

Foreign Direct Investment and Carbon Emission Accounting Efficiency the Moderating Role of Regulatory Quality

Hong Van Tran¹ and Thi Phuong Lan Tran^{2*}

¹Lecturer, Faculty of Accounting and Auditing, University of Finance – Marketing, Ho Chi Minh City, Vietnam

^{2*}Lecturer, Faculty of Accounting and Auditing, University of Finance – Marketing, Ho Chi Minh City, Vietnam

Email: ¹hongvan@ufm.edu.vn, ²tranlan@ufm.edu.vn

ORCID: ¹<https://orcid.org/0009-0004-9006-8339>, ²<https://orcid.org/0009-0007-8951-5332>

(Received 19 May 2026; Revised 29 June 2026, Accepted 10 August 2026; Available online 29 September 2026)

Abstract - The developing and emerging Asian nations are the main targets of foreign direct investment (FDI), and at the same time, they are having growing pressure to bring down their carbon emissions and achieve sustainable development. This double challenge poses an interesting policy dilemma: will FDI add to or detract from the efficiency of carbon emission accounting under various institutional environments? This study investigates whether FDI has an impact on the accounting efficiency of carbon emissions-CO₂ emission intensity per unit of economic output and whether regulatory quality makes a difference. A balanced panel data set of 25 developing/emerging Asian economies over the 2014–2023 period (250 country-year observations) was analyzed using a fixed-effect model with an interaction term and cross-sectionally dependent Driscoll–Kraay standard errors and a two-step System GMM estimator to address endogeneity. The empirical results show that FDI is significantly related to increasing the carbon emission intensity, lending support to the pollution haven hypothesis, and regulatory quality is significantly related to improving the carbon emission accounting efficiency. Furthermore, the relationship between FDI and the regulatory quality is found to be statistically significant, which indicates that the negative environmental impacts of FDI are reduced by the improvement of the regulatory quality. The threshold and country-group analyses also show that FDI is associated with better emission efficiencies only when the economy has a relatively high regulatory quality. The results in this study indicate that the improvement of regulatory institutions is crucial in the process of making foreign investment contribute to sustainable development and offer concrete policy suggestions on how to reconcile the economy and the environment in developing and emerging Asian economies.

Keywords: Foreign Direct Investment, Carbon Emission Accounting Efficiency, Carbon Emission Intensity, Regulatory Quality, Pollution Haven Hypothesis, Pollution Halo Hypothesis, Sustainable Development

I. INTRODUCTION

Over the past decade, developing Asia has consolidated its position as the leading destination for global foreign direct investment inflows. According to the United Nations Conference on Trade and Development, FDI inflows into the region reached approximately US\$621 billion in 2023, and

the region attracted about 70% of the capital flowing into developing economies, remaining the world's largest FDI recipient even as global capital flows declined (Mai, 2025; Giroud & Ivarsson, 2020). In addition to being an engine of growth and a magnet for capital, the region is also an epicenter of the climate crisis: the developing Asian economies now contribute about half of global CO₂ emissions, largely because this contribution has increased from about two-fifths in 2015 to approximately one-quarter in 2000 (Tutar & Bilan, 2025; Din et al., 2024). The fact that the intensity of the flow of foreign capital is coinciding with that of the intensity of the flow of emissions leaves with a very important question with respect to the environmental dimension of the development process of the foreign capital in Asia.

The question is even more pressing today due to a fundamental policy dilemma of the region's economies. On the other hand, many countries offer incentives to companies to keep their investment levels competitive and, in some instances, agree to lower environmental regulations, which is a good environment for the "pollution haven" hypothesis, in which high-emission industries move to laxly regulated countries (Cai et al., 2016; Sarkodie & Strezov, 2019). Concurrently, the same countries have set targets for themselves to become carbon neutral and made nationally determined contributions under the Paris Agreement. Institutional quality is a critical moderating factor that can either be a fast track to or a stumbling block for foreign capital inflows to and investments in domestic emission efficiency; the regulatory capacity can either boost or constrain foreign capital inflows.

Additionally, a cross-border carbon mechanism has emerged in this context, reshaping the context further. In October 2023, the European Union's Carbon Border Adjustment Mechanism (CBAM) started its transitional period and will generate financial obligations from January 2026, and the financial disclosure standard IFRS S2 has entered into force in January 2024 (Bellora & Fontagné, 2023; Legaspi, 2026). These mechanisms transform the emissions per output as an

environmental issue to a direct link between trade competitiveness and market access. Under this view, the national level-understood as the efficiency of carbon emission accounting in creating economic value of a dollar-emerges as a macroeconomic variable of strategic importance.

The existing literature on the FDI–environment relationship has received a lot of scholarly attention, but there are three gaps. First, there is no consensus among the empirical evidence: some suggest that the pollution haven hypothesis still holds true, some reveal a clean technology "halo" effect, and some others reveal there is a nonlinear relationship (Shahbaz et al., 2018; Zhu et al., 2016). This dispersion suggests that the binary approach-asking whether FDI raises or lowers emissions-may itself be the source of the lack of consensus, and that what is overlooked is the institutional condition that determines the direction of the effect. Second, most studies measure environmental outcomes using total emissions or per-capita emissions, which reflect economic scale rather than efficiency; very few use emission intensity per unit of purchasing-power-adjusted GDP, a measure that directly reflects the efficiency of converting carbon into output and aligns with an emissions-accounting perspective (Pham, 2026). Third, the moderating role of regulatory quality-a distinct component of the Worldwide Governance Indicators, different from the composite institutional indices commonly used-has not been systematically tested for a sample of emerging Asian economies in the post-Paris Agreement period (Xaisongkham & Liu, 2024).

This study addresses the gaps identified above and establishes its contribution through three core departures. First, rather than asking whether FDI raises or lowers emissions, this study reframes the question conditionally-under what institutional conditions does FDI become a driver of emission efficiency?-thereby elevating regulatory quality from a peripheral control variable to a central moderating mechanism. Second, the study approaches environmental outcomes from the perspective of carbon emission accounting efficiency, measured as emission intensity per unit of purchasing-power-adjusted output rather than aggregate emissions, thereby linking the analysis directly to the emissions-disclosure standards now reshaping the region's competitiveness. Third, drawing on panel data for 25 developing and emerging Asian economies over the 2014–2023 period and an identification strategy that thoroughly addresses endogeneity through a two-step System GMM estimator with a collapsed instrument set, the study moves beyond affirming that institutions matter to precisely quantifying the boundary condition of that role. This leads to the pivotal question the study sets out to answer: does a specific critical point of regulatory quality exist-a threshold beyond which the very same foreign capital ceases to worsen and begins to improve the host country's emission efficiency-and if so, where do Asian economies currently stand relative to it?

To answer this, the study poses three questions: (RQ1) how does FDI affect carbon emission intensity in developing and emerging Asian economies; (RQ2) does regulatory quality moderate this relationship, and in which direction; and (RQ3) does a threshold of regulatory quality exist at which the effect of FDI shifts from adverse to beneficial for emission efficiency?

The study aims to provide new empirical evidence, which will help clarify the complex relationship between regulatory quality and FDI's environmental impact in the context of developing and emerging Asian economies that simultaneously fight for capital and are committed to decarbonization. The outcomes are not only academically relevant but also have implications for policymakers and regulators in the region in the improvement of institutional capacity and screening foreign capital to improve national emission efficiency.

The rest of the paper is organized as follows: The theoretical model and formulation of the hypothesis are presented in Section II. The data, measurement, and estimation of variables are described in Section III. The empirical results and the robustness checks are provided in Section IV. The results of the research are discussed in section V. Finally, Section VI brings the paper to a close and offers policy implications by stakeholder groups.

II. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1. Theoretical Framework

Theoretically, FDI-environment linkages can be explained by two opposing arguments: one from the environmental-economics perspective of international trade, and the other from the environmental perspective of international trade. Theoretically, there are two arguments that have emerged-and diverged-on the linkage between FDI and the environment: on the linkage between FDI and the environment, one from the environmental-economics perspective of international trade and the other from the environmental perspective of international trade.

