Journal of Information Systems Engineering and Management
2025, 10(28s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

The Role of Corruption Control and Financial Markets in Advancing Green Economy Transitions: An Empirical Analysis of CO2 Emissions in Emerging Economies

Liu SiYuan [1*], Muhamad Zulkiflee Osman [2], Xu YeHui [3], Han YuShan [4], Dai LiBo [5]
[1] PhD Candidate, Graduate School of Business, SEGi University, Petaling Jaya, Malaysia
[2] Senior Lecturer/Researcher, Graduate School of Business, SEGi University, Petaling Jaya, Malaysia
[3, 4, 5] PhD Candidate, Graduate School of Business, SEGi University, Petaling Jaya, Malaysia
Email: [1] sukd2001247@segi4u.my, [2] zulkifleeosman@segi.edu.my, [3] 510190473@qq.com, [4] 16775824@qq.com, [5] 251886068@qq.com

ARTICLE INFO

Received: 18 Dec 2024

Revised: 10 Feb 2025

Accepted: 28 Feb 2025

ABSTRACT

This study evaluates the impact of corruption control and financial markets on CO_2 emissions, including per capita emissions, in emerging economies, contributing to the green transition. Utilizing panel data from 28 emerging economies spanning 2003 to 2020, the research employs a GMM regression model to examine these effects.Findings reveal that financial market consistently correlates with higher CO_2 emissions, suggesting that economic expansion driven by financial growth can exacerbate environmental challenges if sustainability measures are not integrated.The effect of corruption control on emissions is more complex and context-dependent;while stronger anti-corruption measures are linked to increased emissions in some cases, this effect diminishes when considering governance quality factors such as accountability.Robustness checks affirm the stability of these findings, highlighting the intricate interplay between governance, financial markets, and environmental outcomes.This study contributes to the literature by providing new empirical evidence on the dynamic relationships among governance, financial markets, and environmental sustainability in emerging economies, underscoring the importance of targeted governance reforms and sustainable financial practices in mitigating climate change and promoting a green economy transition.

Keywords: Green economy transition, Corruption control, Financial markets, CO_2emissions, Emerging economies.

INTRODUCTION

Since the signing of the Paris Agreement, countries around the world have made significant efforts to address climate change, particularly in controlling greenhouse gas emissions (Shammas et al.,2024) to avoid the goal of catastrophic climate consequences (Jianguo et al.,2022). To achieve this objective, many countries have introduced innovative low-carbon technologies in key sectors such as energy production, industrial manufacturing, and transportation, while promoting sustainable development through strengthened environmental regulations (Shang et al.,2023). Moreover, the international community increasingly recognizes that enhancing international cooperation and sharing resources, as well as formulating a global policy framework, can better support these efforts toward green economic transitions (Schröder & P, 2020; Miller & Watanabe, 2022; Liu et al., 2023). However, it should be noted that corruption will hinder the enforcement of environmental policies (Owusu et al.,2020; Boubaker et al.,2024). Chaparro-Banegas et al. (2024) further point out that the path to sustainable development not only requires technological innovation but also the protection of ecosystems. In addition, the combination of policies can not only effectively address the challenges of climatic change but also lay a foundation for future green growth (Jones et al.,2023). Therefore, the transformation to a green economy has become a crucial issue in global economic development, requiring countries to undertake comprehensive reforms and innovations in policy design (Schröder & P, 2020) and financial market(Abid,2022;Xu et al.,2022;Li et al.,2023).

Despite the continuous efforts of all parties, the global carbon emission situation remains complex and difficult to deal with(Fang et al., 2022;Pan et al., 2024). In particular, developing economies account for more than three-quarters of global carbon emissions(Jianguo et al.,2022). Although the 2008 financial crisis led to a temporary reduction in emissions, the post-pandemic recovery in industrial activity and energy consumption could push them up again. Comprehensive financial and institutional reforms are therefore essential to achieve lasting environmental sustainability (Godil et al.,2021a; Ullah et al.,2021).

The role of FM in influencing environmental outcomes has attracted considerable attention. Developed financial markets can facilitate capital allocation (Li et al.,2022) and stimulate investment in R&d (Hsu et al., 2022),thus using environmentally friendly technologies to improve energy efficiency(Khan et al., 2021).There is evidence that financial markets can help reduce carbon emissions through technological innovation and attracting investment (Chishti et al.,2022).However, if financial markets primarily support energy intensity, this process may also lead to increased emissions (Deng et al., 2023).

This paper attempts to explore the dual role of FM and CC in reducing or exacerbating carbon emissions. By examining the interplay between FM, CC, and CO_2 emissions, we highlight the key role that these factors play in influencing CO_2 emissions in both emerging and advanced economies.

LITERATURE REVIEW

The literature review in this paper aims to introduce the key problem to be addressed in this study. It also seeks to provide critical literature that helps identify gaps in key research questions, including literature, theoretical and conceptual issues. It also shows how this research could fill in those gaps.

Corruption control and CO_2 emission

The importance of corruption control in improving environmental quality has been paid more and more attention. Research shows that corruption often impedes the deployment of environmental policies and thus affects the achievement of goals (Owusu et al., 2020). Corruption not only leads to waste of resources, but also to resource pollution and overexploitation (Akalin et al., 2021). In many developing countries, weak governance structures and widespread corruption make it challenging to enforce environmental protection measures (Leal et al., 2021). For example, Sadiq (2024) points out the complex relationship between CC and CO_2 emissions, highlighting the potential role of transparent governance in reducing emissions..

Research indicates that robust anti-corruption measures can drive environmental management by enhancing public participation and policy transparency, effectively decreasing CO_2 emissions (Fontaine et al., 2022; Hassan et al., 2024).Zhang (2021) found that controlling corruption could promote the adoption of clean production technologies, thus impacting CO_2 emissions.Furthermore, the quality of governance, especially with respect to anti-corruption policies, is essential for reducing risks in environmental management (Abreu et al., 2022).However, there are conflicting views on the relationship between CC and CO_2 emissions.Some studies suggest that controlling corruption does not always correlate with emission reductions, particularly in settings where institutional weaknesses or social and cultural factors are prevalent (Usman et al., 2022).This implies that while CC is critical for environmental sustainability, its effectiveness may depend on other governance factors, such as political stability, public awareness, and social responsibility (Sahoo et al., 2023; Ali et al., 2021).

Furthermore, the impact of anti-corruption on CO_2 emissions in environmental management has been debated in many ways (Ragmoun et al.,2024; Tawiah et al.,2024). Research shows that anti-corruption drives economic development, which in turn may increase emissions, especially in countries that rely on energy-intensive industries (Basheer et al., 2024). Moreover, political stability plays a key role in the environmental benefits of anti-corruption policies. In an unstable political environment, the coherence and effectiveness of anti-corruption measures may be affected (Naidoo et al., 2024). Public participation also plays an important role in fighting corruption and protecting the environment. Studies have shown that high levels of public oversight and participation can enhance the environmental benefits of anti-corruption (Agu et al., 2024), but anti-corruption has a limited impact on CO_2 emissions in societies lacking public scrutiny (Boubaker et al., 2024). In addition, weak governance structures can make it difficult for anti-corruption to achieve desired environmental goals, especially in regions with weak regulatory enforcement (Agu et al., 2024). In summary, while anti-corruption has positive implications for environmental sustainability, its effectiveness depends on governance stability, policy transparency, and public participation

(Basheer et al., 2024 ; Naidoo et al., 2024 ; Agu et al., 2024 ; Agu et al., 2024). So we first put forward the hypothesis:

Hypothesis 1: CC has a positive impact on CO_2 emissions.

