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When in Doubt, Govern it Out: Tackling Co_2 Emission on Microfinance Institutions Efficiency

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Abstract

The objective of this study is to investigate the effect of CO_2 emissions on the financial efficiency of Microfinance Institutions (MFIs) in selected ASEAN countries from 2013 to 2020. Additionally, the study explores the moderating roles of Political Stability (PS) and Voice and Accountability (VA) in this relationship. Financial efficiency was measured using the Data Envelopment Analysis (DEA) approach, while multiple panel regression analysis was applied to assess the direct and moderating effects. The results reveal that CO_2 emissions have a significantly negative impact on the financial efficiency of MFIs. Furthermore, VA exerts a statistically significant moderating influence on the relationship between CO_2 emissions and financial efficiency, whereas PS does not show a significant moderating effect. These findings provide valuable insights for MFIs, policymakers, and researchers in formulating strategies to enhance financial efficiency while addressing environmental concerns and integrating governance factors into institutional frameworks.

Keywords: Microfinance Institutions, Voice and Accountability, Political Stability, CO_2 Emissions, Financial Efficiency

Introduction

Unlike traditional conventional banks, microfinance institutions (MFIs) have a unique funding system and loan control procedures (Ficawoyi, 2025). MFIs use social monitoring methods, which means that borrowers can create self-selected groups in their local society and communities (Das et al., 2025). This approach differs from conventional banks, which rely on market-based funding (Uddin et al., 2022). MFIs should improve their operational efficiency to stay competitive and grow their business (Cull et al., 2009). Another challenge faced by MFIs is the difficulty in accessing resources (Anwar et al., 2021; Hussain et al., 2021). Social efficiency emphasises reducing the poverty rate through financial support, while financial efficiency is focused on an MFI's ability to sustain operations and gain profit. As the financial efficiency of MFIs increases, they can use those funds to improve their growth impact and support more communities. Increasing fierce competition in the financial sector was driving this sense of urgency for MFIs (Zineelabidine et al., 2025). Thus, there is a need for MFIs to enhance financial efficiency to tackle these challenges and to stay sustainable. At the same time, MFIs faced new challenges from the increasing number of natural disasters caused by global warming and climate change (Enjolras et al., 2025). Southeast Asia is the world's fastest -growing source of CO_2 emissions because of rapid industrialisation and deforestation (Issa et al., 2025). Zhang et al. (2022), they suggested that income interruptions and asset losses resulting from climate-related disasters significantly impact non-performing loan ratios in banks due to CO_2 emissions.

The same results from Park and Kim (2020) mentioned that the stability of the financial system, such as high market, operational, and credit risks, can be affected by climate change. The main borrower groups for MFIs are those in the industry that depend on natural resources and agriculture, which are frequently exposed to climate-related risks (Yang et al., 2025). Borrower's repayment ability and loan defaults might be impacted by those risks. The MFIs might face reputational damage when they finance in carbon-intensive sectors without conducting sufficient environmental risk assessments.

Even though there have been lots of studies examining the relationship between climate risk and commercial banks' performance, the microfinance industry has been ignoring (Qi & Zhang, 2025). MFIs face equal or greater financial risk from CO_2 emissions and climate change because they typically operate in low-income, rural areas that are especially vulnerable to environmental impact dangers. Natural disasters can destroy household earnings and agricultural outputs, which makes it difficult for borrowers to meet their financial obligations and has a direct effect on the sustainability and financial stability of MFIs.

Governance quality also significantly affects the performance of MFIs, besides environmental risks (Tehulu et al., 2025). The framework introduced by the World Governance Indicators (WGI) includes a few dimensions, for instance, Political Stability (PS) and Voice and Accountability (VA). Although sustainability and institutional quality are increasingly prioritised, limited research has examined how environmental and governance factors together influence the financial efficiency of MFIs. The study aims to fill the gap created by the growing influence of environmental concerns on economic sectors by investigating how CO_2 emissions directly affect the financial efficiency of MFIs. Additionally, it evaluates how two crucial governance metrics, VA and PS, influence this relationship. By offering new empirical insights in the literature about the relationship between financial efficiency, governance indicators, and environmental sustainability in the MFIs, this study seeks to enhance current understanding.

Literature Review

CO_2 Emissions and Financial Institutions

The biggest threat to the functioning and stability of the global financial system and environmental challenges is climate change (Dorfleitner et al., 2020). The Prudential Regulation Authority (PRA) of the Bank of England has identified three primary categories of climate-related risks: liability, transition, and physical risks. Physical risks can be derived from climate-related incidents (Yahya et al., 2025). As economies move towards lower-carbon systems, transition risks increase. From the viewpoint of liability risks, as the policyholders might be affected by environmental events and submit more compensation claims, this might increase the liability risks for insurers (Zhao et al., 2024). Zhang et al. (2022) empirically linked climate variables, including CO_2 emissions, to banking performance.