The pollution haven hypothesis is based on the North–South trade model and states that the variation of the stringency of environmental regulation between countries creates a type of comparative advantage (Cantore & Cheng, 2018). High-emission industries are likely to shift to lower environmental standards in countries that are called "havens." Developed economies face the potential of "havens" for high-emission industries as costs of environmental compliance increase. Based on this argument, an increase in the FDI inflows to the developing economies will increase the emission intensity of the receiving economies. Evidence in support of this hypothesis is available in a variety of contexts, such as high-emission developing countries (Sarkodie & Strezov, 2019; Shahbaz et al., 2018).

The pollution halo hypothesis is the opposite of the argument presented above, which posits that foreign direct investment is a vehicle for the transfer of knowledge spillovers, the pollution abatement standards of multinational companies, and advanced environmental governance to domestic companies. FDI can contribute to an increase in energy efficiency and to the lowering of the emission intensity in the recipient country via these channels. The evidence for this effect is mixed: taking a closer look at ASEAN-5, in high-emission countries, FDI can lead to a reduction in carbon emissions, meaning that the impact of FDI might not be the same in all countries but depends on the characteristics of the recipient country (Zhu et al., 2016).

However, the empirical evidence is contradictory, and both hypotheses could be true and affect each other differently, depending on institutional conditions. The three-part decomposition framework for the environmental impact of economic openness is a scale effect (increased production increases emissions), a composition effect (changing production structure affects emissions), and a technique effect (expanded production does not increase emissions) (Nemati et al., 2019). The question is what the dominant one is, and that is what institutional theory is all about. Institutional theory also suggests that the formal rules and enforcement power of the state affect economic agents' incentives and environmental behaviors, and in the regional context, the regulatory quality of a country has a key moderating effect, either amplifying or attenuating the impact of economic activity on sustainability outcomes: if a country has a low regulatory quality, foreign firms are forced to trigger the technique effect; if a country has a high regulatory quality, foreign firms can exploit the scale effect in an uncontrolled way (Handoyo & Anas, 2024). When regulatory capacity is weak, low compliance costs allow the scale and composition effects to dominate, pushing the FDI–emissions relationship toward the pollution haven outcome; when regulatory capacity is sufficiently strong, strict enforcement forces capital to be accompanied by clean technology, activating the technique effect and steering this relationship toward the pollution halo outcome. Recent empirical studies reinforce this argument by showing that institutional quality significantly moderates the relationship between FDI and emissions and that the emission-reducing effect of institutions may be nonlinear, contingent on crossing certain thresholds (Acheampong et al., 2021; Khan et al., 2022).

2.2. Hypothesis Development

2.2.1. FDI and Carbon Emission Intensity

The pollution haven hypothesis provides the theoretical foundation for the relationship between FDI and carbon emission intensity. By this argument, differences in the stringency of environmental regulation across countries generate a form of comparative advantage for countries with lower standards (Cantore & Cheng, 2018).

To minimize environmental compliance costs, multinational corporations tend to relocate high-emission production to

developing economies. This capital typically concentrates in energy-intensive manufacturing and extractive industries. As a result, the scale and composition effects dominate the technique effect, raising the amount of carbon emitted per unit of output in the recipient country.

Some studies confirm the emission-increasing effect of FDI, supporting the pollution haven hypothesis (Sarkodie & Strezov, 2019; Shahbaz et al., 2018). Conversely, other studies find that FDI improves environmental quality through the transfer of clean technology (Zhu et al., 2016). Notably, several studies find evidence for both effects simultaneously within the same sample of Asian countries (Abbasi et al., 2023). This inconsistency stems from three methodological differences. First, the dependent variable is measured differently, across total emissions, per-capita emissions, and emission intensity. Second, the sectoral structure of FDI differs across countries. Additionally, the samples will vary in terms of their developmental and institutional levels.

Within the developing and emerging Asian economies—which are one of the main destinations of the relocation wave of global supply chains and where FDI is mainly focused on high-emission industries. Concurrently, the drive for capital to attract and the lack of capacity to implement environmental laws give rise to the scale effect. Meanwhile, competition for investment and the lack of capacity to regulate the environment give rise to the scale effect (Khan et al., 2022). Based on the above arguments, it is suggested that the study should be conducted in this manner:

H1: FDI has a positive effect on carbon emission intensity, that is, it reduces carbon emission accounting efficiency, in developing and emerging Asian economies.

2.2.2. Regulatory Quality and Carbon Emission Intensity

The regulatory quality–carbon emission intensity relationship is based on institutional theory. According to this argument, the state's ability to establish and implement formal rules influences the economic agents' environmental actions (Handoyo & Anas, 2024). High regulatory quality means environmental standards are enforced rigorously, putting a cost on firms' emissions. Moreover, a predictable and clear environmental regulatory framework allows investment in clean technology and environmental innovation. Furthermore, effective managerial capacity promotes a shift in economic structure toward lower emissions. As a result, carbon emission intensity is expected to decline as regulatory quality improves.

Empirical evidence on this relationship shows that one group of studies confirms that institutional and regulatory quality reduces carbon emissions in developing economies, including Asian subregions (Acheampong et al., 2021; Jahanger et al., 2023). Conversely, some studies find an unexpected positive effect, in which high regulatory quality is accompanied by rising emissions (Khan et al., 2022). This incongruity is due to three differences. There is a first level to this: the difference between legislation and enforcement.

Second, an indirect effect through a scale effect due to good institutions attracting further economic activity and investment, thus increasing emissions. Third, the time delay after institutional reform until environmental impacts occur, with the emission-reducing effect only occurring after several years.

The emission-reducing effect of regulatory quality has the potential to become a reality, though not evenly, in developing and emerging Asian economies. In response to international climate agreements and carbon market mechanisms across borders, environmental regulations are being tightened in many countries in the region. Regulation can be used to limit emissions and encourage technological change if enforcement capacity is adequate. Based on these arguments, the study suggests the following:

H2: Regulatory quality has a negative effect on carbon emission intensity in developing and emerging Asian economies.

2.2.3. *The Moderating Role of Regulatory Quality*

The two hypotheses outlined above imply that the relationship between FDI and emission intensity will not be constant but rather will vary among countries depending on their regulatory quality. Based on institutional theory and the scale–composition–technique decomposition framework, the research finds that the relationship between FDI and environment is a boundary condition determined by institutions (Handoyo & Anas, 2024).

When regulatory quality is low, environmental compliance costs are negligible, allowing foreign firms to exploit the scale and composition effects; FDI then raises emission intensity according to the pollution haven logic. Conversely, when regulatory quality is sufficiently high, strict enforcement compels capital to be accompanied by clean technology and compliance with emission standards, activating the technique effect; FDI then shifts toward improving emission efficiency according to the pollution halo logic. As a result, regulatory quality weakens, and at a certain critical point may reverse, the positive effect of FDI on emission intensity.

Several studies confirm that institutional quality significantly moderates the FDI–emissions relationship (Khan et al., 2022). More importantly, some studies have demonstrated the existence of a threshold beyond which the effect of FDI reverses. For instance, that when a conditioning factor of the recipient country exceeds a certain level, the effect of FDI shifts from a pollution haven effect to a pollution halo effect in developing countries (Khan et al., 2023). Similarly, a panel threshold model and find that institutional conditions govern the direction of the environmental effect in Asian subregions (Jahanger et al., 2023). However, these studies use different conditioning variables and have not directly tested the threshold role of regulatory quality.

In the context of developing and emerging Asian economies, this moderating mechanism is especially meaningful. The region exhibits deep institutional stratification, with regulatory quality ranging from low to relatively high across countries. This dispersion creates conditions for a critical point of regulatory quality to lie within the sample's observed range, dividing countries into a group in which FDI reduces emission efficiency and a group in which FDI improves it. Pressure from cross-border carbon mechanisms further drives countries to strengthen regulatory capacity, making this reversal effect all the more pressing. Based on these arguments, the study proposes:

H3: Regulatory quality moderates the effect of FDI on carbon emission intensity in the opposite direction; specifically, at a sufficiently high level of regulatory quality that exceeds a critical point, the net effect of FDI shifts from increasing to decreasing emission intensity, that is, from reducing to improving carbon emission accounting efficiency.

