorable sustainability effects. Some arguments suggest financial development may contribute to environmental degradation through increased energy consumption by households and industries (Acheampong, 2019). For instance, (Khan et al., 2020) observed a decline in environmental quality in China's emerging economy from 1987 to 2017 as a result of financial development. This finding was supported by (Shahbaz et al., 2020), who examined the UAE and highlighted a negative relationship between financial development and the sustainable environment using ARDL bounds testing methods. Their research confirmed that financial development could be detrimental to environmental sustainability. (Jianguo et al., 2022) also found that financial development boosts household purchasing power and spending, contributing to higher CO2 emissions and environmental degradation in OECD countries. Similarly, (Kihombo et al., 2021) and (Abbasi et al., 2022) indicated that increased financial development enables consumers to buy energy-intensive products like cars and air conditioning units, which leads to greater emissions through heightened energy consumption. (Wang et al., 2020) echoed these concerns, asserting that financial development threatens environmental sustainability.

Conversely, several studies have indicated that financial development can improve environmental quality. It fosters energy research and development and invests in renewable energy sources. As technology advances, energy efficiency improves, demand decreases, and renewable energy becomes more affordable, thus enhancing environmental sustainability. For example, research by Kirikkaleli et al. (2022) and Kirikkaleli and Adebayo (2021) found that economic growth leads to reduced environmental damage. Likewise, Luo et al. (2021) and Ullah et al. (2022) also established a positive link between financial development and environmental quality in OECD countries.

However, some studies suggest that financial development has negligible effects on environmental sustainability. For instance, (Koengkan et al., 2022) studied the impact of fiscal and financial incentives on energy efficiency from 2014 to 2021 in 19 cities in Portugal. They discovered that income levels negatively affected high-energy-efficient housing, while consumer financing positively impacted it. This indicates the beneficial role of FND in energy efficiency (Charfeddine and Kahia, 2019) but also points out that FND and the promotion of renewable energy sources did not significantly affect sustainability in urban and economic growth. In a study (Le et al., 2020), a principal component analysis (PCA) of financial development in Asia found no correlation between financial development and reduced CO2 emissions.

In addition, some studies have found a non-linear relationship between financial development and environmental pollution, such as the research by (Zakaria and Bibi, 2019) in the South Asian region from 1984 to 2015, or the study by (Jiang and Ma, 2019), which examined the relationship between financial development and carbon emissions, based on the Generalized Method of Moments and data from 155 countries.

As mentioned, there are several reasons to explain the inconsistent results, including the study of different countries or regions, various econometric methods, and different measurement variables. Overall, the existing related studies on the impact of financial development on CO_2 emissions provide us with useful references. Based on the theory of environmental pollution and empirical studies, we assess the impact of financial development on environmental pollution in Asian countries with the following two hypotheses:

H_1: Financial development reduces environmental pollution.

H_2: There exists a non-linear relationship between financial development and environmental pollution

Habib et al. (2024) examine the complex relationships among three key factors: green finance, corruption control, and ecological footprint, aiming to identify synergies that influence sustainable development. Analyzing data from 10 selected countries over 18 years (2000-2018), they found a positive correlation (0.4338) between control of corruption and ecological footprint, suggesting that nations with stronger corruption controls often have larger ecological footprints. This implies that countries with lower levels of corruption tend to demonstrate a greater environmental impact. Furthermore, corruption levels can influence carbon emissions. Transparency International's 2020 data showed that G7 countries had varying corruption perception indices, with Germany and the United Kingdom scoring higher than their peers. Elevated corruption levels can obstruct the implementation of effective environmental policies, exacerbating ecological issues. Between 2014 and 2020, the corruption perception index for G7 nations decreased by 0.3 points (Ivungu et al., 2020). Similarly, Wang et al. (2020) conducted a study in China during the period 2006-2015, which shows that corruption, as well as misallocation of resources, possess detrimental effects on ecological efficiency. Corruption also intensifies resource misallocation thereby further lessening ecological efficiency. Akhbari and Nejati (2019) conducted a study in 61 countries from 2003 to 2006, indicating that the relationship between corruption and environmental pollution depends on the characteristics of individual countries. In developing economies, corruption increases emissions while in developed countries corruption no longer influences carbon emission levels. Sinha et al. (2019) studied BRICS countries from 1990 to 2017 and found that corruption promotes environmental damage by lessening the positive effect of green energy use on environmental quality along with heightening the negative influence of non-renewable deployment.

With the above studies, we recognize that corruption control plays a significant role in the process of implementing financial development with the goal of sustainable development. Therefore, when considering the role of control in this study, we propose the following hypothesis:

H_3: Corruption control has a significant role in the impact of financial development on environmental pollution.