However, in countries with strong VA, the public and Non-governmental organizations are more likely to pressure governments to implement effective environmental policies and ensure compliance (Chu et al., 2022) An environment in which transparency and accountability support the enforcement of environmental regulations, which reinforces the impact of CC on emissions reductions. Conversely, when VA is weak, even well-intentioned anti-corruption efforts may fail to significantly reduce CO_2 emissions due to limited public oversight and enforcement (Zhao et al., 2022). Thus, in strong VA countries, enhanced transparency and accountability mechanisms not only support the enforcement of environmental regulations, but also effectively increase the impact of anti-corruption measures on emissions reduction (Yu et al., 2024; Oyewo et al., 2024). In this environment, public engagement and civil society pressure have led governments to ensure policy compliance, and anti-corruption efforts have played a greater role in reducing CO_2emissions (Wang et al., 2024). In contrast, lack of transparency and public oversight can limit the actual environmental effects of anti-corruption, making it difficult to achieve significant progress in emissions control (Anawati et al., 2024). Thus, the strength of VA determines whether anti-corruption policies can achieve positive results in environmental management, and further demonstrates the critical role of public accountability and transparency in achieving environmental sustainability. Therefore, based on this understanding,So put forward the hypothesis:

Hypothesis 2: VA moderates the significant relationship between CC and CO_2 emissions.

Financial markets and CO_2 emission

Financial markets and environmental quality are receiving increasing attention (Chishti et al., 2022). However, the available literature gives different results. Numerous studies have demonstrated a positive correlation between FM and CO_2 emissions. (Shoaib et al., 2020), suggesting that a well-functioning FM can mobilize funds for environmentally sustainable projects (Abid et al., 2022) and contribute to emissions reductions (Meo et al., 2022). In this context, renewable energy and green technologies require excellent FM support (Zhang et al., 2022) and facilitate the transition to a green economy, especially LC (Habiba et al., 2023). In contrast, other studies have shown a positive correlation between FM and increased CO_2 emissions (Bui et al., 2020; Habiba et al., 2022; Shoaib et al., 2020; Deng et al., 2023). Moreover, the expansion of FM is often associated with an increase in capital flows (Liu et al., 2024). Yang (2022) emphasizes that mature FM attract foreign direct investment, this drives economic up and has a profound impact on energy consumption patterns.

Numerous studies demonstrate that financial markets significantly affect CO_2 emissions (Bui et al., 2020; Habiba et al., 2022; Shoaib et al., 2020). As sustainable development and climate change mitigation receive increasing focus, Shoaib et al. (2020) highlighted that emissions levels in a country are influenced by its income and the conditions of its FM. Similarly, Godil et al. (2020) examined the role of FM and information in shaping environmental quality in Pakistan. finding that financial markets and ICT have a negative impact on CO_2 emissions, while regime quality positively influences it. Ahmed et al. (2022) added that financing for low-carbon energy enhances clean production in ASEAN nations. Moreover, empirical research by Paramati et al. (2021) indicated that financial markets and development play vital roles in lowering CO_2 emissions in OECD economy.

In addition, both FM and credit can have adverse effects on CO_2 levels (Bui et al., 2020), indicating a negative impact on environmental quality on financial markets (Hunjra et al., 2020). Similar studies also investigated the impact of FM on CO_2 emissions in different regional environments (Tahir et al., 2021; Naeem et al., 2021; Saud et al., 2020). These studies usually focus on key factors related to FM, such as FM, regime quality and technological innovation (Bekun et al., 2024;Yasin et al., 2021;Adeel-Farooq et al., 2023).From a multi-country perspective, Ahmad et al. (2021) argues that good FM can have an environmental impact, such as market innovation reducing emissions in an economy, while Habiba (2020) compared different types of countries according to development level and revealed the dialectical relationship between FM and CO_2emissions. In addition, Xu et al. (2022) conducted a study on the Group of Seven and found similar results. Other studies have applied FM analysis to the study of carbon emissions in different economies, such as Abid (2022) for Group of eight and Wang et al. (2022) for Next-11. Therefore, based on this understanding,So put forward the hypothesis:

Hypothesis 3: FM has a positive impact on CO_2 emissions.

Voice accountability (VA) can serve as a key moderator of the FM and CO_2 emissions relationship because capturing the extent to which citizens have a say in government decisions and holding authorities accountable, the public and ngos often push for environmentally responsible policies in countries with strong VA (Manu et al., 2024). With stronger public scrutiny, governments are also under pressure to implement regulations that limit environmentally harmful practices (Zhao, 2022). Therefore, higher VA may enhance the positive role of FM in reducing CO_2 emissions by directing financial resources to green investment, environmental innovation, and clean energy technologies.

In contrast, in countries with weak value-added capacity, accountability mechanisms may not be sufficient to ensure that FM prioritize sustainability. In this case, FM may favor short-term profitability over long-term environmental concerns, leading to increased industrial activity and increased CO_2 emissions. Lack of public pressure and weak regulatory enforcement may undermine efforts to align FM with environmental goals, resulting in higher CO_2 emissions despite market growth (Abbas et al. 2022). Therefore, based on this understanding,So put forward the hypothesis:

Hypothesis 4: VA moderates the significant relationship between FM and CO_2 emissions.

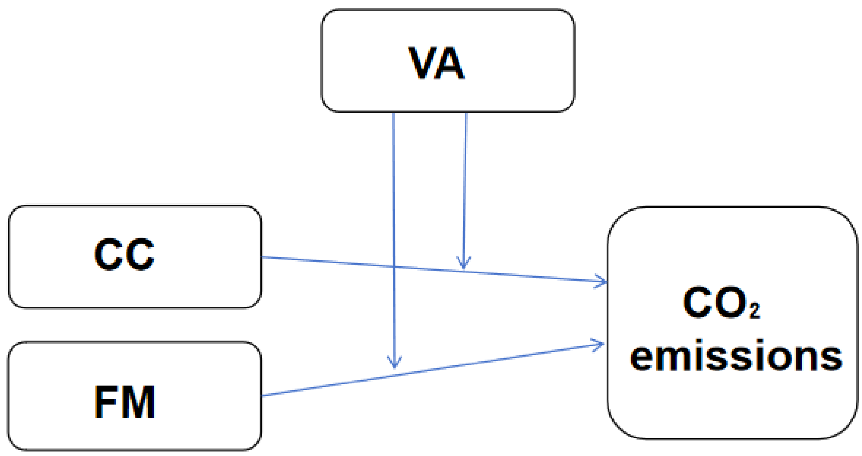

Figure 1. Research Framework (Source: Created by the author)

METHODOLOGY

In order to ensure the reliability of data and the validity of results, we used a variety of methods, such as unit root test, system GMM, data collection and analysis, robustness test, etc.