III. RESEARCH METHODOLOGY

3.1. *Research Design*

The study uses a quantitative explanatory research design to explore the relationship between foreign direct investment (FDI) and carbon emission accounting efficiency and also the moderating role of regulatory quality in the developing and emerging economies in Asia. The conceptual framework is rooted in the pollution haven hypothesis, the pollution halo hypothesis, and institutional theory that all together suggest that the environmental effect of FDI relates to the quality of the regulatory institutions in a country. The study analyzes the direct impacts of FDI and regulatory quality on the carbon emission intensity using a balanced panel data set of 25 countries for the period 2014–2023 and examines any moderating role that regulatory quality plays on the relationship between FDI and carbon emission intensity. To enhance model specification, the following variables are also included as control variables: renewable consumption, industrial structure, trade openness, and growth (Pham, 2026). To deal with the unobserved heterogeneity, cross-sectional dependence, and endogeneity, the empirical analysis uses fixed-effects estimation with Driscoll–Kraay standard errors and a two-step system GMM estimator and is then subjected to robustness and threshold analyses to ensure consistency and reliability of the results (Driscoll & Kraay, 1998; Sarkodie & Strezov, 2019).

Fig. 1 shows the conceptual framework of the study proposed. Foreign direct investment (FDI) is expected to directly impact carbon emission accounting efficiency (H1) as well, and regulatory quality is expected to have a direct impact on emission intensity (H2). More importantly, the effect of FDI on carbon emission accounting efficiency (H3) is moderated by the regulation quality, meaning that the effect of FDI on the carbon emission accounting efficiency is positive or negative. Macroeconomic and structural variations across countries are controlled for by including

renewable energy consumption, industrial structure, trade openness, and economic growth.

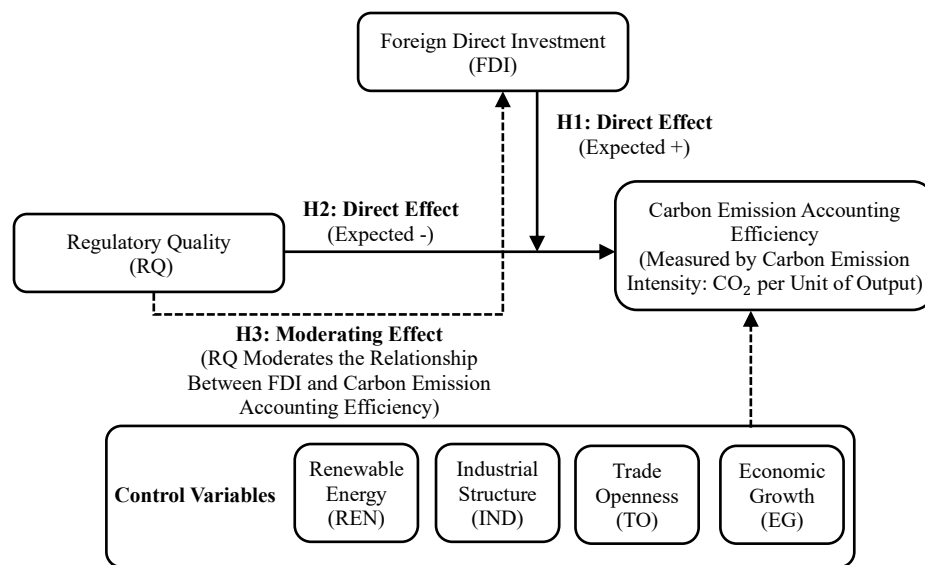


Fig. 1 Proposed Conceptual Framework

3.2. Sample and Data

The study utilises the panel data of all developing and emerging Asian countries (IWF classification) during 2014–2023. This 10-year choice is based on three reasons. Firstly, the timeframe is before and after the 2015 Paris Agreement, in order to capture the climate policy environment that changed the climate emission incentives in the region. Second, this was a time of robust FDI relocation to Asia in the wake of the wave of supply-chain restructuring of the world economy, making the FDI–emissions link relevant. Third, data on carbon emission intensity in the WDI platform are currently updated to 2023, ensuring the completeness and timeliness of the dependent variable.

The initial sample comprised 30 developing and emerging Asian economies included in the IMF classification. To guarantee the reproducibility and transparency of the sampling strategy, inclusion and exclusion criteria were defined prior to the collection of data. Countries were only considered if they had complete annual observations for both the dependent and principal explanatory variables, along with the moderating and the control variables, for at least 80% of the study period (2014–2023). Countries were dropped from the panel if they failed to provide more than 20% of the observations for any core variable; had more than 3 years of missing regulatory quality information; or lacked information on the carbon emission intensity for any year. To form a reliable panel, countries were dropped if they had any core variable with more than 20% missing observations, discontinuous regulatory quality records, or unavailable carbon emission intensity data, or if the records were missing for more than 3 years. Excluded: (i) countries lacking continuous data on the dependent variable or the main explanatory variables over the study period, mainly small economies and countries in conflict such as Afghanistan,

Turkmenistan, Bhutan, Maldives, and some island states; and (ii) countries with severely interrupted regulatory quality data. Applying these objective screening criteria resulted in the exclusion of five countries from the initial IMF-based sample. The final sample comprises 25 countries–Vietnam, Thailand, Indonesia, Malaysia, the Philippines, Cambodia, Laos, Myanmar, Brunei, China, India, Bangladesh, Pakistan, Sri Lanka, Nepal, Mongolia, Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, Armenia, Azerbaijan, Georgia, Jordan, and Egypt–corresponding to a balanced panel of 250 country-year observations, thereby ensuring complete data availability for all variables throughout the study period and facilitating consistent panel estimation.

The data were collected from publicly available and internationally reputable sources. The economic and environmental variables were obtained from the World Bank's WDI (<https://databank.worldbank.org>). The regulatory quality variable was obtained from the World Bank's WGI (<https://info.worldbank.org/governance/wgi>). Alternative measures used for robustness checks were additionally obtained from the database of the United Nations Conference on Trade and Development (<https://unctadstat.unctad.org>) and Climate Watch of the World Resources Institute (<https://www.climatewatchdata.org>). To mitigate the influence of extreme values, all continuous variables were winsorized at the 1st and 99th percentiles.

3.3. Variable Definitions and Measurement

3.3.1. Dependent Variable

The dependent variable is carbon emission accounting efficiency, approached inversely through carbon emission intensity, denoted CEI. The primary measure is CO₂ emissions in kilograms per PPP dollar of GDP at constant

2021 prices, obtained from WDI. In the regression model, the variable is expressed in natural logarithm and denoted $\ln CEI$. A lower value of CEI reflects higher carbon emission accounting efficiency, as the country generates the same unit of output with lower carbon emissions.

The choice of emission intensity per PPP-adjusted GDP rather than total emissions or per-capita emissions is because the emission-intensity measure has been widely used in studies of environmental efficiency to separate the efficiency of carbon conversion from pure economic scale (Khan et al., 2022). Conceptually, emission intensity directly reflects emission accounting efficiency at the national level, which is more aligned with the study's focus than total emissions, which are governed by population and economic size. In terms of contextual specificity, developing Asian economies differ greatly in economic size, from China and India to Laos and Brunei; normalizing emissions by PPP-adjusted GDP removes distortions arising from size differences, allowing emission efficiency to be compared across countries on a compatible basis.

3.3.2. Independent Variable

Foreign direct investment (FDI) is the independent variable and is represented by net FDI inflows per GDP (in percentages) from WDI. This measure is directly borrowed from the most prominent empirical research on the FDI–emissions relationship (Sarkodie & Strezov, 2019; Zhu et al., 2016). Using the GDP for normalisation is fitted to the regional context because the economic size of the different

countries is widely different; using the GDP is a relative measure, and it reflects the penetration of foreign capital in the recipient economy rather than the absolute amount of foreign capital, which is a better indicator of the intensity of multinational presence in relation to domestic productive capacity.

3.3.3. Moderating Variable

Regulatory capacity is represented by the regulatory quality estimate from the WGI, which ranges between -2.5 and $+2.5$ and acts as the moderating variable. Two arguments support the use of the regulatory quality component and not a composite institutional index: Two arguments support this choice of using the regulatory quality component and not a composite institutional index: This component has been used as an institutional moderating variable in the Asian regional context in terms of precedent (Handoyo & Anas, 2024). Conceptually, regulatory quality most closely represents the institutional dimension of governance, which is the most strongly linked to the moderating mechanism tested in this study, namely, the state's ability to develop and implement policies that govern the private sector, such as environmental standards imposed on foreign-invested firms. FDI and RQ are mean-centred before calculating the interaction to avoid multicollinearity and to aid interpretation of the first-order terms.