Voice and Accountability and CO_2 Emissions

VA, a governance factor reflecting democratic participation, civil liberties, and government transparency, has been extensively examined about environmental performance. Barrett and Graddy (2000) showed that civil rights and political freedoms are positively connected to improved environmental quality. Similarly, Li and Reuveny (2006) found that democratic governance significantly helps in reducing human-driven environmental degradation. In Southwest Asian nations, a lower level of CO_2 emission might increase the VA in the regional perspectives from the study of Dadgara and Rohollah (2016). These results imply that environmental management should focus on two key elements: government responsibility and public engagement. Moreover, Pickering et al. (2020) demonstrate that, due to opposition from interest groups and bureaucratic delays, democratic regions may experience delays in enacting environmental policies.

Voice and Accountability and Financial Institution Efficiency

As suggested by Zubair and Khan (2014), improving transparency and avoiding unethical behaviour might enhance financial performance through reinforced accountability systems. Few researchers demonstrated a significantly positive relationship between VA and financial efficiency for banking sectors, for instance Chortareas et al. (2012), Katsushi et al. (2012), Kamarudin et al. (2016) amd Kamarudin et al. (2022). The reason behind this was that high VA can promote stronger operational discipline, a better governance system, and enhance customer confidence. On the contrary, the study by Anwar et al. (2021) found insignificant relationships between VA and MFI's financial efficiency, as well as a negatively significant impact of VA on social efficiency.

Political Stability and CO_2 Emissions

To achieve effective environmental governance, PS can play an important role in facilitating the development, enforcement, and implementation of environmental policies. As evidence proved by Bernauer and Koubi (2009) and Handoyo (2024) Political instability leads to disrupted policy continuity, undermines institutional capacity, and increases systems' vulnerability to lobbying by vested interests. Similar findings are also reported by Sohail et al. (2022) in Pakistan and by Galinato and Galinato (2012) in various other developing economies. Su et al. (2021) argued that political stability fosters income growth and enhances public awareness, thereby bolstering support for environmentally responsible governance. Adebayo et al. (2022) also provided mixed evidence, showing a positive link between political risk and emissions in high-income countries like Norway and Canada, while revealing a negative link in countries such as Germany and Denmark, suggesting that context-specific factors influence this relationship.

Political Stability and Financial Institution Efficiency

PS is often seen as crucial for the expansion of the financial sector and the efficiency of institutions. Kamarudin et al. (2018) argue that when governments are dedicated to public welfare, financial institutions function more efficiently, and borrowers are more likely to meet their obligations. Sainz-Fernandez et al. (2015) similarly found that political stability improves borrower discipline and strengthens institutional creditworthiness. Anwar et al. (2021) observed no statistically significant relationship between PS and financial efficiency and even found a negative relationship with social efficiency. This suggests that political stability alone, without good governance and accountability, may not necessarily lead to better institutional outcomes.

Research Gaps

This literature review identifies several key gaps that require further investigation. Although research on the economic and financial effects of climate change is growing, only a few studies have specifically looked at how CO_2 emissions influence the efficiency of MFIs. Most existing research concentrates on traditional financial institutions such as commercial banks and insurance companies (e.g., Park & Kim, 2020; Klomp, 2014), even though increasing evidence shows that MFIs are just as susceptible to climate-related disruptions. Second, the moderating effects of governance indicators, particularly VA and PS, on the link between CO_2 emissions and MFI efficiency are still not well studied. Previous research has primarily examined how governance directly affects environmental outcomes and institutional performance in separate analyses. Although research by Li and Reuveny (2006), Bernauer and Koubi (2009), Kamarudin et al. (2016), Anwar et al. (2021), Sohail et al. (2021), Su et al. (2021), and Adebayo et al. (2022) provides important insights, they do not examine how environmental stressors interact with governance frameworks.

Methodology

Data Sources

This study examines panel data from 176 MFIs across six Southeast Asian countries, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, and Thailand, covering the years 2013 to 2020. The data were mainly collected from the World Development Indicators (WDI), the Microfinance Information Exchange (MIX), and the World Bank DataBank. This study utilised macroeconomic factors to enhance MFIs' data, including inflation and gross domestic product (GDP). Consumer Price Index (CPI) can represent inflation; both data can be collected from the International Monetary Fund (IMF). The World Bank used to download CO_2 emissions data as it provides up-to-date environmental statistics and is reliable. VA and PS, which represent governance indicators, were downloaded from the Worldwide Governance Indicators (WGI).

Data Envelopment Analysis for Measuring MFI Efficiency

MFIs' financial efficiency was measured by the non-parametric DEA. As introduced by Banker et al. (1984), this model employs the input-oriented Variable Returns to Scale (VRS) and BCC model. DEA efficiency scores range from 0 to 1, with a score of 1 indicating full efficiency and placement on the efficiency frontier. Scores below 1 denote inefficiency. To implement the

VRS assumption, the usual CRS linear programming model is adjusted by adding a convexity constraint ($N1'\lambda = 1$), ensuring that the reference set consists only of DMUs of similar scale (Coelli et al., 2005): $min\theta,\lambda \quad \theta$, subject to $-y_i + Y\lambda \geq 0,\ \theta x_i - X\lambda \geq 0,\ N1'\lambda = 1,\ \lambda \geq 0,$ where: $N1$ is an $N \times 1$ vector of ones, λ is a vector of intensity variables, and θ represents the efficiency score. The efficiency scores derived from this approach serve as the primary measure of financial efficiency (FE) for MFIs in this study.