Unit root test

Once the cross-sectional correlations between the variables have been determined, the next step is to evaluate their integration order (Maieret al., 2023). The panel unit root test is crucial for determining the order of integration (Choi, 2001) because cointegration analysis requires that all variables be integrated in first order (Al et al., 2015). which are more robust in considering cross-sectional dependencies - a problem not adequately addressed by first-generation methods (Luo et al., 2021; Ullah et al., 2022). The econometric model is as follows:

$$Y_{it} = \alpha_{it} + \beta_i x_{it-1} + \rho_i T + \sum_{j=1}^{n} \theta_{it} \Delta x_{it-j} + \epsilon_{it} \quad (1)$$

Where term Δ represents the difference operator and ϵ indicates the error term. x_{it} indicates the examined variable. The term α signifes the intercept, t shows the time tendency.

System GMM method（SYS-GMM）

Our research adopts systematic gmm method. First, the setting of the time dimension (T) for 18 years (2003-2020) and the cross-sectional dimension (N) for 28 countries conforms to the strengths of the systematic gmm model, as it effectively solves the problem of small sample sizes in the time dimension relative to the number of observations (Genaro et al., 2022). In addition, the system-GMM approach is suitable for solving potential endogeneity problems (Ullah et al., 2018). Previous studies, such as Arellano (1995) and Blundell (1998), have established the suitability of systems-GMM for the study of these features. Moreover, system GMM utilizes hierarchical and differential information in the data to improve estimation efficiency (Ahn and Schmidt, 1995). Therefore, the following GMM model is adopted in this paper:

$$\mathrm{CO}_{2it} = \alpha + \beta_1 \mathrm{CO2}_{it-1} + \beta_2 \mathrm{CC}_{it} + \beta_3 \mathrm{RL}_{it} + \beta_4 \mathrm{GE}_{it} + \beta_5 \mathrm{PS}_{it} + \beta_6 \mathrm{VA} * \mathrm{CC}_{it} + \varepsilon_{it} \quad (2)$$

$$\mathrm{CO}_{2it} = \alpha + \beta_1 \mathrm{CO2}_{it-1} + \beta_2 \mathrm{FM}_{it} + \beta_3 \mathrm{RL}_{it} + \beta_4 \mathrm{GE}_{it} + \beta_5 \mathrm{PS}_{it} + \beta_6 \mathrm{VA} * \mathrm{FM}_{it} + \varepsilon_{it} \quad (3)$$

$$\mathrm{CO}_2 pc_{it} = \alpha + \beta_1 CO2pc_{it-1} + \beta_2 CC_{it} + \beta_3 RL_{it} + \beta_4 GE_{it} + \beta_5 PS_{it} + \beta_6 VA * CC_{it} + \varepsilon_{it} \quad (4)$$

$$\mathrm{CO}_2\mathrm{pc}_{it} = \alpha + \beta_1 \mathrm{CO2pc}_{it-1} + \beta_2 \mathrm{FM}_{it} + \beta_3 \mathrm{RL}_{it} + \beta_4 \mathrm{GE}_{it} + \beta_5 \mathrm{PS}_{it} + \beta_6 \mathrm{VA} * \mathrm{FM}_{it} + \varepsilon_{it} \quad (5)$$

Where $CO2_{it}$ and $CO2pc_{it}$ is the carbon dioxide emissions for country i at time t; $CO2_{it-1}$;$CC_{it}$is the control of corruption indicator;FM_{it} represents the financial market level; RL_{it}, GE_{it} *and* PS_{it} are control variables for rule of law, government effectiveness, and political stability, respectively,VA is Voice and accountability ; $\varepsilon_{it}$is the error term.

Data collection and analysis

This study utilizes panel data from 28 emerging [1]economies spanning from 2003 to 2020. The data were sourced from the IMF. The analysis focuses on two key dependent variables: total CO_2emissions (in metric tons) and per capita CO_2emissions. These indicators provide a comprehensive assessment of both aggregate and individual contributions to carbon emissions, consistent with methodologies used in previous research (Meo et al., 2022; Deng et al., 2023; Akalin et al., 2021).

The independent variables in this study are CC (corruption control) and FM (financial markets). Data for CC were obtained from the Worldwide Governance Indicators, a metric tied to governance policies, with some studies linking it to environmental outcomes (Owusu et al., 2020; Akalin, 2021; Leal et al., 2021). Similarly, FM data were also sourced from the WGI, with research suggesting that FM can impact CO_2emissions through various channels (Xu et al., 2022; Wang et al., 2022).

Control variables, also derived from the WGI, were included to capture broader institutional effects. These variables encompass RL, GE and PS, while VA serve as a moderator. These dimensions help to capture the quality of governance and its potential influence on the main relationships. The inclusion of these factors aligns with literature that emphasizes the character of institutional quality in environmental performance (Waris et al., 2024).

Robustness test

This robustness check involved substituting the main model with an OLS regression model, employing the robust command to account for potential heteroskedasticity in the error terms (Huber, 1967;Cameron & Trivedi, 2005).

Using OLS as an alternative model allows for the evaluation of the stability of the estimated coefficients obtained from the GMM method. Comparing the results from both models helps determine whether the relationships observed between corruption control (CC), financial markets (FM), and CO_2 emissions remain consistent across different estimation techniques (Baltagi, 2008; Wooldridge, 2010).

Furthermore, this approach aids in identifying any biases or inconsistencies that may arise from GMM estimation, particularly concerning the choice of instruments (Hayashi, 2000). The robustness tests contribute significantly to the overall reliability of the research findings and provide additional insights into the impact of CC and FM on CO_2 emissions. Therefore, the equation of robust test is:

$$\mathrm{CO}_2 = \beta_0 + \beta_1 \mathrm{FM} + \beta_2 \mathrm{RL} + \beta_3 \mathrm{GE} + \beta_4 \mathrm{PS} + \beta_5 \mathrm{VA} * \mathrm{FM} + \mathrm{u} \quad (6)$$

[1] Mexico, China, South Africa, Kazakhstan, Egypt, Qatar, Turkey, Vietnam, Peru, Poland, Indonesia, Bangladesh, Saudi Arabia, Thailand, India, Nigeria, Brazil, Hungary, Russia, Chile, Malaysia, Pakistan, Argentina, the Philippines, Croatia, Colombia, Bulgaria, the United Arab Emirates.

$$CO_2 = \beta_0 + \beta_1 CC + \beta_2 RL + \beta_3 GE + \beta_4 PS + \beta_5 VA * CC + u \quad (7)$$

$$CO_2pc = \beta_0 + \beta_1 FM + \beta_2 RL + \beta_3 GE + \beta_4 PS + \beta_5 VA * FM + u \quad (8)$$

$$CO_2pc = \beta_0 + \beta_1 CC + \beta_2 RL + \beta_3 GE + \beta_4 PS + \beta_5 VA * CC + u \quad (9)$$

RESULTS

In the results section of this study, we will present detailed results on various aspects of data analysis, including descriptive statistics, variance inflation factor (VIF) tests, unit root tests, regression analysis, and robustness tests.

Descriptive statistics

A preliminary analysis that helps to understand the variability and distribution of the data across different countries, which will be critical to interpreting subsequent regression results.