Table I summarizes the definitions, measurements, data sources, and expected signs of all variables.

TABLE I DEFINITIONS, MEASUREMENTS, DATA SOURCES, AND EXPECTED SIGNS OF VARIABLES

Variable type	Symbol	Variable name	Measurement	Source	Expected sign
Dependent	$\ln CEI$	Carbon emission intensity	Natural logarithm of CO ₂ emissions (kg) per PPP dollar of GDP at constant 2021 prices	WDI	
Dependent (alternative)	CEI_2	Total greenhouse gas intensity	Total GHG emissions (kt CO ₂ equivalent) divided by GDP at constant PPP prices	Climate Watch	
Dependent (alternative)	CO_2PC	Per capita emissions	CO ₂ emissions per capita (tonnes/person)	WDI	
Independent	FDI	Foreign direct investment	Net FDI inflows as a share of GDP (%)	WDI	+
Independent (alternative)	FDIS	FDI stock	Inward FDI stock as a share of GDP (%)	UNCTAD	+
Moderator	RQ	Regulatory quality	Regulatory Quality estimate (scale from -2.5 to $+2.5$)	WGI	–
Control	REN	Renewable energy	Share of renewable energy in total final energy consumption (%)	WDI	–
	IND	Industrial structure	Industry value added, including construction, as a share of GDP (%)	WDI	+
	TO	Trade openness	Sum of exports and imports of goods and services divided by GDP (%)	WDI	±
	EG	Economic growth	Annual real GDP growth rate (%)	WDI	+

Source: Compiled by the authors

3.4. Research Models

To test the hypotheses, the study constructs three models. The baseline model tests the direct effects of FDI and regulatory quality (H1 and H2) equation (1):

$$\ln CEI_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 RQ_{it} + \beta_3 REN_{it} + \beta_4 IND_{it} + \beta_5 TO_{it} + \beta_6 EG_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

The moderation model adds an interaction term to test H3 using equation (2):

$$\ln CEI_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 RQ_{it} + \beta_3 (FDI_{it} \times RQ_{it}) + \beta_4 REN_{it} + \beta_5 IND_{it} + \beta_6 TO_{it} + \beta_7 EG_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Because carbon emission intensity is highly persistent over time and endogeneity is a concern, the study estimates a dynamic model in the System GMM form by equation (3):

$$\ln CEI_{it} = \alpha_0 + \alpha_1 \ln CEI_{it-1} + \alpha_2 FDI_{it} + \alpha_3 RQ_{it} + \alpha_4 (FDI_{it} \times RQ_{it}) + \alpha_5 REN_{it} + \alpha_6 IND_{it} + \alpha_7 TO_{it} + \alpha_8 EG_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

In the moderation model, the marginal effect of *FDI* on emission intensity is not fixed but varies with the level of regulatory quality:

$$\partial \ln CEI_{it} / \partial FDI_{it} = \alpha_2 + \alpha_4 RQ_{it} \quad (4)$$

From equation (4), the level of regulatory quality at which the effect of *FDI* reverses is identified as $RQ^* = -\alpha_2 / \alpha_4$. Study compares this RQ^* value with the actual distribution of *RQ* in the sample to assess its practical significance, specifically identifying countries above and below the threshold. In all equations, $i = 1, \dots, 25$ indexes countries; $t = 2014, \dots, 2023$ indexes years; μ_i is the unobserved country-specific fixed effect; λ_t is the time fixed effect; and ε_{it} is the random error term.

3.5. Estimation and Testing Strategy

The estimation strategy is designed sequentially to ensure the reliability of the results. First, present descriptive statistics, the correlation matrix, and variance inflation factor (VIF) checks to screen for multicollinearity. Next, given the macro-level cross-country panel nature of the data, cross-sectional dependence (CD) test and a second-generation stationarity test (CIPS) that accounts for cross-sectional dependence (Pesaran, 2021).

A potential concern in country-level panel analysis is the presence of spatial cross-sectional dependence. This phenomenon arises when macroeconomic shocks or idiosyncratic events—such as market turbulence from financial crises, or the COVID-19 pandemic within the study period—affect all countries in the sample simultaneously. If

uncontrolled, this autocorrelation and cross-sectional dependence can bias standard-error estimates, leading to erroneous conclusions about statistical significance. In the static estimation step, successively use pooled OLS (POLS), random effects (RE), and fixed effects (FE), with the Hausman test to choose between RE and FE. To thoroughly address potential heteroskedasticity, autocorrelation, and cross-sectional dependence, re-estimate the model using Driscoll–Kraay standard errors (Driscoll & Kraay, 1998). This method produces standard errors that are robust not only to the presence of heteroskedasticity and autocorrelation but also to very general forms of cross-sectional dependence.

In the dynamic estimation step, apply two-step System GMM with the Windmeijer correction to the standard errors. The choice of this method arises from three reasons: the presence of a lagged dependent variable, the persistence of emission intensity, and the risk of endogeneity. Specifically, *FDI* and *RQ* are treated as potentially endogenous variables due to bidirectional causality: countries with high emission efficiency may attract higher-quality *FDI*, and regulatory quality may respond endogenously to environmental pressure. To control for endogeneity, use the second and deeper lags of the endogenous variables as instruments. With a sample of $N = 25$ and $T = 10$, collapse the instrument set and limit the number of lags to ensure the number of instruments is smaller than the number of countries, avoiding instrument proliferation that would weaken the Hansen test. In every GMM model, report the number of instruments, the first- and second-order autocorrelation tests AR(1) and AR(2), and the Hansen J test of instrument validity.

To ensure the robustness of the results, the study performs a series of additional tests. First, to address whether the variables included in the model truly measure the intended research concepts, successively replace the dependent variable with total greenhouse gas intensity (*CEI₂*) and per-capita emissions (*CO2PC*), and replace the independent variable with *FDI* stock (*FDIS*). Second, to examine whether differences exist across country groups, conduct separate analyses for the group with high regulatory quality and the group with low regulatory quality, to test whether the moderating role of regulatory quality differs between the two groups. Third, to test whether this is a nonlinear relationship, add a panel threshold model in which regulatory quality serves as the threshold variable, in order to independently verify the existence of the break point implied in equation (4). All regression models are estimated using Stata version 17.0.

IV. RESULTS

4.1. Descriptive Statistics and Correlation Matrix

Table II presents the descriptive statistics of all variables used in the model over the balanced sample of 250 country–year observations.

TABLE II DESCRIPTIVE STATISTICS OF VARIABLES

Variable	Observations	Mean	Std. dev.	Minimum	Maximum
lnCEI	250	-1.284	0.612	-2.973	0.147
FDI (% of GDP)	250	4.187	5.093	-3.216	27.645
RQ	250	-0.418	0.581	-1.634	0.912
REN (%)	250	28.63	19.47	2.184	74.82
IND (% of GDP)	250	33.71	8.926	16.58	58.34
TO (% of GDP)	250	82.46	39.15	22.13	187.6
EG (%)	250	4.912	3.874	-11.32	14.53

Source: Authors' calculations based on WDI and WGI data (World Bank). All continuous variables are winsorized at the 1st and 99th percentiles. lnCEI is the natural logarithm of CO₂ emission intensity (kg per PPP dollar of GDP at constant 2021 prices).

The results reveal considerable dispersion across countries, reflecting the region's heterogeneity. The moderating variable RQ ranges from -1.634 to 0.912, spanning both the weak-regulatory-capacity group and the relatively strong group—a prerequisite for a threshold RQ* to lie within the sample. The magnitude of FDI ranges from negative values (net divestment) to more than 27% of GDP, and the level of lnCEI is significantly different across coal-based economies and service economies, like the cases of Mongolia and Sweden, respectively. The large range of standard deviations for both REN and TO again confirms the diversity of structure in the sample.

As for the correlation matrix, the pairwise correlation between FDI and lnCEI is positive and moderate (around 0.21), which is largely in line with H1, and the correlation between RQ and lnCEI is negative (around -0.34), which is consistent with H2. The highest correlation between any pair of explanatory variables is 0.65, suggesting that there is no serious multicollinearity. This is confirmed by the variance inflation factor check: the mean VIF is 1.79 and the maximum VIF is 2.64, well below the warning level, and the mean centring of FDI and RQ before forming the interaction term has been done.