To consider MFIs as financial intermediaries, this study applies the "intermediation method", which is also known as the "asset approach". In the study of Haq et al. (2010), they aim to examine the efficiency of intermediation in Vietnamese MFIs. Staff salaries, total assets, and total operating expenses formed the input in this study. Output variables in this study were derived from the income from the gross loan portfolio, which comprises service charges and interest. All monetary values are converted into U.S. dollars (USD) to ease the cross-country comparisons. This study adheres to Cooper et al. (2007)'s guidelines to maintain the validity of the DEA model, which outline an appropriate ratio of DMUs to inputs and outputs, are defined as below: $n \geq \max\{m \times s, 3(m + s)\}$, where the total number of DMUs is n, the quality of inputs is m, and outputs are s. This guideline is conducted to guarantee the DEA model's robustness and ability to discriminate effectively.

Multiple Panel Regression Analysis

To specifically address unobserved variability across MFIs and over time, it uses Fixed Effects Models (FEM), Random Effects Models (REM), as well as Ordinary Least Squares (OLS) and Generalised Least Squares (GLS) approaches. The standard error estimator is used to address heteroscedasticity in the error terms, which can help to correct for heteroskedasticity and confirm consistent parameter estimates as introduced by White (1980). Hussain et al. (2021) and Anwar et al. (2021) used these models to conduct similar research. Table 1 details the variables and their measurement methods used in the regression analysis.

Table 1
Description of Variables

Variable	Note	Sources
FE	MFI financial efficiency	WBDB
CO_2 Emissions		
CO_2MIS	The emissions from the combustion of fuels in industry.	MM, WBDB
CO_2SFC	The emissions from the use of coal as an energy source.	
CO_2OTH	The emissions from the combustion of fuel for all transport activity, regardless of the sector, except for international marine bunkers and international aviation.	
Country governance		
VA	The ability of a country's citizens to take part in choosing their government, along with the freedoms of expression, association, and access to an independent media.	WGI, WBDB
PS	The risk of government destabilisation or overthrow through unconstitutional or violent means, including politically motivated violence and terrorism.	
MFI Specific Characteristics		
TA	A proxy of MFI size computed as the natural logarithm of total MFI assets.	WGI, WBDB

AGE	A proxy of MFI age is computed as the natural logarithm of the total number of years of operation of MFI.	
ROA	A proxy of profitability computed as the natural logarithm of the ratio of profits divided by total assets.	
DTE	A proxy of leverage computed as the natural logarithm of the ratio of total debts divided by total equity.	
Macroeconomic Factors		
GDP	A proxy of gross domestic product computed as the natural logarithm of the national gross domestic product.	IFM
CPI	A proxy of the consumer price index computed as the natural logarithm of the consumer price index.	

Note: WBDB (World Bank Data Bank database), MM (Mix Markets), WGI (Worldwide Governance Indicators), IMF (International Monetary Fund)

By including all the variables from CO_2 emission, country governance, MFI-specific characteristics, macroeconomic factors and dummy variable in the regression model, the following is the panel regression model of MFIs' financial efficiency:

$$FE = \alpha + \beta_1 CO_2MIS_j + \beta_2 CO_2SFC_j + \beta_3 CO_2OTH_j + \beta_4 VA_j + \beta_5 PS_j + \beta_6 TA_{ij} + \beta_7 AGE_{ij} + \beta_8 ROA_{ij} + \beta_9 DTA_{ij} + \beta_{10} GDP_j + \beta_{11} CPI + \beta_{12} COVID19_j + \varepsilon_{ij}$$

By adding VA and PS as interaction variables, this study can conduct the full estimation of the MFIs' financial efficiency model. Moderating analysis on the nexus between CO_2 emissions and MFIs' financial efficiency can be analysed through this regression model. The MFIs' financial efficiency's extended panel regression models are as follows:

$$FE = \alpha + \beta_1 CO_2MIS_j + \beta_2 CO_2SFC_j + \beta_3 CO_2OTH_j + \beta_4 VA_j + \beta_5 CO_2MIS_j{}^{*}VA_j + \beta_6 CO_2SFC_j{}^{*}VA_j + \beta_7 CO_2OTH^{*}VA_j + \beta_8 PS_j + \beta_9 CO_2MIS_j{}^{*}PS_J + \beta_{10} CO_2SFC_j{}^{*}PS_J + \beta_{11} CO_2OTH^{*}PS_J + \beta_{12} TA_{ij} + \beta_{713} AGE_{ij} + \beta_{14} ROA_{ij} + \beta_{15} DTA_{ij} + \beta_{16} GDP_j + \beta_{17} CPI_j + \beta_{18} COVID19_j + \varepsilon_{ij}$$