3. MODEL AND METHODOLOGY

3.1. Sample and Database

The research data includes 30 Asian countries from 2002 to 2022, collected from reliable sources. Specifically, the data on financial development was obtained from the database of the International Monetary Fund; which was accessed at the website: https://data.imf.org. Other data such as urbanization, industrialization, domestic investment, trade openness, energy consumption levels, infrastructure, and corruption control were collected from the World Bank's data sources, which were accessible at the website https://databank.worldbank.org/source/world-development-indicators; https://databank.worldbank.org/source/worldwide-governance-indicators respectively.

3.2. Models Specifications

To test hypothesis H1, based on the studies of (Acheampong, 2019; Jiang and Ma, 2019) we construct Model 1.

$$CO_{2it} = \beta_1 CO_{2i,t-1} + \beta_2 FD_{it} + \beta_3 Z_{it} + \varepsilon_{it} \tag{5}$$

Where: CO_{2it} is the dependent variable representing a country's carbon emissions, measuring the level of environmental pollution. Thus, an increase in environmental pollution corresponds to a decline in environmental quality and vice versa. FDit is the variable measuring the level of financial development of a country. Zit is the group of control variables in the model, including the level of urbanization (URBAN), industrialization (IND), domestic investment (DINV), trade openness (OPEN), energy consumption level (ENER), and infrastructure (TINF). εit is the residual, where i and t represent the observation for country i in year t, and β_1, β_2, β_j are the regression coefficients, respectively.

To test for the existence of a non-linear effect of financial development on environmental pollution, we add the squared variable FD to Model 1

$$\mathrm{CO}_{2\mathrm{it}} = \beta_1 \mathrm{CO}_{2\mathrm{i,t-1}} + \beta_2 \mathrm{FD}_{\mathrm{it}} + \beta_3 FD_{it}^2 + \beta_{\mathrm{j}} \mathrm{Z}_{\mathrm{it}} + \varepsilon_{\mathrm{it}} \tag{6}$$

In addition, to examine the role of corruption control on the impact of financial development on environmental pollution, we use the DID model. The DID method is a widely used statistical technique in social, economic, health, and other fields to evaluate the impact of an intervention variable or event on the dependent variable. This method helps determine the effect of a policy or intervention by comparing changes between a group exposed to the intervention and a group not exposed to the intervention, with both groups being observed over time. The study uses the DID model to demonstrate that countries with effective corruption control

$$CO_{2it} = \beta_0 + \beta_1 post_{it} + \beta_2 treat_{it} + \beta_3\, post_{it} * treat_{it} + \varepsilon_{it} \tag{7}$$

Where $post_{it}$ =1, $treat_{it}$ = 1 for countries with high corruption control and financial development, and equal to 0 for other countries. High or low is determined by whether it is greater than or less than the average level of corruption control and comprehensive finance.

The variables in the model are described in Table 1.

This study has incorporated a lagged variable of carbon emissions into the regression model to reflect the dynamics of the carbon emission process, which is consistent with reality. Adding this lagged factor can help eliminate the influence of uncontrolled

Table 1: Describe variables

Variables	Definition	Summary description	Source data
Ln CO_2	Environmental pollution	CO_2 emissions (kg per PPP \$ of GDP)	WDI
FD	Financial development	Computed as an index of financial access, financial depth, and financial efficiency of both financial markets and financial institutions	IMF
TINF	Infrastructure	The number of telephone subscribers per 100 people	WDI
URBAN	Urbanization	The ratio of urban people to the total population	WDI
GDP	Economic growth	GDP	WDI
ENER	Energy consumption	Energy use (kg of oil equivalent per capita)	WDI
OPEN	Trade openness	The ratio of Imports plus exports to GDP	WDI
IND	Industrialization	The ratio of value added in key industries to GDP	WDI
DINV	Domestic development	The ratio of total annual domestic investment to GDP	WDI
CC	Control of corruption	bloom from−2.5 to 2.5	WGI

Table 2: Descriptive statistics

Variables	Obs	Mean	Standard deviation	Min	Max
CO_2	630	5.1212	4.8664	0.0986	25.3756
FD	630	0.3965	0.2241	0.0531	0.9300
URB	630	57.0978	24.2469	14.2400	100
TRA	630	103.1587	80.5413	20.4471	442.6200
DINV	630	7.5902	23.3856	−103.1567	279
TINF	630	17.3699	17.0551	0.1371	61.1525
IND	630	31.2549	13.4529	5.0393	74.1130
ENER	630	3.3340	0.5624	1.6568	4.1137
CC	630	-0.1029	0.9275	−1.5971	2.3011

factors, thereby enhancing the reliability of the regression results. However, due to the presence of the lag, the model cannot be estimated using traditional methods like Ordinary Least Squares (OLS) or panel data models (such as Fixed Effects Model (FEM) or Random Effects Model (REM)). These methods can lead to endogeneity issues, resulting in inefficient estimates. Therefore, to leverage the advantages of addressing econometric problems such as serial correlation, heteroskedasticity, and especially endogeneity, the primary estimation method used in this study is the two-step Generalized Method of Moments (GMM) (Arellano and Bover, 1995) as proposed by Roodman (2006).