4.2. Panel Data Diagnostic Tests

Before estimation, conduct a series of diagnostic tests to determine the appropriate estimation methods. Pesaran's cross-sectional dependence test yields a statistic of CD = 14.87 ($p < 0.01$), strongly rejecting the null hypothesis of independence across countries; this reflects the fact that Asian economies are simultaneously affected by common shocks such as global energy-price fluctuations and the COVID-19 pandemic, and justifies the use of Driscoll–Kraay standard errors in the static estimation step (Driscoll & Kraay, 1998). The second-generation CIPS stationarity test, which accounts for cross-sectional dependence, confirms that the variables are stationary in levels or first differences, with no variable integrated of order two—a necessary condition for the validity of the System GMM estimator. The CIPS results are presented in table III.

TABLE III SECOND-GENERATION PANEL UNIT ROOT TEST (CIPS)

Variable	CIPS (level)	CIPS (first difference)	Order of integration
lnCEI	-1.973	-4.128***	I(1)
FDI	-2.641**	-	I(0)
RQ	-1.884	-3.967***	I(1)
REN	-1.752	-4.315***	I(1)
IND	-2.208	-3.746***	I(1)
TO	-2.559**	-	I(0)
EG	-3.174***	-	I(0)

Notes: The table reports Pesaran's (2007) cross-sectionally augmented IPS (CIPS) statistics with one lag and a constant. *** and ** denote rejection of the unit root null at the 1% and 5% levels, respectively. Critical values are -2.57 (1%), -2.33 (5%).

Source: Authors' calculations based on WDI and WGI data (World Bank).

The Hausman model-selection test yields a statistic of $\chi^2 = 31.46$ ($p < 0.01$), rejecting the null hypothesis and confirming that the fixed-effects model is more appropriate than random effects. Taken together, these diagnostic results justify the study's two-step estimation approach: the fixed-effects model with Driscoll–Kraay standard errors serves as the baseline static estimator to address heteroskedasticity, autocorrelation, and cross-sectional dependence, while two-step System GMM serves as the main estimator to simultaneously address endogeneity and the persistence of emission intensity (Driscoll & Kraay, 1998).

4.3. Baseline Estimation Results: Direct Effects of FDI and RQ

Table IV presents the static estimation results for the baseline model (1) and the moderation model (2), using pooled OLS (POLS), fixed effects (FE), and fixed effects with Driscoll–Kraay standard errors, respectively (Driscoll & Kraay, 1998).

TABLE IV BASELINE STATIC ESTIMATION RESULTS - DEPENDENT VARIABLE: LNCEI

	(1) POLS	(2) FE	(3) FE-DK	(4) FE-DK (interaction)
FDI	0.0179*** (0.0051)	0.0113** (0.0049)	0.0113** (0.0044)	0.0126** (0.0052)
RQ	-0.4126*** (0.0783)	-0.2358** (0.1041)	-0.2358*** (0.0725)	-0.2094** (0.0817)
FDI × RQ				-0.0158** (0.0069)
REN	-0.0121*** (0.0022)	-0.0087** (0.0038)	-0.0087*** (0.0026)	-0.0083*** (0.0025)
IND	0.0094*** (0.0027)	0.0067* (0.0039)	0.0067** (0.0031)	0.0071** (0.0030)
TO	-0.0009 (0.0011)	0.0014 (0.0017)	0.0014 (0.0013)	0.0011 (0.0013)
EG	0.0086** (0.0038)	0.0052* (0.0031)	0.0052** (0.0024)	0.0049** (0.0023)
Constant	-1.017*** (0.148)	-1.284*** (0.176)	-1.284*** (0.132)	-1.271*** (0.129)
Country FE	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Observations	250	250	250	250
R ² (within)	0.318	0.472	0.472	0.489

Notes: Standard errors in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Columns (3) and (4) report Driscoll–Kraay (DK) standard errors robust to heteroskedasticity, autocorrelation, and cross-sectional dependence (Driscoll & Kraay, 1998). The Hausman test ($\chi^2 = 31.46$, $p < 0.01$) favors fixed effects over random effects; the Pesaran CD test ($CD = 14.87$, $p < 0.01$) confirms cross-sectional dependence, justifying the use of DK standard errors. FDI and RQ are mean-centered before constructing the interaction term.

Source: Authors' calculations based on WDI and WGI data (World Bank).

The results consistently support H1 and H2. The coefficient on FDI is positive and statistically significant at least at the 5% level across all models ($\beta_1 = 0.0113$ in the FE-DK column), confirming that FDI raises emission intensity and supporting the pollution haven hypothesis; specifically, an additional one percentage point of GDP in FDI inflows is associated with roughly 1.1% higher emission intensity. The coefficient on RQ is negative and significant at the 1% level ($\beta_2 = -0.2358$ in the FE-DK column), confirming that regulatory quality improves emission efficiency. Among the control variables, REN lowers emission intensity while IND and EG raise it, all consistent with expectations and the literature; TO is not statistically significant, reflecting the

offsetting between the technique and scale effects in regional trade. Notably, the FDI × RQ interaction term in column (4) already carries a significant negative sign, providing preliminary evidence of the moderating role examined more deeply with System GMM in the next section.

4.4. Dynamic Model Results and the Moderating Effect

Table V presents the two-step System GMM estimation results for the dynamic model without interaction (column 1) and the full moderation model per equation (3) (column 2); these are the study's main estimates.

TABLE V TWO-STEP SYSTEM GMM ESTIMATION RESULTS - DEPENDENT VARIABLE: LNCEI

	(1) Without interaction	(2) With interaction
$\ln\text{CEI}_{t-1}$	0.6412*** (0.0783)	0.6237*** (0.0821)
FDI	0.0104** (0.0046)	0.0091** (0.0043)
RQ	-0.1876** (0.0814)	-0.1729** (0.0776)
FDI × RQ		-0.0212** (0.0094)
REN	-0.0076** (0.0034)	-0.0071** (0.0032)
IND	0.0058* (0.0031)	0.0061** (0.0029)
TO	0.0008 (0.0014)	0.0006 (0.0013)
EG	0.0043* (0.0025)	0.0041* (0.0024)
Constant	-0.4517*** (0.1129)	-0.4382*** (0.1087)
Observations	225	225
Number of countries	25	25
Number of instruments	21	23
AR(1) p-value	0.004	0.005
AR(2) p-value	0.317	0.284
Hansen J p-value	0.286	0.241
Implied threshold RQ*	-	0.429

Notes: Two-step System GMM estimates with Windmeijer (2005) finite-sample corrected standard errors in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels. FDI and RQ are treated as potentially endogenous and instrumented with their second and deeper lags; the instrument set is collapsed to limit proliferation. FDI and RQ are mean-centered before constructing the interaction term. The number of observations falls to 225 due to the one-period lag of the dependent variable. $RQ = -\alpha_2/\alpha_4$.

Source: Authors' calculations based on WDI and WGI data (World Bank).

The results support all three hypotheses. The coefficient on the lagged term $\ln CEI_{t-1}$ is 0.6237, which is significant at the 1% level, indicating strong persistence in emission intensity, which makes the dynamic approach appropriate. The coefficient of FDI still has a positive and significant sign ($\alpha_2 = 0.0091$), and that of RQ still has a negative sign, and it is significant ($\alpha_3 = -0.1729$) as per H1 and H2. The most important result is that the interaction term between FDI and regulatory quality is negative and significant at the 5% level of significance ($\alpha_4 = -0.0212$), which supports H3: regulatory quality reduces the emission-enhancing power of FDI.

It can be seen from equation (4) that the marginal effect of FDI becomes negative with the increase of RQ. At the 10th percentile of RQ (about -1.21), the marginal effect is +0.035; at the median (-0.45) it is +0.019; and at the 90th percentile (0.42) it is close to zero. $RQ^* = -\alpha_2/\alpha_4 = 0.429$ is within the actual range of RQ (from -1.634 to 0.912 per table II), which confirms the scenario D: below RQ^* , FDI leads to an increase in the emission intensity, following the pollution haven logic, and above RQ^* , FDI promotes improvement in emission efficiency, following the pollution halo logic.