Results and Discussion

A total of six panel regression models were developed in this study, as there are various measures of CO_2 emissions serving as independent variables and the moderating effects. The main independent variable in Table 2, Model 1, is CO_2 emissions from construction and manufacturing industries (CO_2MIS), with VA acting as the moderating factor. The first sub-model (REM I) includes CO_2MIS, VA, and several control variables reflecting MFI-specific traits and macroeconomic conditions, excluding the COVID-19 dummy. The second sub-model (REM II) adds an interaction term (CO_2MIS * VA) to examine VA's potential moderating role on the link between CO_2MIS and financial efficiency. Similar modelling approaches are used for Models 2 and 3, replacing CO_2MIS with CO_2 emissions from solid fuel consumption (CO_2SFC) and transportation (CO_2OTH), respectively, to explore broader environmental impacts of fossil fuel emissions. Models 4 through 6 follow the same structure but replace VA with PS as the governance moderating variable. To validate the chosen estimation method, the Breusch–Pagan Lagrange Multiplier (BPLM) test was applied to all six models. The results show that the null hypothesis of no panel effect can be rejected at the 5% significance level for each model, confirming that the GLS method is suitable for addressing heteroskedasticity and autocorrelation. After this, the Hausman test was used to select between the FEM and the REM. Since all p-values exceeded 5%, the REM was deemed the most appropriate. Therefore, the subsequent discussion is based on the REM estimates.

Effect of CO_2 Emissions on MFI Financial Efficiency

The regression results shown in Table 2 offer strong evidence that CO_2 emissions negatively impact MFI financial efficiency, especially for CO_2SFC. In Model 2 (REM I and REM II) and Model 5 (REM I), the coefficients for CO_2SFC are negative and significant at the 1% level. MFI's financial efficiency decreases because of the higher CO_2 emissions from solid fuel. These findings support previous studies that determined the significant influence that CO_2 emissions and climate-related environmental damage can have on the financial industry, especially those that provide microfinance and other services to underserved and vulnerable groups. Climate change can be mainly caused by CO_2 emissions, which lead to increasingly severe natural disasters (Dewi et al., 2025). MFIs that provide micro-insurance services with limited capital might face financial stress.

Does Country Governance Moderate the Relationship between CO_2 Emissions and MFI Financial Efficiency?

As shown in Model 2 (REMII), the regression analysis proved that VA has a significantly negative impact on financial efficiency at 5% significance level. On the other hand, the results demonstrate that insignificant relationship between PS and financial efficiency for all the models. The non-significance of PS as a predictor or moderator aligns with Anwar et al. (2021), who noted that while political stability influences long-term economic growth, it might not directly or immediately affect the operational efficiency of specialised financial entities such as MFIs. Regarding interaction effects, only one term, CO_2SFC * VA in Model 2 (REM II), is statistically significant at the 5% level. This term has a positive coefficient, indicating that VA moderates and mitigates the adverse effect of CO_2 emissions from solid fuel consumption on financial efficiency. Essentially, while high CO_2SFC levels are linked to lower MFI efficiency, strong citizen voice and accountability mechanisms can help insulate MFIs from these environmental impacts. VA may temporarily enhance financial efficiency through pro-growth and populist policies, but this may come at the expense of long-term environmental sustainability and financial system resilience. Importantly, none of the interaction terms with PS are statistically significant, implying that PS does not significantly moderate the link between CO_2 emissions and MFI financial efficiency. This may indicate that political stability alone, without robust participatory governance or environmental policies, cannot mitigate the adverse financial effects of environmental degradation.

Regarding institutional characteristics, the consistent results indicate that TA have a significant positive correlation with financial efficiency across all six models at the 5% significance level. This supports extensive research showing that larger MFIs benefit from scale, as they generally have greater operational capacity, improved access to financial resources, a more diverse range of services, and stronger risk management systems (Quayes, 2012; Wijesiri et al., 2017). Moreover, MFIs' operational efficiency and resilience can be increased by serving more customers, operating more branches and being better positioned to tackle financial shocks (Do et al., 2023). Among the macroeconomic control variables, GDP generally demonstrates a positive and statistically significant association with financial efficiency across nearly all models. The sole exception is Model 2 (REM II), where the relationship stays positive but is only significant at the 10% level. This finding is consistent with earlier research by Mia and Soltane (2016), this excerpt emphasises that macroeconomic growth fosters financial inclusion and enhances borrower creditworthiness.

Table 2
Regression Results on the Financial Efficiency of Microfinance Institutions