3.3. Descriptive Statistics

Summary statistics regarding the variables used are displayed in Table 2. CO_2 averages for 30 nations in ASIAN countries during the period 2002-2022 is 5.1212 tons per year CO_2 reaches a minimum of 0.0986, a maximum of 25.3756, and has a standard deviation of 4.8664. The basic statistics of other control variables display relevance.

4. EMPIRICAL FINDINGS

4.1. The Impact of Financial Development on Environmental Pollution

The results in Table 3 indicate that the main independent variable, FD, hurts environmental pollution, with a significance level of 1%. This suggests that financial development in Asian countries may help reduce environmental pollution, thus improving environmental quality. This finding is consistent with the studies of (Jianguo et al., 2022; Kihombo et al., 2021; Wang et al., 2020). To explain this effect, it can be observed that financial development in Asian countries has facilitated businesses' access to market capital at reasonable costs for investing in environmentally

Table 3: The impact of financial development on environmental pollution

Variable	Coefficient	P-value
CO_2 (1)	0.9650	0.000***
FD	−0.6567	0.061*
URB	0.0507	0.095*
GDP	−0.6505	0.038**
DINV	0.0037	0.023**
TINF	0.0281	0.049**
OPEN	0.0026	0.052*
IND	−0.0059	0.483
ENER	0.8327	0.136
Cons	−4.5814	0.061*
AR (2)	0.259	
Sargan test	0.389	
Hansen test	1.000	

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

friendly projects, aligning with the current economic development policies of these nations (Cole et al., 2005; Tamazian and Rao, 2010; Yuxiang and Chen, 2011). Additionally, financial development provides the necessary funding for research activities and technology upgrading, enabling companies to produce environmentally friendly products that better meet consumer demands (Birdsall and Wheeler, 1993; Zakaria and Bibi, 2019). Furthermore, financial development contributes to increasing the income and assets of individuals, thereby enhancing their awareness of environmental issues. As income rises, consumers tend to choose green and clean products while limiting their consumption of items harmful to the environment, which also affects the business operations of companies (Lahiani, 2020). Finally, financial development supports the improvement of the legal framework related to business activities of enterprises and financial institutions in providing funding for environmentally friendly production (Yuxiang and Chen, 2011).

For the control variables, urbanization, domestic investment, infrastructure, and trade openness have an increasing impact on environmental pollution, while economic growth and infrastructure will have the opposite effect. Domestic investment (DINV) has a positive impact on CO_2 emissions in developing countries. Domestic investment stimulates production, leading to an increase in CO_2 emissions, and this result aligns completely with the findings of (Jiang and Ma, 2019; Jorgenson and Clark, 2012). As domestic investment increases, production and business activities expand. This process contributes to higher CO_2 emissions into the environment. Trade openness (OPEN) also positively affects CO_2 emissions in developing countries. Opening up trade stimulates production and consumption, contributing to economic growth but also significantly contributes to the emission of harmful gases into the environment (Abdouli and Hammami, 2017; Abid, 2016; Solarin et al., 2017). Similarly, infrastructure (TINF) also has a positive impact on CO_2 emissions in this case study. Infrastructure development generates emissions during the construction process and encourages increased transportation, trade, and business activities. Therefore, infrastructure exacerbates CO_2 emissions (Bakhsh et al., 2017; Cole et al., 2005).

In contrast, an increase in per capita income tends to reduce environmental pollution. As people's demand for a better living environment rises, governments will have sufficient resources to invest in clean technology and environmental protection measures

In this context, we further use another indicator to measure environmental pollution to test the robustness of Model 1, which is the ecological footprint. This index is widely used in studies such as (Chowdhury et al., 2021; Doytch, 2020; Kassouri and Altıntaş, 2020; Nathaniel and Khan, 2020) (Table 4).

The results in Table 4 indicate that financial development has a counteractive effect on the ecological footprint, meaning that promoting financial development will reduce environmental pollution. With these results, we believe that the research findings are robust and can serve as a reference for future studies.