The average total CO2 emissions is 12.151 metric tons, with a standard deviation of 1.292, indicating relatively consistent emission levels across countries. However, per capita CO2 Per capita emissions (CO2pc) show a higher variability, with a mean of 5.704 and a standard deviation of 7.225, ranging from 0.21 to 47.657. This significant variation suggests notable differences in emissions depending on population size, reflecting disparities in industrialization levels and environmental policies among countries.

The control of corruption (CC) has a mean score of 46.591 and a standard deviation of 19.684, pointing to substantial differences in governance quality within the sample. This range, from 4.233 to 91.388, highlights countries with both stringent and lax anti-corruption measures. Similar variation is observed in other governance indicators: the rule of law (RL) has a mean of 47.52 with a range of 4.975 to 88.038, and government effectiveness (GE) averages 54.708, with a minimum of 8.612 and a maximum of 85.437. These wide ranges underscore significant disparities in institutional quality and public service efficiency.

The FM exhibits less variability, with a mean of 0.379 and a standard deviation of 0.17, indicating moderate levels of financial infrastructure across countries. In contrast, political stability (PS) displays greater dispersion, with a mean score of 38.045 and a standard deviation of 24.658, ranging from 0.474 to 92.462. This suggests considerable differences in political environments, from highly stable to politically volatile regions.

Table 1: Descriptive Statisticsns (Source: Author's own computation using Stata)

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	504	12.151	1.292	9.657	16.208
CO_2pc	504	5.704	7.225	.210	47.657
CC	504	46.591	19.684	4.233	91.388
FM	504	.379	.170	.045	.739
RL	504	47.52	17.732	4.975	88.038
GE	504	54.708	15.707	8.612	85.437
PS	504	38.045	24.658	.474	92.462
VA	504	43.962	22.828	2.347	67.740

VIF test

All values below 10 in the VIF analysis in Table 2 are considered to be free of serious multicollinearity problems (Kyriazos et al.,.2023). Among them, the VIF value of RL and CC is 6.174 and 6.15, respectively, while the VIF value of GE is 4.208. While these values are slightly higher compared to other variables, they are still within an acceptable range. The VIF values of PS, FM and CO2 emissions are low, between 1.656, indicating minimal collinearity. And the average VIF is 3.707.

Table 2: Test of multicollinearity (Source: Author's own computation using Stata)

	VIF	**1/VIF**
CO_2pc	1.57	.638
CO_2	1.656	.604
FM	1.683	.594
CC	6.15	.163
RL	6.174	.162
GE	4.208	.238
PS	2.369	.422
VA	1.420	.706
Mean VIF	3.707	.

Unit root test

The non-stationarity null hypothesis was rejected for all variables, and the P-values were significant (less than 0.05).Thus, CO_2 emissions($CO_2$and CO_2pc), FM, CC, GE, PS and RL are stationary in their level forms, meaning they do not exhibit time-dependent trends. Stationarity ensures that subsequent regression analyses, such as the GMM, produce reliable results that are not biased by trends in the data. The large adjusted t-statistics for several variables further confirm the robustness of the stationarity results, ensuring the appropriateness of using these variables in the econometric models.

The findings confirm that the dataset meets essential econometric requirements, thus supporting the validity of the model specifications in studying the impact of governance and FM on CO_2 emissions. Previous studies emphasize the importance of using stationary data in time series analyses to avoid spurious regression results.

Table 3: Unit root test (Source: Author's own computation using Stata)

	Unadjusted t	**Adjusted t***	**p-value**
CO_2	-9.087	-2.1118	0.0174
CO_2pc	-10.3461	-4.0009	0.0000
FM	-13.6378	-4.8740	0.0000
CC	-13.0572	-4.1990	0.0000
GE	-11.2899	-2.9548	0.0016
PS	-14.8361	-7.3941	0.0000
VA	-14.3769	-6.5904	0.0000
RL	-12.4196	-5.0701	0.0000

Regression analysis

The CC coefficient is positively correlated, indicating that the increase in CC may be related to the increase in CO_2 emissions.This result is consistent with previous research findings, indicating that strict governance and anti-corruption measures tend to stimulate economic growth and industrial development, leading to higher emissions from increased production and energy consumption (Usman et al., 2022). FM is also positively and significantly related to CO_2 emissions, indicating that more developed financial markets are associated with higher carbon emissions. This result is some with the findings of Meo et al (2022) and Deng et al. (2023), who argue that FM can drive economic expansion and industrial activity, which in turn can exacerbate environmental degradation when environmental regulations are weak or poorly enforced. The positive relationship between FM and emissions suggests that without adequate environmental monitoring, FM growth may promote the prioritization of non-long-term sustainable investments (Shoaib et al., 2020).

Moreover, when the interaction terms VA*CC and VA*FM are added, where VA stands for voice and accountability, the relationships between CC and CO_2 and FM and CO_2 become negative. This suggests that high-quality governance characterized by strong accountability mechanisms can mitigate the environmental impact of corruption control and financial development (Manu et al., 2024). This finding is consistent with the view that public participation and government accountability may play a key role in promoting environmental policies and ensuring their implementation (Zhao, 2024).

These findings highlight the intricacy dynamics between governance, FM, and environmental sustainability, underscoring the importance of strengthening governance frameworks to effectively balance economic growth with environmental protection.

Table 4: GMM Regression Analysis

	CC-Model 2	**FM-Model 3**	**CC-Model 4**	**FM-Model 5**
L.CO2	1.001***	0.997***		
	(-0.002)	(-0.002)		
L.CO2pc			0.968***	0.966***
			(-0.004)	(-0.004)
FM		0.084***		0.843***
		(-0.021)		(-0.175)
CC	0.001***		0.007**	
	(0.000)		(-0.003)	
RL	-0.001*	0.000	-0.004	-0.002
	(0.000)	(0.000)	(-0.003)	(-0.002)
GE	0.000	0.000	0.002	0.000
	(0.000)	(0.000)	(-0.002)	(-0.002)
PS	0.000	0.000	0.002*	0.004***
	(0.000)	(0.000)	(-0.001)	(-0.001)
VA*CC	-.0176***		- 0.149***	
	(0.003)		(0.031)	
VA*FM		-0.001***		-0.009***
		(0.000)		(-0.003)
_cons	.135	0.043	0.928	-0.031
	(0.039)	(-0.029)	(0.316)	(-0.075)
N	476	476	476	476
adj. R2	0.030	0.034	0.243	0.246

Standard errors in parentheses
$p < 0.1$*, $p < 0.05$**, $p < 0.01$***

Robustness check

In order to ensure the validity and reliability of the preliminary research results obtained by generalized estimation of Moments (GMM) (Table 4), we use OLS regression for robustness test, as shown in Table 5. This analysis aims to compare the consistency of the results of different estimation methods and to address the potential problem of heteroscedasticity in the error term according to the established method (Cameron & Trivedi, 2005; Huber,1967). While the consistency of the main results of the GMM and OLS models supports their robustness, the interaction effects illustrate the intricacy interplay between governance, economic development and environmental sustainability. These findings suggest that strengthening governance frameworks, especially those related to accountability and regulatory quality, can be effective in steering economic growth toward a more sustainable trajectory (Hayashi, 2000).