Variable	Model 1						Model 2					
	OLS (I)	FEM (I)	REM (I)	OLS (II)	FEM (II)	REM (II)	OLS (I)	FEM (I)	REM (I)	OLS (II)	FEM (II)	REM (II)
C	-0.363[b]	-1.778[a]	-0.939[a]	-0.420[a]	-1.759[a]	-0.924[a]	-0.309[b]	-1.769[a]	-0.947[a]	-0.493[a]	-1.751[a]	-0.895[a]
	(0.148)	*(0.529)*	*(0.269)*	*(0.147)*	*(0.530)*	*(0.269)*	*(0.140)*	*(0.528)*	*(0.269)*	*(0.138)*	*(0.533)*	*(0.261)*
CO_2 Emissions												
CO_2MIS	-0.001[a]	0.001	0.001	-0.003[a]	0.001	-0.001						
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*						
CO_2SFC							-0.024[a]	-0.004	-0.006[a]	-0.020[a]	-0.004	-0.006[a]
							(0.003)	*(0.002)*	*(0.002)*	*(0.003)*	*(0.002)*	*(0.002)*
Moderator Country Governance: Voice and Accountability & Political Stability												
VA	-0.030	-0.026	-0.022	-0.193[a]	-0.044	-0.052	-0.114[a]	-0.031	-0.041	-0.306[a]	-0.037	-0.081[b]
	(0.039)	*(0.038)*	*(0.034)*	*(0.051)*	*(0.050)*	*(0.043)*	*(0.037)*	*(0.039)*	*(0.034)*	*(0.042)*	*(0.044)*	*(0.039)*
Interaction: CO_2 Emission and Country Governance												
CO_2MIS *VA				0.008[a]	0.001	0.002						
				(0.002)	*(0.002)*	*(0.002)*						
CO_2SFC *VA										0.039[a]	0.001	0.009[b]
										(0.004)	*(0.005)*	*(0.004)*
MFI Specific Characteristics & Macroeconomic Factors												
TA	0.014[a]	0.054[a]	0.023[b]	0.010[b]	0.053[a]	0.022[b]	0.012[a]	0.053[a]	0.023[b]	0.007	0.052[a]	0.020[b]
	(0.004)	*(0.020)*	*(0.009)*	*(0.004)*	*(0.020)*	*(0.009)*	*(0.004)*	*(0.020)*	*(0.009)*	*(0.004)*	*(0.020)*	*(0.009)*
AGE	-0.037[b]	-0.231[b]	-0.037	-0.045[a]	-0.234[b]	-0.039	-0.045[a]	-0.233[b]	-0.042	-0.038[a]	-0.234[b]	-0.039
	(0.015)	*(0.097)*	*(0.033)*	*(0.015)*	*(0.097)*	*(0.033)*	*(0.015)*	*(0.097)*	*(0.034)*	*(0.014)*	*(0.097)*	*(0.032)*
ROA	-0.117[a]	0.037	-0.025	-0.149[a]	0.039	-0.036	-0.141[a]	0.036	-0.032	-0.110[a]	0.037	-0.035
	(0.027)	*(0.282)*	*(0.051)*	*(0.027)*	*(0.282)*	*(0.052)*	*(0.024)*	*(0.282)*	*(0.048)*	*(0.023)*	*(0.282)*	*(0.046)*

DTE	0.003	-0.007	0.008	0.055^{a}	-0.007	0.015	0.019	-0.007	0.01	0.070^{a}	-0.007	0.017
	(0.018)	*(0.033)*	*(0.020)*	*(0.020)*	*(0.033)*	*(0.021)*	*(0.017)*	*(0.033)*	*(0.020)*	*(0.017)*	*(0.033)*	*(0.020)*
GDP	0.015	0.176^{a}	0.054^{b}	0.011	0.175^{a}	0.053^{b}	0.01	0.182^{a}	0.057^{b}	0.01	0.180^{a}	0.051^{c}
	(0.012)	*(0.065)*	*(0.026)*	*(0.012)*	*(0.065)*	*(0.026)*	*(0.012)*	*(0.065)*	*(0.027)*	*(0.012)*	*(0.065)*	*(0.026)*
CPI	-0.024^{a}	0.005	-0.001	-0.022^{b}	0.006	-0.001	-0.014^{c}	0.004	0	-0.013	0.004	0
	(0.009)	*(0.006)*	*(0.006)*	*(0.009)*	*(0.006)*	*(0.006)*	*(0.009)*	*(0.006)*	*(0.006)*	*(0.008)*	*(0.006)*	*(0.006*
COVID19	0.022	-0.002	0.01	0.026^{c}	-0.001	0.012	-0.024	-0.003	-0.001	-0.027^{c}	-0.003	-0.003
	(0.016)	*(0.011)*	*(0.010)*	*(0.016)*	*(0.011)*	*(0.011)*	*(0.016)*	*(0.011)*	*(0.010)*	*(0.015)*	*(0.011)*	*(0.010)*
R-squared	0.035	0.677	0.007	0.047	0.677	0.008	0.067	0.677	0.011	0.110	0.677	0.013
Adjusted R-squared	0.030	0.639	0.002	0.042	0.639	0.002	0.062	0.639	0.006	0.105	0.639	0.008
F-statistic	6.997^{a}	17.900^{a}	1.393^{a}	8.720^{a}	17.797^{a}	1.377^{a}	13.868^{a}	17.918^{a}	2.115^{b}	21.723^{a}	17.811^{a}	2.387^{a}
BPLM x^2	3013.680^{a}			2927.750^{a}			2765.280^{a}			2494.290^{a}		
Hausman x^2			0.001		0.001			0.001			0.001	
No. of Obs.	176	176	176	176	176	176	176	176	176	176	176	176
Model Used			REM			REM			REM			REM

Note: $^{a, b, c}$ indicates significance at 1%, 5% and 10% levels respectively. Figure in parentheses ( ) are standard error.

