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SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 12201-12212
Open Access. Online & Print

DOI: 10.5281/zenodo.20314831

THE CONDITIONAL IMPACT OF FINANCIAL DEVELOPMENT ON CO_2 EMISSIONS: THE THRESHOLD ROLE OF GOVERNMENT EFFECTIVENESS

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Received: 07/04/2026
Accepted: 08/05/2026

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ABSTRACT

This study examines the relationship between financial development and carbon dioxide (CO_2) emissions by incorporating the moderating role of government effectiveness. Using an unbalanced panel dataset covering 85 countries over the period 2009–2020, the analysis employs a panel threshold regression model based on Hansen's methodology to capture potential nonlinearities. The results identify a statistically significant governance threshold at approximately −0.6. Below this threshold, financial development has a positive and statistically significant effect on CO_2 emissions, which can be attributed to weak institutional capacity that allows financial resources to be directed toward carbon-intensive activities with limited regulatory oversight. Above the threshold, the effect of financial development on emissions consistently weakens across all model specifications, with smaller coefficients and reduced statistical significance, indicating that stronger governance structures can partially mitigate the environmental impact of financial expansion. The study contributes to the literature by demonstrating that the environmental consequences of financial development are conditional on institutional quality and highlight the critical role of governance in aligning financial systems with sustainability objectives.

KEYWORDS: Financial Development, CO_2 Emissions, Government Effectiveness, Threshold Model.

JEL Codes: Q53, G20, C23, O44

1. INTRODUCTION

Today, climate change and planetary warming are amid the most critical matters on the agenda of governments worldwide (Wen *et al.*, 2022). CO_2, one of the main drivers of these problems, dominates the man-made greenhouse gas emissions. Therefore, carbon emissions occupy a central place in climate research (Liang *et al.*, 2024). Indeed, this trend is supported by concrete indicators. In the last 50 years, the number of climate-related adversities has rose fivefold, and economic harms have increased sevenfold; an average of $202 million in damages occurs daily (Yuan *et al.*, 2025). For this reason, UN-defined SDGs and global climate agreements have made reducing greenhouse gas emissions an urgent priority (United Nations, 2015; UNFCCC, 2015). When all these are considered together, managing the environmental and economic impacts of greenhouse gas emissions constitutes a strategic priority for countries.

Numerous policies and factors contribute to the management of carbon emissions. Factors frequently examined in the literature include variables such as energy use, economic development, trade openness, and technological advancement (Hossain, 2011; Liang *et al.*, 2024). However, the impact of these factors can be two-sided in the management of carbon emissions. Trade openness can be beneficial in the promotion of clean production technologies through the introduction of new technologies and foreign direct investments. Trade openness can also increase carbon emissions through the introduction of polluting industries (Bakri *et al.*, 2025). Financial development is also a factor with a two-way effect on emissions. Advanced financial systems can encourage environmentally friendly investments by providing low-cost financing for renewable energy and clean technology projects. Conversely, financial development can lead to the expansion of economic activity by facilitating access to credit. This can increase energy consumption, leading to higher CO_2 emissions (Abbasi and Riaz, 2016).

These factors can be analyzed separately, but it is essential to note that these factors are linked to the institutional capacity of the country. The quality of the institutional structure is a determining factor for the formulation, implementation, and monitoring of environmental policies. Proper administration of the government can become a factor for the reduction of carbon emissions through the implementation of environmental policies, the use of clean technology, and the implementation of environmental standards (Cooray and Özmen, 2024; Yuan *et al.*, 2025). In addition, the implementation of environmental policies can be low in countries with low institutional capacity, leading to the low internalization of the environmental costs of the activities of the country's economy. Thus, even if two countries have the same economic or financial conditions, the quality of governance and the administration of the country can become a factor for the differentiation of carbon emissions. In this context, government effectiveness is considered a critical institutional element that shapes the success of environmental policies and can influence the environmental outcomes of other economic factors.

A growing number of studies have shown that the relationship between these variables may not be linear. For example, in the threshold approach, countries can be categorized as "low" and "high" governance quality regimes, and the effects of the same factors in different contexts can be examined. Indeed, Cheikh and Rault (2024) showed that the effect of financial inclusion varies according to the country's income level: in low-income countries, financial inclusion rises CO_2 emissions, while in high-income nations, financial inclusion improves environmental quality. Similarly, Yadav *et al.* (2024), while examining the influence of renewable energy investments on emissions, argued that there is a threshold of government effectiveness that must be reached for renewable energy investments to diminish CO_2 emissions. These studies support the idea that governance quality can alter the effectiveness of other policy tools.