Table 5: Robustness Check

	FM-Model 6	CC-Model 7	FM-Model 8	CC-Model 9
L.CO2	0.997***	1.001***		
	(-0.002)	(-0.002)		
L.CO2pc			0.967***	0.972***
			(-0.010)	(-0.010)
FM	0.090***		0.784***	
	(-0.020)		(-0.179)	
CC		0.001***		0.003
		(0.000)		(-0.004)
RL	0.000	-0.001	-0.002	-0.003
	(0.000)	(0.000)	(-0.003)	(-0.002)
GE	0.000	0.000	0.000	0.003
	(0.000)	(0.000)	(-0.002)	(-0.002)
PS	0.000	0.000	0.004*	0.002
	(0.000)	(0.000)	(-0.002)	(-0.002)
VA*FM	-0.001***		-0.007***	
	(0.000)		(-0.003)	
VA*CC		-0.000***		-0.000*
		(0.000)		(0.000)
_cons	0.042	0.002	-0.018	0.054
	(-0.032)	(-0.029)	(-0.077)	(-0.077)
N	476	476	476	476
adj. R2	0.998	0.998	0.996	0.996

Standard errors in parentheses
$p < 0.1^*$, $p < 0.05^{**}$, $p < 0.01^{***}$

DISCUSSION

Model 2 and Modela 4 Corruption control is associated with an increase in CO_2 emissions. This finding may seem counterintuitive, but is consistent with the hypothesis that economic development driven by improved governance can lead to higher industrial activity and thus increased emissions. As Owusu et al. (2020) argued, corruption often hinders the implementation of environmental policies, and controlling corruption may stimulate economic sectors that rely heavily on energy consumption, potentially increasing carbon dioxide emissions. However, Leal et al. (2021) pointed out that weak governance structures in developing countries make it difficult to enforce environmental regulations, which aggravates resource waste and pollution.

A transition occurs when VA is introduced as a moderator. The negative interaction terms between VA and CC in Models 2 and 4 suggest that increasing levels of VA weaken the positive relationship between CC and CO_2 emissions. This result supports the view that strong governance frameworks, including mechanisms for public participation, can help ensure that the benefits of corruption controls extend to environmental outcomes (Fontaine and others, 2022; Chu et al., 2022). In an environment where citizens hold governments accountable, policy makers are more likely to implement and enforce effective environmental regulations, thereby reducing emissions (Zhao et al., 2022).

The FM coefficients in both Models 3 and 5 are positive and significant, confirming the hypothesis that FM is associated with increased CO_2 emissions. This finding supports the view that while FM are critical for economic growth, they may also contribute to environmental degradation in the absence of appropriate environmental safeguards (Khan et al. 2021; Chishti et al., 2022). As Meo et al. (2022) points out, FM can channel capital to energy-intensive sectors, thereby increasing emissions.

However, the inclusion of VA as a moderator reveals an important nuance. The negative and significant interaction term between VA and FM suggests that higher levels of accountability can reduce the opposite environmental impact of FM growth. Zhao et al. (2022) argued that public pressure in countries with strong VA can push financial institutions to finance more sustainable and green investments, thus mitigating the environmental hazards typically associated with financial development.

The significant moderating effect of VA on CC and FM suggests that public participation and governance accountability play a big role in achieving environmental sustainability. Strong VA ensures that anti-corruption efforts and financial development contribute to reducing CO_2 emissions. When citizens have a voice in governance and can hold authorities accountable, there is greater transparency and better enforcement of environmental institution (Manu et al., 2024; Zhao et al., 2022). In contrast, when VA is weak, even well-designed financial and anti-corruption policies may fail to produce the desired environmental outcomes due to weak enforcement (Abbas et al., 2022).

The results have significant policy implications. First, while CC and FM are critical for economic progress, their environmental consequences must be carefully managed. Additionally, the moderating role of VA emphasizes the importance of enhancing governance quality.Strengthening public accountability mechanisms can ensure that both financial development and anti-corruption efforts contribute to reducing CO_2 emissions and promoting a green economy transition.

One limitation of this analysis is the potential endogeneity of governance indicators, which could be influenced by other unobserved factors. Future research could address this issue by using instrumental variables or more advanced econometric techniques.Additionally, further investigation into sector-specific emissions could provide a clearer picture of how FM and governance influence environmental outcomes in different industries.

CONCLUSIONS

The positive correlation between CC and CO_2 emissions suggests that enhanced governance can lead to increased industrial activity and thus increased emissions. This finding is supports with the assertion by Owusu (2020) that effective anti-corruption measures may stimulate energy-intensive sectors. However, it highlights the complexity of the relationship, where improved governance may inadvertently lead to increased emissionsdue to heightened production and energy use. At the same time, FM is strongly linked with CO_2 emissions, which again proves that FM is essential for economic growth, but without adequate safeguards, FM can exacerbate environmental degradation. the analysis shows that VA play a significant moderating role. Higher VA levels weaken the positive correlation between CC and FM and CO_2 emissions, suggesting that a strong governance framework can translate anti-corruption efforts into positive environmental outcomes.

The implications for policy are profound. to effectively tackle the intricate interplay among CC, FM, and CO_2 emissions, the study makes the following policy recommendations to facilitate the transition to a green economy: First, strengthen mechanisms for public accountability and participation. Studies have shown that VA can effectively weaken the positive correlation between carbon emissions and carbon dioxide emissions, thus playing a key role in environmental governance (Fontaine et al., 2022; Chu et al., 2022). To this end, it is recommended that the government strengthen public accountability through legislation, policy reform, community participation and other measures, strengthen the supervision of environmental policies, and ensure the transparency and accountability of policy implementation. Such oversight not only enhances the environmental benefits of CC, but also ensures people's participation in environmental decision-making (Zhao et al., 2022; Manu et al., 2024). Second, promote the transformation of FM towards green investment. This study found that in the absence of environmental protection measures, FM, while promoting economic growth, may also exacerbate Ecological decline (Khan et al., 2021; Meo et al., 2022). Third, increase the regional adaptability of anti-corruption. While corruption control is essential for governance and economic development, its effectiveness varies according to regional governance structures (Owusu et al., 2020; Leal et al., 2021). When implementing anti-corruption measures, policymakers should pay attention to the level of governance and socio-cultural context in each place to ensure that measures do not inadvertently encourage the development of energy-intensive industries. At the same time, strict environmental standards should be established, especially for resource-intensive industries, to ensure that these industries meet environmental requirements in the process of economic growth (Akalin et al., 2021; Abbas et al., 2022).

ACKNOWLEDGMENT

The study was not funded.