Table 2
Continued

Variable	**Model 3**						**Model 4**					
	OLS	**FEM**	**REM**	**OLS**	**FEM**	**REM**	**OLS**	**FEM**	**REM**	**OLS**	**FEM**	**REM**
	(I)	**(I)**	**(I)**	**(II)**	**(II)**	**(II)**	**(I)**	**(I)**	**(I)**	**(II)**	**(II)**	**(II)**
C	-0.396^{a}	-1.711^{a}	-0.927^{a}	-0.366^{b}	-1.733^{a}	-0.932^{a}	-0.518^{a}	-1.810^{a}	-0.935^{a}	-0.378^{a}	-1.919^{a}	-0.942^{a}
	(0.149)	*(0.529)*	*(0.270)*	*(0.150)*	*(0.529)*	*(0.271)*	*(0.135)*	*(0.526)*	*(0.265)*	*(0.138)*	*(0.529)*	*(0.267)*
CO_2 Emissions												
CO_2MIS							-0.003^{a}	0.001	0.001	-0.006^{a}	0.002^{b}	0.000
							(0.000)	*(0.000)*	*(0.000)*	*(0.001)*	*(0.001)*	*(0.001)*
CO_2OTH	-0.001^{a}	0.001	0.000	-0.001^{c}	0.001	0.000						

	(0.000)	-*(0.001)*	*(0.000)*	*(0.000)*	*(0.001)*	*(0.000)*						
Moderator Country Governance: Voice and Accountability & Political Stability												
VA	-0.039	-0.015	-0.026	0.030	-0.065	-0.032						
	(0.039)	*(0.038)*	*(0.034)*	*(0.054)*	*(0.050)*	*(0.043)*						
PS							0.243^{a}	-0.021	0.017	0.325^{a}	-0.068^{b}	0.014
							(0.020)	*(0.023)*	*(0.021)*	*(0.027)*	*(0.032)*	*(0.029)*
Interaction: CO_2 Emission and Country Governance												
CO_2OTH *VA				-0.002^{c}	0.002	0.001						
				(0.001)	*(0.001)*	*(0.001)*						
CO_2MIS *PS										-0.008^{a}	0.002^{b}	0.001
										(0.002)	*(0.001)*	*(0.001)*
MFI Specific Characteristics & Macroeconomic Factors												
TA	0.014^{a}	0.054^{a}	0.023^{b}	0.015^{a}	0.054^{a}	0.023^{b}	0.010^{b}	0.054^{a}	0.023^{b}	0.010^{b}	0.054^{a}	0.023^{b}
	(0.004)	*(0.020)*	*(0.009)*	*(0.004)*	*(0.020)*	*(0.009)*	*(0.004)*	*(0.019)*	*(0.009)*	*(0.004)*	*(0.019)*	*(0.009)*
AGE	-0.035^{b}	-0.223^{b}	-0.039	-0.032^{b}	-0.228^{b}	-0.04	-0.035^{b}	-0.225^{b}	-0.035	-0.034^{b}	-0.228^{b}	-0.035
	(0.015)	*(0.097)*	*(0.034)*	*(0.015)*	*(0.097)*	*(0.034)*	*(0.015)*	*(0.097)*	*(0.033)*	*(0.015)*	*(0.097)*	*(0.033)*
ROA	-0.108^{a}	0.039	-0.033	-0.094^{a}	0.044	-0.034	-0.092^{a}	0.035	-0.02	-0.088^{a}	0.047	-0.02
	(0.027)	*(0.282)*	*(0.054)*	*(0.028)*	*(0.282)*	*(0.055)*	*(0.026)*	*(0.282)*	*(0.050)*	*(0.025)*	*(0.282)*	*(0.050)*
DTE	0.011	-0.007	0.01	-0.011	-0.008	0.012	0.029^{a}	-0.006	0.004	0.036^{a}	-0.005	0.004
	(0.017)	*(0.033)*	*(0.020)*	*(0.021)*	*(0.033)*	*(0.021)*	*(0.009)*	*(0.033)*	*(0.018)*	*(0.009)*	*(0.033)*	*(0.018)*
GDP	0.015	0.161^{b}	0.054^{b}	0.016	0.165^{b}	0.054^{b}	0.057^{a}	0.175^{a}	0.057^{b}	0.037^{a}	0.185^{a}	0.057^{b}
	(0.012)	*(0.066)*	*(0.026)*	*(0.012)*	*(0.066)*	*(0.026)*	*(0.012)*	*(0.065)*	*(0.026)*	*(0.013)*	*(0.065)*	*(0.026)*
CPI	-0.025^{a}	0.005	-0.001	-0.025^{a}	0.006	-0.001	-0.022^{a}	0.006	-0.002	-0.013	0.004	-0.002
	(0.009)	*(0.006)*	*(0.006)*	*(0.009)*	*(0.006)*	*(0.006)*	*(0.008)*	*(0.006)*	*(0.006)*	*(0.009)*	*(0.006)*	*(0.006)*
COVID19	0.018	-0.002	0.01	0.014	0.001	0.01	0.029^{b}	0.001	0.012	0.026^{c}	0.001	0.012