The geographical distribution of countries on the threshold is closely related to the institutional stratification in the region. However, most countries in the sample (including China, India, Vietnam, Indonesia, Pakistan, Bangladesh, Laos, and Cambodia) are below the threshold RQ^* , suggesting that at present FDI is an emissions burden on this group of countries. A handful of economies have regulatory capacity that trends high enough Malaysia, Georgia, and Armenia and FDI starts to help to improve the efficiency of emissions.

The validity of the model is confirmed by the diagnostic tests. The AR(1) test is significant ($p = 0.005$), but AR(2) is not significant ($p = 0.284$), which means that there is no second-order autocorrelation. The number of instruments is not too high 23 instruments and there is no instrument proliferation, and the Hansen J test does not reject the validity of instrument set $p = 0.241$.

To illustrate the moderating effect specified in table V, fig. 2 of the paper presents the marginal effect of FDI on the carbon emission intensity of the sample across all the values of the regulatory quality variable in the sample using equation (4).

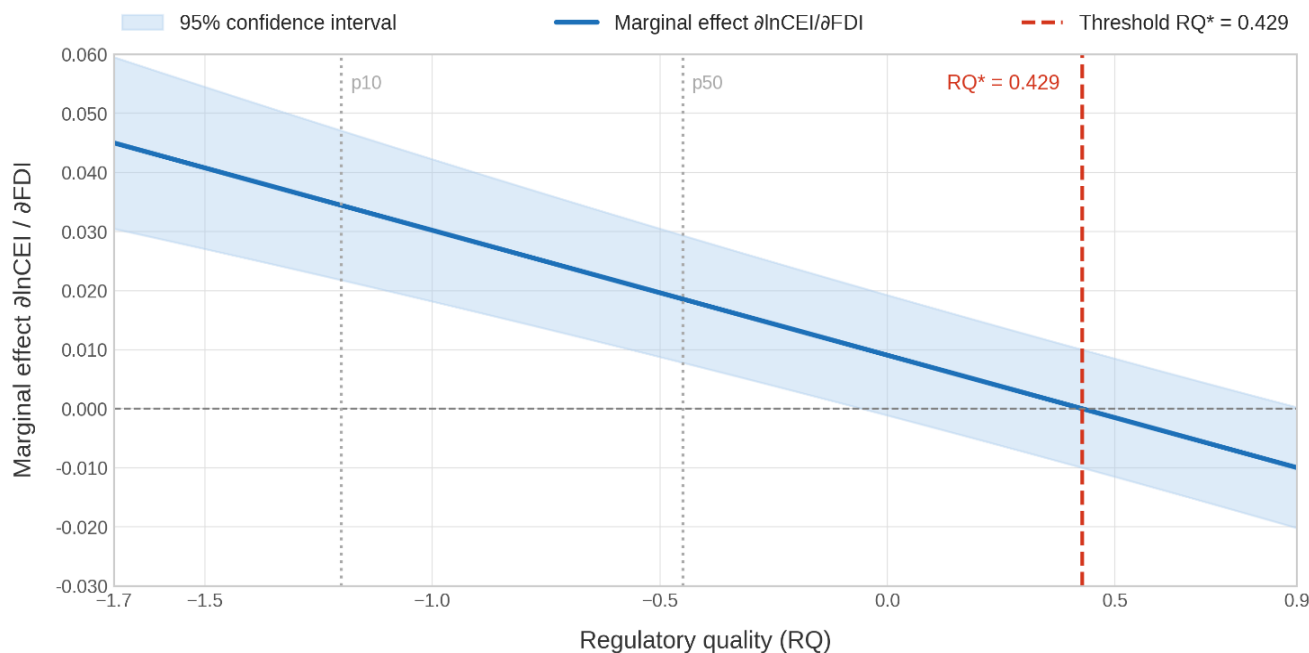


Fig. 2 Marginal Effect of FDI on Carbon Emission Intensity Across Levels of Regulatory Quality

The solid line plots the marginal effect $\partial \ln CEI / \partial FDI = \alpha_2 + \alpha_4 \cdot RQ$; the shaded band shows the 95% confidence interval; the red dashed line marks the threshold $RQ = 0.429$; the gray dashed lines mark the 10th, 50th, and 90th percentiles of RQ^* .

Source: Authors' calculations based on the System GMM results in table V.

The marginal-effect line slopes downward, reflecting the negative sign of the interaction coefficient α_4 : the higher the level of regulatory quality, the more the emission-increasing effect of FDI diminishes. This line crosses the horizontal axis at the threshold $RQ^* = 0.429$, dividing the sample into two regions. To the left of the threshold-where most countries in

the sample are concentrated, spanning all three percentiles p10, p50, and p90-the marginal effect is positive and the 95% confidence interval lies entirely above zero, confirming that FDI raises emission intensity according to the pollution haven logic. Only in the high-regulatory-quality region beyond the threshold does the confidence interval move

below zero, indicating that FDI begins to improve emission efficiency.

4.5. Robustness Checks

To verify the robustness of the main findings, table VI consolidates several robustness checks, with each column

corresponding to a different test, reporting only the core coefficients together with diagnostic statistics and the recomputed threshold value RQ^* .

TABLE VI ROBUSTNESS CHECKS - CORE PARAMETERS ACROSS ALTERNATIVE SPECIFICATIONS

	(1) DV: CEL_2	(2) DV: $CO2PC$	(3) IV: $FDIS$	(4) High-RQ subsample	(5) Low-RQ subsample	(6) Threshold model
FDI (α_2)	0.0115** (0.0051)	0.0682** (0.0308)	-	0.0037 (0.0064)	0.0128** (0.0056)	-
$FDIS$ (α_2)	-	-	0.0058** (0.0026)	-	-	-
RQ (α_3)	-0.2013** (0.0894)	-0.7124** (0.3156)	-0.1655** (0.0742)	-0.1207 (0.1382)	-0.1984** (0.0951)	-0.1783** (0.0805)
$FDI \times RQ$ (α_4)	-0.0247** (0.0108)	-0.1391** (0.0637)	-0.0134* (0.0071)	-	-	-
Implied RQ^*	0.466	0.490	0.433	-	-	0.412
Threshold (bootstrap p)	-	-	-	-	-	0.008
Observations	225	225	214	108	117	250
Countries	25	25	24	12	13	25
Instruments	23	23	22	18	19	-
AR(1) p	0.006	0.009	0.007	0.041	0.008	-
AR(2) p	0.264	0.193	0.312	0.407	0.238	-
Hansen J p	0.219	0.174	0.298	0.361	0.207	-

Notes: Two-step System GMM with Windmeijer (2005) corrected standard errors in parentheses for columns (1)–(5); ***, **, * denote significance at 1%, 5%, 10%. Columns (1)–(2) replace the dependent variable with total GHG emission intensity (CEL_2 , Climate Watch) and per-capita CO_2 emissions ($CO2PC$, WDI) respectively to test measurement validity of the dependent variable. Column (3) replaces net FDI inflows with the inward FDI stock as a share of GDP ($FDIS$, UNCTAD); the observation count falls to 214 because of narrower UNCTAD data coverage for some country-years. Columns (4) and (5) split the sample at the sample median of RQ into high- and low-regulatory-quality subsamples, so observations and country counts are smaller than the full sample. Column (6) reports a panel threshold model with RQ as the threshold variable; it is estimated by a different method, so an estimated threshold value and its bootstrap p-value are reported in place of an interaction coefficient. $RQ = -\alpha_2/\alpha_4$. FDI and RQ are mean-centered before constructing the interaction term. The high- and low- RQ subsamples in columns (4)–(5) are split at the sample median of RQ and therefore capture a relative contrast between groups rather than the absolute reversal threshold RQ .

Source: Authors' calculations based on WDI, WGI (World Bank), UNCTAD, and Climate Watch data.