REFERENCES

[1] Akalin, G., Erdogan, S., & Sarkodie, S. A. (2021). Do dependence on fossil fuels and corruption spur ecological footprint?. Environmental Impact Assessment Review, 90, 106641.https://doi.org/10.1016/j.eiar.2021.106641

[2] Agu, J. C., Nkwo, F. N., & Eneiga, R. U. (2024). Governance and anti-corruption measures in Nigeria: Strategies for enhancing transparency, accountability and public trust. International Journal of Economics and Public Policy, 8(1), 1-15. https://doi.org/10.5281/zenodo.12576796

[3] Abreu, M., Soares, I., & Silva, S. (2022). Governance quality and environmental policy on emergent, resource-rich economies: The case of Brazil. Energy Reports, 8, 70-75. https://doi.org/10.1016/j.egyr.2022.01.041

[4] Ali, E. B., Anufriev, V. P., & Amfo, B. (2021). Green economy implementation in Ghana as a road map for a sustainable development drive: A review. Scientific African, 12, e00756. https://doi.org/10.1016/j.sciaf.2021.e00756

[5] Adeel-Farooq, R. M., Raji, J. O., & Qamri, G. M. (2023). Does financial development influence the overall natural environment? An environmental performance index (EPI) based insight from the ASEAN countries. Environment, Development and Sustainability, 25(6), 5123-5139.https://doi.org/10.1007/s10668-022-02258-x

[6] Ahmad, M., Khan, Z., Rahman, Z. U., Khattak, S. I., & Khan, Z. U. (2021). Can innovation shocks determine CO2 emissions (CO2e) in the OECD economies? A new perspective. Economics of Innovation and New Technology, 30(1), 89-109.https://doi.org/10.1080/10438599.2019.1684643

[7] Abid, A., Mehmood, U., Tariq, S., & Haq, Z. U. (2022). The effect of technological innovation, FDI, and financial development on CO2 emission: evidence from the G8 countries. Environmental Science and Pollution Research, 1-9. https://doi.org/10.1007/s11356-021-15993-x

[8] Abbas, S., Gui, P., Chen, A., & Ali, N. (2022). The effect of renewable energy development, market regulation, and environmental innovation on CO2 emissions in BRICS countries. Environmental Science and Pollution Research, 29(39), 59483-59501.https://doi.org/10.1007/s11356-022-20013-7

[9] Al-Mulali, U., Tang, C. F., & Ozturk, I. (2015). Does financial development reduce environmental degradation? Evidence from a panel study of 129 countries. Environmental Science and Pollution Research, 22, 14891-14900.https://doi.org/10.1007/s11356-015-4726-x

[10] Arellano M, Bover O (1995) Another look at the instrumental variable estimation of error-components models. J Econ 68(1):29–51https://doi.org/10.1016/0304-4076(94)01642-D

[11] Ahn SC, Schmidt P (1995) Efcient estimation of models for dynamic panel data. J Econ 68(1):5–27https://doi.org/10.1016/0304-4076(94)01641-C

[12] Anawati, A., Ramsoondar, N., & Cameron, E. (2024). Environmental accountability: why it matters in social accountability strategies: Rapid evidence narrative from the SAFE for Health Institutions project team. Canadian Family Physician, 70(4), 228-232.DOI: 10.46747/cfp.7004228

[13] Bui, D. T. (2020). Transmission channels between financial development and CO2 emissions: A global perspective. Heliyon, 6(11). DOI: 10.1016/j.heliyon.2020.e05509

[14] Boubaker, S., Liu, P. Z., Ren, Y. S., & Ma, C. Q. (2024). Do anti-corruption campaigns affect corporate environmental responsibility? Evidence from China. International Review of Financial Analysis, 91, 102961.https://doi.org/10.1016/j.irfa.2023.102961

[15] Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. J Econ 87(1):115–143https://doi.org/10.1016/S0304-4076(98)00009-8

[16] Baltagi, B. H., & Baltagi, B. H. (2008). Econometric analysis of panel data (Vol. 4, pp. 135-145). Chichester: Wiley.

[17] Bekun, F. V., Gyamfi, B. A., Köksal, C., & Taha, A. (2024). Impact of financial development, trade flows, and institution on environmental sustainability in emerging markets. Energy & Environment, 35(6), 3253-3272.https://doi.org/10.1177/0958305X2211476

[18] Basheer, M. F., Sabir, S. A., & Hassan, S. G. (2024). Financial development, globalization, energy consumption, and environmental quality: Does control of corruption matter in South Asian countries?. Economic Change and Restructuring, 57(3), 112.https://doi.org/10.1007/s10644-024-09699-6

[19] Chaparro-Banegas, N., Sánchez-Garcia, M., Calafat-Marzal, C., & Roig-Tierno, N. (2024). Transforming the agri-food sector through eco-innovation: A path to sustainability and technological progress. Business Strategy and the Environment.DOI:10.1002/bse.3968

[20] Chu, Z., Bian, C., & Yang, J. (2022). How can public participation improve environmental governance in China? A policy simulation approach with multi-player evolutionary game. Environmental Impact Assessment Review, 95, 106782.https://doi.org/10.1016/j.eiar.2022.106782

[21] Choi, I. (2001). Unit root tests for panel data. Journal of international money and Finance, 20(2), 249-272.https://doi.org/10.1016/S0261-5606(00)00048-6

[22] Chishti, M. Z., & Sinha, A. (2022). Do the shocks in technological and financial innovation influence the environmental quality? Evidence from BRICS economies. Technology in Society, 68, 101828.https://doi.org/10.1016/j.techsoc.2021.101828

[23] Deng, X., Yang, J., Ahmed, Z., Hafeez, M., & Salem, S. (2023). Green growth and environmental quality in top polluted economies: the evolving role of financial institutions and markets. Environmental Science and Pollution Research, 30(7), 17888-17898. https://doi.org/10.1007/s11356-022-23421-x

[24] Falcone, P. M. (2020). Environmental regulation and green investments: The role of green finance. International Journal of Green Economics, 14(2), 159-173.https://doi.org/10.1504/IJGE.2020.109735

[25] Fontaine, G., Carrasco, C., & Rodrigues, C. (2022). How transparency enhances public accountability: The case of environmental governance in Chile. The Extractive Industries and Society, 9, 101040.https://doi.org/10.1016/j.exis.2021.101040

[26] Hamid, I., Alam, M. S., Kanwal, A., Jena, P. K., Murshed, M., & Alam, R. (2022). Decarbonization pathways: the roles of foreign direct investments, governance, democracy, economic growth, and renewable energy transition. Environmental Science and Pollution Research, 29(33), 49816-49831.https://doi.org/10.1007/s11356-022-18935-3

[27] Hassan, S. U., Basumatary, J., & Goyari, P. (2024). Impact of governance and effectiveness of expenditure on CO2 emission (air pollution): lessons from four BRIC countries. Management of Environmental Quality: An International Journal.DOI 10.1108/MEQ-12-2023-0424

[28] Habiba, U., & Xinbang, C. (2022). The impact of financial development on CO2 emissions: new evidence from developed and emerging countries. Environmental Science and Pollution Research, 29(21), 31453-31466.https://doi.org/10.1007/s11356-022-18533-3

[29] Hayashi, F. (2011). Econometrics. Princeton University Press.

[30] Huber, P. J. (1967, June). The behavior of maximum likelihood estimates under nonstandard conditions. In Proceedings of the fifth Berkeley symposium on mathematical statistics and probability (Vol. 1, No. 1, pp. 221-233).