This study aims to evaluate the role of government effectiveness as a variable in examining the factors affecting per capita carbon emissions within the framework of a threshold approach for a group of countries. In this context, it investigates whether the influencing factors, like financial development, energy consumption, and trade openness, on carbon emissions differ depending on the level of government effectiveness. In other words, it analyzes how the impacts of these economic variables on carbon emissions change in regimes with low and high government effectiveness. Accordingly, the study examines the influence of financial development on CO_2 emissions as a function of the government effectiveness threshold using a regime-based (threshold) model.

This paper provides multiple contributions to the literature. Firstly, it contributes methodologically. While the relationships between carbon emissions and economic variables are often examined using linear models, this research employs a regime-based approach that considers that these relationships may differ around a specific threshold. This aims to move beyond linear assumptions and obtain more differentiated inferences. Secondly, by treating government effectiveness as a threshold, the study aims to demonstrate that the environmental consequences of economic factors can vary depending on institutional capacity. Thus, the combined effect of economic and institutional factors, which are often considered separately in the literature, is analyzed. Thirdly, while a significant portion of existing studies focus on specific country groups or regions, this research examines as broad a group of countries as possible. In this respect, it is expected that the findings will contribute to generating more general policy implications.

2. LITERATURE REVIEW

Carbon dioxide emissions, central to global climate change discussions, have also found extensive coverage in economic literature. Particularly with industrialization, increasing energy demand, and the acceleration of global economic activity, the environmental and economic impacts of CO_2 emissions have become a significant focus of academic research. Generally, the literature adopts a multidimensional and interdisciplinary research approach to explain the dynamics of CO_2 emissions. We see various studies that examine both regions within a country and those covering different country groups or regions (Wang *et al.*, 2019; Zhang *et al.*, 2024). In addition, studies that consider sectoral differences are also observed (Georgatzi *et al.*, 2020; Ata *et al.*, 2023). These studies utilize different theoretical frameworks and empirical approaches to explain emission dynamics (Dong *et al.*, 2019; Thio *et al.*, 2022). In this context, it is observed that various variables representing factors such as economic, technological, structural, and governance quality are included in the analyses (See: Ang, 2009; Aller *et al.*, 2021; Khan *et al.*, 2022; Ifelunini *et al.*, 2023). Therefore, in this part of our study, empirical studies examining the factors affecting emissions will be discussed within the framework of the variables used and methodological approaches, and the general trends in the literature will be revealed.

Trade openness and fossil energy consumption are key factors shaping CO_2 emissions through the intensity of economic activity, the structure of production processes, and energy use habits. Increased trade openness can increase emissions by affecting economic activity; conversely, it can also have emission-reducing effects through technology transfer and the spread of cleaner production techniques. In the empirical literature, the path and extent of this association vary relying on the region and period. For example, Dou *et al.* (2021) found that trade openness in China generally increases greenhouse gases, but regional trade agreements can mitigate this effect, with imports increasing emissions while exports have a mitigating effect. In their panel data analysis for 64 countries under the Belt and Road Initiative, Chen *et al.* (2021) showed that the effect of trade openness on increasing CO_2 emissions varies at different CO_2 levels, and indirect effects can be negative through energy substitution and technology. Zhang *et al.* (2017) showed that trade openness reduces CO_2 emissions in the long term in ten newly industrialized countries. In addition, fossil energy consumption stands out as a direct determinant of CO_2 emissions. Lin and Xu (2020) found that the abundance of fossil energy in China shows different effects across regions; a positive "U-shaped" effect in the eastern and central regions, and an inverse "U-shaped" effect in the western region. Ali *et al.* (2020) showed that in the case of Pakistan, fossil fuel consumption increased CO_2 emissions in both the short and long term, and the effect of economic development was inverted "U-shaped". Similarly, Li and Haneklaus (2021) found that in China, fossil fuel uses significantly increased CO_2 emissions, while renewable energy use played a role in reducing emissions in the long term. These findings reveal that the effects of trade openness and energy use on CO_2 emissions are complex and context-dependent, and can provide environmental benefits when supported by technological innovation and renewable energy.