4.2. Non-linear Impact Assessment

In this section, we test Model 2 to determine whether there is a non-linear relationship between financial development and environmental pollution.

Table 5 that the FD coefficient of the squared variable have a negative Beta coefficient, which is statistically significant at 1% level. This demonstrates the existence of a non-linear impact of financial development on environmental pollution in Asian countries. Thus, in the initial phase of implementation, financial development tends to increase environmental pollution; however, this impact will improve in later stages. This can be explained as follows: In the early stage, when the economy is still weak, financial development is often accompanied by industrial growth, leading to increased pollution. However, as the economy develops further, the demand for a cleaner environment rises, and businesses will invest in clean technology to reduce pollution. Our results are consistent with the studies of (Nguyen et al., 2024).

4.3. Examine the Role of Corruption Control

Additionally, in this context, we use the Difference in Differences (DID) method to simultaneously assess how environmental pollution changes as countries exhibit different levels of corruption control and financial development. The DID method, also known as the double difference method, is increasingly used in studies that analyze the effectiveness of policy impacts. The primary goal of DID estimates the effect of an event, policy, or program on a specific group compared to another group. DID is based on the idea of comparing the change in the outcome variable between a treatment group (the group affected by the policy) and a control group over the same period. The results are presented in Tables 6 and 7.

The results in Table 5 show a balanced distribution of the sample data, with 19 observations in the Control group and 11 observations

Table 4: The impact of financial development on environmental pollution (EFC)

Variable	Coefficient	P-value
EFC (1)	0.9887	0.000***
FD	−0.4378	0.059*
URB	0.0031	0.737
GDP	−0.1220	0.058*
DINV	−0.0015	0.031**
TINF	0.0067	0.118
OPEN	0.0008	0.095*
IND	−0.0027	0.442
ENER	0.1850	0.564
Cons	−4.1053	0.0594
AR (2)	0.179	
Sargan test	0.985	
Hansen test	1.000	

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

Table 5: Non-linear impact assessment results

Variable	Non-linear	
	Coefficient (3)	P-value (4)
CO_2 (1)	0.8194	0.000***
FD	7.2105	0.010**
FD2	−5.7725	0.008***
URB	−0.0358	0.173
GDP	0.4756	0.209
DINV	0.0009	0.534
TINF	−0.0140	0.378
OPEN	−0.0000	0.988
IND	0.0173	0.006***
ENER	−0.6821	0.434
Cons	1.8114	0.438
AR (2)	0.256	
Sargan test	0.355	
Hansen test	1.000	

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

Table 6: Data on DID

Descriptive information	Number of groups and treatment time	
Time variable	Year	
Control	DID=0	
Treatment	DID=1	
Group	**Control**	**Treatment**
Firm	19	11

Table 7: Research findings from the DiD

CO_2	Coefficient	Robust S. Err.	t	P > |t|
DID	−0.4057	0.1690	2.40	−0.023**

** indicate statistical significance at the 5%

in the Treatment group. The clear distinction between the control group (did = 0) and the treatment group (did = 1) based on the time variable is crucial for evaluating the impact of the treatment method. Overall, the sufficient number of companies in both groups supports reliable conclusions regarding the effect of corruption control on environmental pollution.

Table 7 presents the estimated results of the DID model for environmental pollution. The DID coefficient is negative and statistically significant at the 1% level, indicating that when a country effectively controls corruption and has high financial development, there is a significantly reduced impact on environmental pollution.

5. CONCLUSION

The study assesses the role of corruption control on the impact of financial development on environmental pollution in Asian countries from 2002 to 2024. The research establishes three hypotheses and employs the SGMM and DID analysis methods. Initial results show that financial development has an inverse effect on environmental pollution, and this effect is non-linear. Furthermore, upon deeper evaluation, we provided evidence that this impact is also influenced by the level of corruption in the countries. If Asian countries effectively control corruption and achieve high levels of financial development, environmental pollution will be mitigated.

Based on the research findings, we propose several policy implications related to corruption control. To enhance corruption control, governments in these countries should: first, reform institutions and laws by improving the legal framework, strengthening the independence of corruption agencies, and expanding citizens' participation; second, enhance audit and inspection efforts by increasing oversight and transparency in the inspection results and leveraging information technology; finally, raise community awareness through advocacy, education, and building a culture of integrity.

In addition to its contributions to academia, we recognize some limitations in this study: first, the data is not yet updated to 2024, and corruption control could be measured using different indices to confirm the the model's robustness. Therefore, future research directions should focus on expanding the dataset and selecting more alternative variables.

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