[31] Gu, W., Yan, W., & Yu, S. (2024). Rule of law, corruption and transparency impacts on green growth of East Asian economies. Humanities and Social Sciences Communications, 11(1), 1-8. https://doi.org/10.1057/s41599-024-03659-1

[32] Godil, D. I., Sharif, A., Ali, M. I., Ozturk, I., & Usman, R. (2021). The role of financial development, R&D expenditure, globalization and institutional quality in energy consumption in India: New evidence from the QARDL approach. Journal of environmental management, 285, 112208. https://doi.org/10.1016/j.jenvman.2021.112208

[33] Godil, D. I., Sharif, A., Agha, H., & Jermsittiparsert, K. (2020). The dynamic nonlinear influence of ICT, financial development, and institutional quality on CO2 emission in Pakistan: new insights from QARDL approach. Environmental Science and Pollution Research, 27, 24190-24200.https://doi.org/10.1007/s11356-020-08619-1

[34] Jianguo, D., Ali, K., Alnori, F., & Ullah, S. (2022). The nexus of financial development, technological innovation, institutional quality, and environmental quality: evidence from OECD economies. Environmental Science and Pollution Research, 29(38), 58179-58200. https://doi.org/10.1007/s11356-022-19763-1

[35] Fang, G., Huang, M., Zhang, W., & Tian, L. (2024). Exploring global embodied carbon emissions transfer network—An analysis based on national responsibility. Technological Forecasting and Social Change, 202, 123284.https://doi.org/10.1016/j.techfore.2024.123284
[36] Hsu, C. C., Quang-Thanh, N., Chien, F., Li, L., & Mohsin, M. (2021). Evaluating green innovation and performance of financial development: mediating concerns of environmental regulation. Environmental Science and Pollution Research, 28(40), 57386-57397.https://doi.org/10.1007/s11356-021-14499-w
[37] Habiba, U., Xinbang, C., & Ali, S. (2023). Investigating the impact of financial development on carbon emissions: Does the use of renewable energy and green technology really contribute to achieving low-carbon economies?. Gondwana Research, 121, 472-485.https://doi.org/10.1016/j.gr.2023.05.013
[38] Genaro, A. D., & Astorino, P. (2022). A tutorial on the Generalized Method of Moments (GMM) in finance. Revista de Administração Contemporânea, 26, e210287.https://doi.org/10.1590/1982-7849rac2022210287.en
[39] Khan, A., Chenggang, Y., Hussain, J., & Kui, Z. (2021). Impact of technological innovation, financial development and foreign direct investment on renewable energy, non-renewable energy and the environment in belt & Road Initiative countries. Renewable Energy, 171, 479-491.https://doi.org/10.1016/j.renene.2021.02.075
[40] Kyriazos, T., & Poga, M. (2023). Dealing with multicollinearity in factor analysis: the problem, detections, and solutions. Open Journal of Statistics, 13(3), 404-424.DOI: 10.4236/ojs.2023.133020
[41] Nie, L., & Wang, H. (2023). Government responsiveness and citizen satisfaction: Evidence from environmental governance. Governance, 36(4), 1125-1146. https://doi.org/10.1111/gove.12723
[42] Naeem, M. A., Mbarki, I., Alharthi, M., Omri, A., & Shahzad, S. J. H. (2021). Did COVID-19 impact the connectedness between green bonds and other financial markets? Evidence from time-frequency domain with portfolio implications. Frontiers in Environmental Science, 9, 657533. https://doi.org/10.3389/fenvs.2021.657533
[43] Li, X., Begum, M., Liu, S., & Zou, Y. (2024). The Impact of Corporate Sustainability Awareness in Medical Device Enterprises on Sustainable Performance. Advances in Economics, Management and Political Sciences, 86, 197-204.DOI: 10.54254/2754-1169/86/20240923
[44] Liu, J., Qiu, F., Zhang, T., & Liu, H. (2023). Dynamics of green economic development in countries joining the belt and road initiative: Is it driven by green investment transformation?. Journal of Environmental Management, 347, 118969.https://doi.org/10.1016/j.jenvman.2023.118969
[45] Liu, S.; Kanjanapathy, M.; Li, X. (2024). Financial Development and Extreme Capital Flows: Uncovering Resilience.Advances in Economics, Management and Political Sciences,87,242-247.https://doi.org/10.54254/2754-1169/87/20240884
[46] Li, X., Ozturk, I., Majeed, M. T., Hafeez, M., & Ullah, S. (2022). Considering the asymmetric effect of financial deepening on environmental quality in BRICS economies: Policy options for the green economy. Journal of Cleaner Production, 331, 129909.https://doi.org/10.1016/j.jclepro.2021.129909
[47] Luo R, Ullah S, Ali K (2021) Pathway towards sustainability in selected Asian countries: infuence of green investment, technology inno_vations, and economic growth on CO2 emission. Sustainability 13(22):12873. https://doi.org/10.3390/su132212873
[48] Leal, P. H., & Marques, A. C. (2021). The environmental impacts of globalisation and corruption: Evidence from a set of African countries. Environmental Science & Policy, 115, 116-124.https://doi.org/10.1016/j.envsci.2020.10.013
[49] Liu, J., Qiu, F., Zhang, T., & Liu, H. (2023). Dynamics of green economic development in countries joining the belt and road initiative: Is it driven by green investment transformation?. Journal of Environmental Management, 347, 118969.https://doi.org/10.1016/j.jenvman.2023.118969
[50] Li, Q., Sharif, A., Razzaq, A., & Yu, Y. (2022). Do climate technology, financialization, and sustainable finance impede environmental challenges? Evidence from G10 economies. Technological forecasting and social change, 185, 122095.https://doi.org/10.1016/j.techfore.2022.122095
[51] Meo, M. S., & Abd Karim, M. Z. (2022). The role of green finance in reducing CO2 emissions: An empirical analysis. Borsa Istanbul Review, 22(1), 169-178.https://doi.org/10.1016/j.bir.2021.03.002
[52] Maier, C., Thatcher, J. B., Grover, V., & Dwivedi, Y. K. (2023). Cross-sectional research: A critical perspective, use cases, and recommendations for IS research. International Journal of Information Management, 70, 102625.https://doi.org/10.1016/j.ijinfomgt.2023.102625

[53] Manu, E. K., Chen, G. S., Hoang, N., & Leu, S. (2024). Natural resource extraction and environmental sustainability in Africa: The role of voice and accountability. Sustainable Development. https://doi.org/10.1002/sd.3017

[54] Naidoo, P., Momba, S., & Jones, A. K. (2024). Effect of Corrupt Practices on the Stability of Political Systems in Sub-Saharan Africa. American Journal of Law and Political Science, 3(1), 1-10.

[55] Owusu, E. K., Chan, A. P., & Hosseini, M. R. (2020). Impacts of anti-corruption barriers on the efficacy of anti-corruption measures in infrastructure projects: Implications for sustainable development. Journal of cleaner production, 246, 119078.https://doi.org/10.1016/j.jclepro.2019.119078

[56] Oyewo, B., Tauringana, V., Tawiah, V., & Aju, O. (2024). Impact of country governance mechanisms on carbon emissions performance of multinational entities. Journal of Environmental Management, 352, 120000.https://doi.org/10.1016/j.jenvman.2023.120000

[57] Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. Journal of applied econometrics, 22(2), 265-312.https://doi.org/10.1002/jae.951

[58] Paramati, S. R., Mo, D., & Huang, R. (2021). The role of financial deepening and green technology on carbon emissions: Evidence from major OECD economies. Finance Research Letters, 41, 101794.https://doi.org/10.1016/j.frl.2020.101794

[59] Pan, L., Li, Y., Fu, X., & Lee, C. L. (2024). Carbon management and the global value chain: have carbon emissions been reduced?. Sustainability Accounting, Management and Policy Journal, 15(2), 382-411.https://doi.org/10.1108/SAMPJ-11-2022-0585