The results confirm the robustness of the main findings across the various tests. When the dependent variable is replaced with total greenhouse gas intensity (column 1) and per-capita emissions (column 2), and the independent variable with FDI stock (column 3), the coefficient on FDI remains positive, the coefficient on RQ remains negative, and the $FDI \times RQ$ interaction term remains significantly negative; the recomputed threshold RQ^* varies within a narrow range of 0.43–0.49, all lying within the actual distribution of RQ . The subsample analysis convincingly reinforces the moderating mechanism. The sample is split at the median of RQ into a relatively high- and a relatively low-regulatory-quality group. In the high-regulatory-quality group (column 4), the coefficient on FDI declines sharply in magnitude and loses statistical significance, indicating that the emission-increasing effect of FDI is offset as regulatory capacity improves; whereas in the low-regulatory-quality group (column 5), the coefficient on FDI is positive and strongly significant, confirming that the pollution haven

effect dominates. It should be noted that splitting the sample at the median only reflects a relative contrast between the two groups, rather than coinciding with the absolute threshold RQ^* , since most countries in both groups still lie below the reversal threshold. Finally, the panel threshold model (column 6) independently identifies a break point at $RQ = 0.412$ with a significant bootstrap test ($p = 0.008$), reinforcing the existence of the threshold implied in equation (4). All GMM models satisfy the AR(2) and Hansen J tests.

V. DISCUSSION

5.1. Discussion

The study's main result—the impact of FDI on carbon emission intensity is not predetermined but is moderated by the quality of regulations—has a theoretical implication that extends beyond its binary construction, which has been prevalent in the literature. Based on the results, the pollution

haven hypothesis and the pollution halo effect are not two fundamentally different propositions but two sides of the same proposition—split into two parts by the institutional capacity of the recipient country. In this regard, the study does not contradict but builds upon the scale–composition–technique decomposition approach of Antweiler et al. (2001): it offers empirical evidence that the regulatory quality is the factor that makes one of the three effects prevail. The scale and composition effects dominate the relationship in the case of regulatory capacity that is low, whereas the technique effect dominates the relationship in the case of regulatory capacity that is sufficiently strong. This is a concretization of institutional theory, turning the abstract concept of the rules governing the behavior of economic agents into a quantifiable boundary condition.

Relative to prior studies, this results both agree and differ in important respects. The finding of an emission-increasing effect of FDI across most of the sample is consistent with, evidence supporting the pollution haven in developing economies (Sarkodie & Strezov, 2019; Shahbaz et al., 2018). However, the core difference is that those studies conclude a fixed average effect for the whole sample, whereas show that this average effect is merely the manifestation of a conditional pattern—it is positive because most countries in the sample lie below the institutional threshold, not because FDI is inherently polluting. Conversely, this results complement the finding of documented FDI reducing emissions in high-emission ASEAN countries: where they use the emission level as the dimension of differentiation, show that regulatory quality is the underlying institutional mechanism explaining that differentiation (Zhu et al., 2016). This results also resonate with the recent threshold literature, yet differ in that directly test the threshold role of a single governance component—Regulatory Quality—rather than human capital or a composite institutional index, thereby precisely pinpointing the policy lever that can be acted upon (Jahanger et al., 2023; Khan et al., 2023).

This is furthered with the marginal-effect analysis. The marginal effect of FDI on emissions is decreasing with each step of improvement in regulatory quality, as demonstrated by the downward sloping marginal-effect line in fig. 1, instead of occurring as a sudden switch. Specifically, the relationship between an additional one percentage point in GDP in FDI and emission intensity is estimated to be approximately 3.5 percentage points at the 10th percentile of regulatory quality, 1.9 percentage points at the median, and approaches zero at the 90th percentile of regulatory quality. This gradualism is significant in the Asian context because of an important institutional fact: the capacity to formulate, monitor, and enforce regulation is on a continuum rather than an on–off switch. Even if a relatively comprehensive environmental legal system is in place in a country like Vietnam or Indonesia, the technical effect of FDI may not be fully realized if there is a weak capacity for enforcement at the local level and low actual compliance costs. The marginal effect, therefore, reflects the difference between regulation

and enforcement, in addition to the legislated effect, and is a natural product of the transition economies in the region.

The results of the moderation test by country group show that in the high-regulatory-quality group, the effect of FDI loses statistical significance entirely and even changes sign, while in the low-regulatory-quality group this effect is positive and strongly significant. This contrast can be illustrated by two opposing real-world situations in the region. For instance, a foreign-invested steel or textile-dyeing project located in a country where environmental approval is a formality and sanctions are weak: the firm has little incentive to invest in emission-treatment technology, and the capital becomes a source of increased carbon intensity. Conversely, the same project located in a country where emission standards are strictly enforced and tied to export-market access forces the firm to import clean technology and the parent company's environmental governance processes. The below-threshold country group, comprising most of the populous, rapidly industrializing economies in the sample, reflects the reality that competitive pressure to attract capital still outweighs the incentive to tighten environmental regulation.

The nonlinear threshold test adds an independent layer of confirmation for the entire argument. The panel threshold model gives an estimate of the break point endogenously without having to specify the functional form of the interaction a priori and has a bootstrap test that rejects the null of no threshold. The convergence of two independent methods—one based on the interaction term, one on threshold regression—on the same value region makes the finding of a critical point far more credible than relying on a single approach. The threshold, rather than a pure linear relationship, suggests that reform of the regulatory framework, if implemented in a fragmented and uncoordinated manner, may not significantly affect emission efficiency unless the capacity to implement such reform reaches a certain level, which is relevant for the region's policymakers where institutional reform can be slow and easily interrupted.

The above findings can be seen to make substantial contributions on three dimensions. Theoretically, the study reconciles two hypotheses long viewed as antagonistic into a conditional framework, shifting the focus of the debate from the question "is FDI clean or dirty" to the question "under what institutional conditions does FDI become clean." In terms of method and measurement, approaching environmental outcomes through emission intensity per unit of output—a macro-level emissions-accounting perspective—links FDI–environment research to the emissions-disclosure standards now reshaping regional competitiveness, while directly testing a single governance component helps clarify the policy lever. Practically, quantifying a specific regulatory-quality threshold and positioning countries relative to it provides an actionable basis for both recipient-country governments and international organizations supporting institutional capacity

building amid increasingly stringent cross-border carbon mechanisms.

5.2. Research Implications

Based on the study's findings on the regulatory-quality threshold, offer specific recommendations for four stakeholder groups, with the common thread being the differentiation of action according to each country's position relative to the threshold.

The number one priority of the governments receiving the FDI is to move the policy debate from the quantity of FDI attracted to the quality of the institutions taking the FDI. Whereas most countries in the sample are still under the threshold, the biggest challenge will be closing the gap between what is prescribed by the law and what the law enforcement institutions can do to ensure that it is executed. It needs to be done through concrete actions: empower and increase the capacity of local-level environmental inspection agencies where most FDI projects operate; increase fines for emission violations high enough to make them substantive and not nominal; and release project-level emission data to establish social pressure to monitor emissions. Meanwhile, investment incentive policies need to be reconfigured according to conditional lines tying investment incentives to specific investments in low-emission technology and a mechanism to pre-screen projects by carbon intensity needs to be put in place from the licensing stage, instead of by investment at any price.

Second, the study highlights the importance of having a reliable measurement infrastructure, which provides the foundation for effective regulation for environmental regulators and accounting-standard-setting bodies. One of the actions that is practical is to complete the national and the firm-level GHG inventory, measurement, reporting, and verification system with consistent procedures and templates. Slowly introducing international emissions disclosure guidelines into domestic legislation will provide the information basis for the sector's emission efficiency monitoring that is funded by foreign investment. The study's key indicator should be made a standard monitoring metric by regulators for FDI companies in high-emission industries.

Third, the results reveal for the investors from multinationals that the regulatory landscape in recipient countries is tightening up due to the implementation of the carbon-based adjustment mechanisms in trading with export partners. It's not just a voluntary measure to integrate carbon costs and emission targets into investment due diligence—it's a risk-management decision that will need to be taken in the long term. Those companies that invest in developing countries that are looking to meet the threshold should proactively update their fleet to low-emission technology before its regulations come into effect and thus become a competitive advantage in the region as the local regulations converge in time to international standards.

Fourth, in the case of international organizations, the threshold finding offers a clear definition for the allocation of targeted support. The leverage effect of each improvement step of the regulatory capacity in emission efficiency shall be maximized in the group of countries that remain below the threshold, both technically and financially. Support should be targeted at specific aspects of enforcement, such as strengthening training inspection capacity, transferring emission-monitoring systems, and helping to develop sanction frameworks, and not just end at macro-level policy advice. Programs that are designed with the objective of pushing countries beyond the critical point will facilitate a change in the direction of foreign capital investment from emissions burden to the green transition of the region.