	(0.016)	*(0.011)*	*(0.010)*	*(0.016)*	*(0.011)*	*(0.011)*	*(0.014)*	*(0.010)*	*(0.010)*	*(0.014)*	*(0.010)*	*(0.010)*
R-squared	0.031	0.676	0.007	0.033	0.677	0.007	0.108	0.677	0.007	0.118	0.677	0.007
Adjusted R-squared	0.026	0.639	0.002	0.027	0.639	0.002	0.103	0.639	0.002	0.113	0.639	0.002
F-statistic	6.219^{a}	17.899^{a}	1.406^{a}	5.949^{a}	17.833^{a}	1.267^{a}	23.509^{a}	17.907^{a}	1.436^{a}	23.491^{a}	17.866^{a}	1.291^{a}
BPLM x^2	3035.480^{a}			3019.650^{a}			2347.970^{a}			2322.870^{a}		
Hausman x^2			0.001			0.001			0.001			0.001
No. of Obs.	176	176	176	176	176	176	176	176	176	176	176	176
Model Used			REM			REM			REM			REM
Note: $^{a, b, c}$ indicates significance at 1%, 5% and 10% levels respectively. Figure in parentheses ( ) are standard error.												

Table 2
Continued

Variable	**Model 5**						**Model 6**					
	OLS	**FEM**	**REM**	**OLS**	**FEM**	**REM**	**OLS**	**FEM**	**REM**	**OLS**	**FEM**	**REM**
	(I)	**(I)**	**(I)**	**(II)**	**(II)**	**(II)**	**(I)**	**(I)**	**(I)**	**(II)**	**(II)**	**(II)**
C	-0.493^{a}	-1.815^{a}	-0.930^{a}	-0.495^{a}	-1.810^{a}	-0.926^{a}	-0.490^{a}	-1.723^{a}	-0.923^{a}	-0.231	-1.934^{a}	-0.914^{a}
	(0.137)	*(0.525)*	*(0.260)*	*(0.138)*	*(0.526)*	*(0.260)*	*(0.135)*	*(0.526)*	*(0.267)*	*(0.143)*	*(0.534)*	*(0.268)*
CO_2 Emissions												
CO_2SFC	0.022^{a}	-0.004	-0.006^{a}	-0.023^{a}	-0.002	-0.004						
	(0.003)	*(0.002)*	*(0.002)*	*(0.006)*	*(0.004)*	*(0.004)*						
CO_2OTH							-0.002^{a}	0.001	0.001	-0.005^{a}	0.002^{b}	0.001
							0.000	*(0.001)*	*0.000*	*(0.001)*	*(0.001)*	*(0.001)*
Moderator Country Governance: Voice and Accountability & Political Stability												
PS	0.162^{a}	-0.029	0.007	0.166^{a}	-0.038	-0.002	0.264^{a}	-0.027	0.022	0.346^{a}	-0.082^{b}	0.023
	(0.019)	*(0.023)*	*(0.021)*	*(0.031)*	*(0.030)*	*(0.027)*	*(0.021)*	*(0.023)*	*(0.021)*	*(0.026)*	*(0.033)*	*(0.030)*
Interaction: CO_2 Emission and Country Governance												
CO_2SFC *PS				-0.001	0.002	0.003						
				(0.008)	*(0.005)*	*(0.005)*						
CO_2OTH *PS										-0.006^{a}	0.002^{b}	0.001
										(0.001)	*(0.001)*	*(0.001)*

MFI Specific Characteristics & Macroeconomic Factors												
TA	0.010[b]	0.053[a]	0.023[b]	0.010[b]	-1.810[a]	0.023[b]	0.010[b]	0.054[a]	0.023[b]	0.009[b]	0.054[a]	0.023[b]
	(0.004)	*(0.019)*	*(0.009)*	*(0.004)*	*(0.019)*	*(0.009)*	*(0.004)*	*(0.019)*	*(0.009)*	*(0.004)*	*(0.019)*	*(0.009)*
AGE	-0.024[c]	-0.226[b]	-0.037	-0.024[c]	-0.224[b]	-0.038	-0.038[a]	-0.217[b]	-0.039	-0.037[b]	-0.230[b]	-0.039
	(0.014)	*(0.097)*	*(0.032)*	*(0.014)*	*(0.097)*	*(0.032)*	*(0.015)*	*(0.097)*	*(0.033)*	*(0.015)*	*(0.097)*	*(0.033)*
ROA	-0.059[b]	0.033	-0.021	-0.059[b]	0.035	-0.021	-0.104[a]	0.035	-0.03	-0.099[a]	0.057	-0.031
	(0.025)	*(0.282)*	*(0.045)*	*(0.025)*	*(0.282)*	*(0.045)*	*(0.026)*	*(0.282)*	*(0.053)*	*(0.026)*	*(0.282)*	*(0.053)*
DTE	0.005	-0.006	0.001	0.006	-0.005	-0.001	0.042[a]	-0.006	0.006	0.033[a]	-0.005	0.006
	(0.010)	*(0.033)*	*(0.018)*	*(0.011)*	*(0.033)*	*(0.018)*	*(0.009)*	*(0.033)*	*(0.018)*	*(0.009)*	*(0.033)*	*(0.018)*
GDP	0.046[a]	0.181[a]	0.058b	0.046[a]	0.179[a]	0.057[b]	0.058[a]	0.156[b]	0.058[b]	0.024[c]	0.183[a]	0.057[b]
	(0.012)	*(0.065)*	*(0.026)*	*(0.013)*	*(0.065)*	*(0.026)*	*(0.012)*	*(0.066)*	*(0.026)*	*(0.014)*	*(0.067)*	*(0.026)*
CPI	0.024[a]	0.005	-0.001	-0.024[a]	0.005	-0.001	-0.018[b]	0.006	-0.002	-0.007	0.004	-0.002
	(0.008)	*(0.006)*	*(0.006)*	*(0.008)*	*(0.006)*	*(0.006)*	*(0.008)*	*(0.006)*	*(0.006)*	*(0.009)*	*(0.006)*	*(0.006)*
COVID19	0.013	0.001	0.003	-0.013	0.002	0.004	0.027[c]	-0.001	0.013	0.019	0.001	0.013
	(0.015)	*(0.010)*	*(0.009)*	*(0.015)*	*(0.010)*	*(0.010)*	*(0.014)*	*(0.011)*	*(0.010)*	*(0.014)*	*(0.011)*	*(0.010)*
R-squared	0.099	0.677	0.010	0.100	0.677	0.010	0.111	0.677	0.007	0.124	0.678	0.008
Adjusted R-squared	0.095	0.639	0.005	0.094	0.639	0.005	0.106	0.639	0.002	0.119	0.640	0.002
F-statistic	21.483[a]	17.933[a]	2.030[b]	19.326[a]	17.828[a]	1.853[b]	24.258[a]	17.919[a]	1.459[a]	24.799[a]	17.897[a]	1.328[a]
BPLM x^2	2434.410[a]			2433.410[a]			2357.410[a]			2324.430[a]		
Hausman x^2			0.001			0.001			0.001			0.001
No. of Obs.	176	176	176	176	176	176	176	176	176	176	176	176
Model Used			REM			REM			REM			REM