[60] Ragmoun, W. (2024). The impact of environmental entrepreneurship and anti-corruption on environmental degradation. Journal of Global Entrepreneurship Research, 14(1), 17.https://doi.org/10.1007/s40497-024-00389-1

[61] Riti, J. S., Shu, Y., & Kamah, M. (2021). Institutional quality and environmental sustainability: The role of freedom of press in most freedom of press countries. Environmental Impact Assessment Review, 91, 106656.https://doi.org/10.1007/s11356-022-21401-9

[62] Shang, M., Ma, Z., Su, Y., Shaheen, F., Khan, R., Mohd Tahir, L., ... & Zaman, K. (2023). Understanding the importance of sustainable ecological innovation in reducing carbon emissions: investigating the green energy demand, financial development, natural resource management, industrialisation and urbanisation channels. Economic research-Ekonomska istraživanja, 36(2). DOI: 10.1080/1331677X.2022.2137823

[63] Shammas, M. I. (2024). Mitigating CO2 emissions in African transport networks under various policies and scenarios of Paris Agreement compliance. International Journal of Sustainable Energy, 43(1), 2393403.https://doi.org/10.1080/14786451.2024.2393403

[64] Shoaib, H. M., Rafique, M. Z., Nadeem, A. M., & Huang, S. (2020). Impact of financial development on CO 2 emissions: A comparative analysis of developing countries (D 8) and developed countries (G 8). Environmental Science and Pollution Research, 27, 12461-12475.https://doi.org/10.1007/s11356-019-06680-z

[65] Sadiq, M., Hassan, S. T., Khan, I., & Rahman, M. M. (2024). Policy uncertainty, renewable energy, corruption and CO2 emissions nexus in BRICS-1 countries: a panel CS-ARDL approach. Environment, Development and Sustainability, 26(8), 21595-21621.https://doi.org/10.1007/s10668-023-03546-w

[66] Schröder, P. (2020). Promoting a just transition to an inclusive circular economy (pp. p-33). Royal Institute of International Affairs.

[67] Saud, S., Chen, S., & Haseeb, A. (2020). The role of financial development and globalization in the environment: accounting ecological footprint indicators for selected one-belt-one-road initiative countries. Journal of Cleaner Production, 250, 119518.https://doi.org/10.1016/j.jclepro.2019.119518

[68] Sahoo, M., Sethi, N., & Padilla, M. A. E. (2023). Unpacking the dynamics of information and communication technology, control of corruption and sustainability in green development in developing economies: New evidence. Renewable Energy, 216, 119088.https://doi.org/10.1016/j.renene.2023.119088

[69] Tahir, T., Luni, T., Majeed, M. T., & Zafar, A. (2021). The impact of financial development and globalization on environmental quality: evidence from South Asian economies. Environmental Science and Pollution Research, 28, 8088-8101.https://doi.org/10.1007/s11356-020-11198-w

[70] Tawiah, V., Zakari, A., & Alvarado, R. (2024). Effect of corruption on green growth. Environment, Development and Sustainability, 26(4), 10429-10459.https://doi.org/10.1007/s10668-023-03152-w

[71] Ullah, S., Ozturk, I., Majeed, M. T., & Ahmad, W. (2021). Do technological innovations have symmetric or asymmetric effects on environmental quality? Evidence from Pakistan. Journal of cleaner production, 316, 128239. https://doi.org/10.1016/j.jclepro.2021.128239

[72] Ullah S, Ali K, Shah SA, Ehsan M (2022) Environmental concerns of fnancial inclusion and economic policy uncertainty in the era of globalization: evidence from low & high globalized OECD economies. Environ Sci Pollut Res 1–15. https://doi.org/10.1007/s11356-022-18758-2

[73] Usman, O., Iorember, P. T., Ozturk, I., & Bekun, F. V. (2022). Examining the interaction effect of control of corruption and income level on environmental quality in Africa. Sustainability, 14(18), 11391.https://doi.org/10.3390/su141811391

[74] Ullah, S., Akhtar, P., & Zaefarian, G. (2018). Dealing with endogeneity bias: The generalized method of moments (GMM) for panel data. Industrial Marketing Management, 71, 69-78. https://doi.org/10.1016/j.indmarman.2017.11.010

[75] Vitvitskyi, S., Syzonenko, A., & Titochka, T. (2022). Peculiarities of corruption risk management in economic activity. Baltic Journal of Economic Studies, 8(3), 42-47. https://doi.org/10.30525/2256-0742/2022-8-3-42-47

[76] Xu, D., Sheraz, M., Hassan, A., Sinha, A., & Ullah, S. (2022). Financial development, renewable energy and CO2 emission in G7 countries: new evidence from non-linear and asymmetric analysis. Energy economics, 109, 105994.https://doi.org/10.1016/j.eneco.2022.105994

[77] Wang, Z., Pham, T. L. H., Sun, K., Wang, B., Bui, Q., & Hashemizadeh, A. (2022). The moderating role of financial development in the renewable energy consumption-CO2 emissions linkage: the case study of Next-11 countries. Energy, 254, 124386.https://doi.org/10.1016/j.energy.2022.124386

[78] Wooldridge, J. M. (2010). Econometric analysis of cross section and panel data. MIT press.

[79] Wang, Y., Zhao, Z., Shi, M., Liu, J., & Tan, Z. (2024). Public environmental concern, government environmental regulation and urban carbon emission reduction—Analyzing the regulating role of green finance and industrial agglomeration. Science of The Total Environment, 924, 171549.https://doi.org/10.1016/j.scitotenv.2024.171549

[80] Yang, B., Ali, M., Hashmi, S. H., & Shabir, M. (2020). Income inequality and CO2 emissions in developing countries: the moderating role of financial instability. Sustainability, 12(17), 6810. https://doi.org/10.3390/su12176810

[81] Yasin, I., Ahmad, N., & Chaudhary, M. A. (2021). The impact of financial development, political institutions, and urbanization on environmental degradation: evidence from 59 less-developed economies. Environment, Development and Sustainability, 23, 6698-6721.https://doi.org/10.1007/s10668-020-00885-w

[82] Yu, D., Hu, K., & Hao, Y. (2024). Can China's leading officials' accountability audit of natural resources policy promote corporate emissions reduction?. Carbon Management, 15(1), 2317282.https://doi.org/10.1080/17583004.2024.2317282

[83] Zhang, Y. (2021). Greasing dirty machines: Evidence of pollution-driven bribery in China. Journal of Business Ethics, 170(1), 53-74. https://doi.org/10.1007/s10551-019-04301-w

[84] Zhao, L., Zhang, L., Sun, J., & He, P. (2022). Can public participation constraints promote green technological innovation of Chinese enterprises? The moderating role of government environmental regulatory enforcement. Technological Forecasting and Social Change, 174, 121198. https://doi.org/10.1016/j.techfore.2021.121198

[85] Zhang, L., Saydaliev, H. B., & Ma, X. (2022). Does green finance investment and technological innovation improve renewable energy efficiency and sustainable development goals. Renewable Energy, 193, 991-1000.https://doi.org/10.1016/j.renene.2022.04.16