5.3. Limitations and Future Research Directions

The research study is successful in meeting the research objectives; however, acknowledge some limitations in the study. The first issue is that the panel data available for 10 years is not adequate to study long-run relationships and cointegration. Second, the measure of regulatory quality is a composite perception-based measure and does not distinguish between regulatory capacity in the environmental sector. Third, the study treats FDI as a whole, but the emission effect could vary significantly according to sector, and fourth, because of the scarcity of publicly available data, the study does not break down FDI by sector, which may have different emission effects. Future research may consider using longer time periods to investigate long-run dynamics; sector-level FDI data to better understand the different channels of transmission; or, using endogenous threshold models and cross-regional comparisons, the generalizability of the institutional-threshold finding to other development contexts.

VI. CONCLUSION

The relationship between foreign direct investment (FDI), accounting efficiency of carbon emissions (AECE), and regulatory quality (RQ) was investigated in 25 developing and emerging economies of Asia from 2014 to 2023. The empirical analysis is based on 250 country-year observations and fixed-effects estimation standard errors and a two-step system GMM estimator to account for cross-sectional dependence, unobserved heterogeneity, and endogeneity. The findings show that the environmental effects of FDI are not necessarily negative. On the other hand, the negative coefficient of carbon emission intensity in the countries where the institutional quality of the economy is low confirms that FDI inflow may increase carbon emission intensity. However, the negative coefficient of carbon emission intensity is statistically significant, suggesting that the regulation of the economy has a positive effect on carbon emission accounting efficiency and that foreign investment can facilitate sustainable development if the economy's institutional quality is high. Robustness checks, alternative model specifications, and threshold analyses in the literature all lead to the same result and thereby increase the reliability of the empirical evidence.

The results indicate that the effects of foreign capital on the environment depend more on the institutional ability of the countries of investment to monitor, regulate, and channel foreign investment into environmentally friendly activities rather than on the amount of foreign investment flows. Along with FDI promotion measures, further efforts should be made to encourage the use of renewable energy and cleaner production technologies, as well as the improvement of environmental governance and the improvement of regulatory quality, which are all becoming more vital to the development of emerging Asian economies facing the challenge of delivering on their climate commitments while maintaining economic growth. Coordinated policies have the potential to allow foreign investment to be a means of economic development and environmental protection.

The study provides robust evidence for the developing and emerging economies of Asia but may not have country-specific secondary data and regional coverage for the period 2014-2023. Future research on these issues should also examine other dimensions of the institutional quality and other factors beyond the regulatory quality, such as the stringency of environmental regulation; other firm- or industry-level data; and other more advanced and sophisticated extensions of the nonlinear and machine learning approaches to further investigate the dynamics between FDI, regulatory quality, and carbon accounting efficiency.

ACKNOWLEDGMENTS

This research is funded by University of Finance – Marketing.

REFERENCES

- [1] Abbasi, M. A., Nosheen, M., & Rahman, H. U. (2023). An approach to the pollution haven and pollution halo hypotheses in Asian countries. *Environmental Science and Pollution Research*, 30(17), 49270-49289. <https://doi.org/10.1007/s11356-023-25548-x>
- [2] Acheampong, A. O., Dzator, J., & Savage, D. A. (2021). Renewable energy, CO2 emissions and economic growth in sub-Saharan Africa: does institutional quality matter?. *Journal of Policy Modeling*, 43(5), 1070-1093. <https://doi.org/10.1016/j.jpolmod.2021.03.011>
- [3] Bellora, C., & Fontagné, L. (2023). EU in search of a Carbon Border Adjustment Mechanism. *Energy Economics*, 123, 106673. <https://doi.org/10.1016/j.eneco.2023.106673>
- [4] Cai, X., Lu, Y., Wu, M., & Yu, L. (2016). Does environmental regulation drive away inbound foreign direct investment? Evidence from a quasi-natural experiment in China. *Journal of development economics*, 123, 73-85. <https://doi.org/10.1016/j.jdeveco.2016.08.003>
- [5] Cantore, N., & Cheng, C. F. C. (2018). International trade of environmental goods in gravity models. *Journal of environmental management*, 223, 1047-1060. <https://doi.org/10.1016/j.jenvman.2018.05.036>
- [6] Din, S., Din, H., Khan, I., & Naheed, S. (2024). Nexus among exchange rate volatility, inflation, and economic growth: a panel data analysis. *Pakistan Journal of Humanities and Social Sciences*, 12(1), 200-206. <https://doi.org/10.52131/pjhss.2024.v12i1.1815>
- [7] Driscoll, J. C., & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of economics and statistics*, 80(4), 549-560. <https://doi.org/10.1162/003465398557825>
- [8] Giroud, A., & Ivarsson, I. (2020). World investment report 2020: international production beyond the pandemic. *Journal of International Business Policy*, 3, 465-468. <https://doi.org/10.1057/s42214-020-00078-2>
- [9] Handoyo, S., & Anas, S. (2024). The effect of environmental, social, and governance (ESG) on firm performance: the moderating role of country regulatory quality and government effectiveness in ASEAN. *Cogent Business & Management*, 11(1), 2371071. <https://doi.org/10.1080/23311975.2024.2371071>
- [10] Jahanger, A., Usman, M., & Ahmad, P. (2023). Investigating the effects of natural resources and institutional quality on CO2 emissions during globalization mode in developing countries. *International Journal of Environmental Science and Technology*, 20(9), 9663-9682. <https://doi.org/10.1007/s13762-022-04638-2>
- [11] Khan, H., Weili, L., & Khan, I. (2022). The role of institutional quality in FDI inflows and carbon emission reduction: evidence from the global developing and belt road initiative countries. *Environmental Science and Pollution Research*, 29(20), 30594-30621. <https://doi.org/10.1007/s11356-021-17958-6>
- [12] Khan, M., Rana, A. T., & Ghardallou, W. (2023). FDI and CO2 emissions in developing countries: the role of human capital. *Natural Hazards*, 117(1), 1125-1155. <https://doi.org/10.1007/s11069-023-05949-4>
- [13] Legaspi, J. L. R. (2026). Climate risk governance and IFRS S2 disclosures in the extractive sector: a baseline analysis. *Cogent Business & Management*, 13(1), 2645729. <https://doi.org/10.1080/23311975.2026.2645729>
- [14] Mai, H. G. (2025). Digital transformation as a catalyst for foreign direct investment: evidence from an emerging economy. *Cogent Economics & Finance*, 13(1), 2586304. <https://doi.org/10.1080/23322039.2025.2586304>
- [15] Nemati, M., Hu, W., & Reed, M. (2019). Are free trade agreements good for the environment? A panel data analysis. *Review of Development Economics*, 23(1), 435-453. <https://doi.org/10.1111/rode.12554>
- [16] Pesaran, M. H. (2021). General diagnostic tests for cross-sectional dependence in panels. *Empirical economics*, 60(1), 13-50. <https://doi.org/10.1007/s00181-020-01875-7>
- [17] Pham, H. H. (2026). The impact of financial statement audit quality and the moderating role of political connections on environmental transparency in listed real estate firms in Vietnam. *Management*, 2025(2), 728-751. <https://doi.org/10.58691/man/216709>
- [18] Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the total environment*, 646, 862-871. <https://doi.org/10.1016/j.scitotenv.2018.07.365>
- [19] Shahbaz, M., Nasir, M. A., & Roubaud, D. (2018). Environmental degradation in France: the effects of FDI, financial development, and energy innovations. *Energy economics*, 74, 843-857. <https://doi.org/10.1016/j.eneco.2018.07.020>
- [20] Tutar, H., & Bilan, Y. (2025). Impact of the Share of Renewable Energy Sources on CO2 Emissions in 2000–2024. *Montenegrin Journal of Economics*, 21(4), 269-283. <https://doi.org/10.14254/1800-5845/2025.21-4.20>
- [21] Xaisongkham, S., & Liu, X. (2024). Institutional quality, employment, FDI and environmental degradation in developing countries: Evidence from the balanced panel GMM estimator. *International Journal of Emerging Markets*, 19(7), 1920-1939. <https://doi.org/10.1108/IJOEM-10-2021-1583>
- [22] Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression. *Economic Modelling*, 58, 237-248. <https://doi.org/10.1016/j.econmod.2016.05.003>