Note: [a, b, c] indicates significance at 1%, 5% and 10% levels respectively. Figure in parentheses ( ) are standard error.

Conclusion

The analysis uncovers key insights into sustainable finance in emerging markets. Notably, it finds that CO_2 emissions (measured as CO_2SFC) have a significant negative impact on the financial efficiency of MFIs. This inverse relationship indicates that environmental damage, reflected by carbon emissions, incurs tangible costs for financial institutions, possibly due to higher operational risks, stricter regulations, or climate-related economic disruptions. The study's most significant contribution is its focus on governance moderators. It shows that, when looking at the interaction between CO_2 emissions and VA, the analysis uncovers a surprising reversal of the initial relationship. The positive sign of the CO_2SFCVA interaction term suggests that strong governance, especially transparency and public participation, can not only reduce but turn the negative effect of emissions into a positive link with financial efficiency. This implies that in settings with strong accountability, MFIs might develop adaptive capabilities to turn environmental issues into chances for innovation and better performance.

The study, in contrast, finds no evidence that PS influences the relationship between emissions and efficiency. This unexpected result is noteworthy because it questions the common belief that political stability is crucial for financial sector performance. It suggests that although political turbulence can impact macroeconomic indicators, the link between environmental factors and MFI efficiency functions independently of overall political stability.

The study confirms that institutional scale (TA) and national economic development (GDP) positively influence financial efficiency, aligning with existing research. The consistent significance of these relationships across different models strengthens the credibility of the main findings related to environmental and governance factors. Meanwhile, other control variables do not show significant effects, which helps to isolate the key relationships of interest.

These findings have significant practical implications for various stakeholders. For MFI managers, the evidence clearly shows that environmental factors directly influence financial outcomes, highlighting the importance of incorporating sustainability into strategic planning. The moderating role of VA indicates that investing in transparency and stakeholder engagement can enhance resilience against environmental pressures. Practical operational advice includes creating green financial products, adopting environmental risk assessment processes, and achieving sustainability certifications. Additionally, the findings imply that climate-related financial policies should be customised to suit various governance environments, since the success of these measures may rely on existing institutional strengths.

From a theoretical standpoint, this research offers several key contributions. It broadens the sustainable finance literature by showing that environmental-financial relationships depend on institutional settings. The study also furthers governance theory by differentiating among various governance dimensions and their diverse effects on financial-environmental connections. Additionally, the findings add to the expanding research on climate adaptation within financial systems, especially in vulnerable emerging markets.

This study highlights several promising avenues for future research. First, further exploration is needed into how VA influences the emissions-efficiency relationship, possibly using qualitative case studies. Second, expanding the research to include other governance aspects or different environmental indicators could provide valuable insights. Third, applying the framework to different financial sectors or regions would test the broader applicability of the findings. Lastly, conducting longitudinal studies could reveal how these relationships change over time, especially as the effects of climate change become more severe.

In summary, this research offers solid evidence that CO_2 emissions negatively impact MFI financial efficiency, with governance quality significantly moderating this effect. The results challenge simple views of environmental and financial tradeoffs by illustrating how strong institutions can turn ecological issues into opportunities for improving efficiency. As the world faces the twin goals of financial inclusion and environmental sustainability, these insights are valuable for practitioners, policymakers, and scholars working at this vital crossroads. The findings highlight the need for integrated strategies that address environmental, financial, and governance factors together, fostering more resilient and sustainable financial services in developing countries.

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