Financial development and institutional quality are critical factors in shaping CO_2 emissions. The depth and efficiency of the financial system can directly or indirectly reduce environmental impacts by facilitating the financing of clean energy investments and improving resource allocation; conversely, emissions may increase when financial development is not compatible with environmental regulations. The empirical literature shows both positive and negative aspects of this relationship. For instance, Shoaib *et al.* (2022), in their panel ARDL model on the impact of financial development on the G8 and D8 countries, revealed the long-run impact of financial development on the emission of CO_2, where energy consumption and trade openness augment the impact. On the other hand, Khan and Ozturk (2021), in their study of 88 developing countries, found that financial development helps reduce emissions by mitigating environmental impacts stemming from income, trade, and FDI. Habiba and Xinbang (2022), examining the sub-dimensions of financial market and institutional development, showed that while financial development improves environmental quality in developed countries, some financial indicators can negatively affect environmental quality in developing countries. Studies focusing on institutional quality similarly report critical findings about CO_2 emissions. Haldar and Sethi (2021) showed that the combined effect of institutional quality and sector-based energy usage significantly reduced emissions in 39 developing economies; Yang *et al*. (2022) found that the interaction between income inequality and institutional quality reduced CO_2 emissions in 42 developing countries. Similarly, Jahanger *et al*. (2022), in their study covering 73 developing countries, showed that institutional quality and natural resource management limited environmental impacts and confirmed the EKC and PHH hypotheses with threshold-dependent moderation effects.

In recent years, the use of threshold analyses, moving beyond linear models, has become increasingly common in the literature on CO_2 emissions. This approach reveals that the environmental impacts of factors such as economic growth, institutional quality, financial development, or technological innovation can vary at certain levels and that this variation is not linear. For example, Subramaniam *et al*. (2024) conducted a panel threshold modeling study on 99 countries, showing that economic growth increases CO_2 emissions when institutional quality is below a certain threshold, but decreases when the threshold is exceeded; the study also confirmed the EKC hypothesis. Similarly, Yang *et al*. (2021) explored the influence of technology transfer on CO_2 in China and found that exceeding threshold values for intellectual property rights and transportation infrastructure can increase environmental pressure. Addressing the role of financial development, Yu *et al*. (2022) showed that innovation improves environmental conditions once private sector credit and stock market size exceed certain thresholds. In Saudi Arabia, Omri *et al*. (2021) found that financial sector development only had a CO_2 emission-reducing effect when combined with good institutional and political governance. Shahnazi *et al*. (2025) showed that in high- and middle-income economies, the informal sector's CO_2 emission-reducing effect is strengthened when ICT use exceeds threshold values.

The literature examines numerous variables related to CO_2 emissions, primarily economic, energy, trade, financial, and institutional factors. However, the findings of these studies can vary significantly depending on the region, methodology, analysis period, and dataset used. Recent research, in particular, focuses on threshold values, differing from classical linear approaches. Threshold-value analyses reveal that the effects of factors such as economic growth, financial development, institutional quality, or technological innovation can vary at certain levels. In this respect, such analyses allow for more accurate modeling of the complex mechanisms influencing CO_2 emissions. In this context, conducting a comprehensive study that examines variables such as financial development and institutional quality in the context of threshold values will enable a more robust identification of the mechanisms affecting CO_2 emissions. Therefore, comprehensive analyses using the threshold-value approach make a significant contribution to the current literature and can provide outcomes that can guide sustainable development and carbon reduction policies.

3. DATA DESCRİPTİON

This study is based on an annual unbalanced panel dataset covering the period 2009-2020. To reflect the heterogeneous nature of governance and financial development, the scope includes developed and underdeveloped countries from diverse geographical regions; small island nations and similar countries have been excluded. Due to the requirement for complete availability of data for all variables, the actual sample size varies between 85 and 97 countries according to the specification. The year 2009 was chosen as the starting point to isolate the structural effects of the 2008 global financial crisis. The World Bank's Financial Development Index has not been published since 2020. Essentially, this situation has also prepared a suitable ground for the analysis. Thus, the years following the COVID-19 pandemic, which emerged in 2020, another crisis, have been excluded from the analysis. The twelve-year observation period does not create a period long enough to raise concerns about unit roots in the panel time series. The short time dimension of the dataset (T = 12) limits the reliability and power of conventional tests, as noted in the Stata panel unit-root documentation. While providing sufficient time series variation for the fixed effects estimator, the panel also keeps the risk of autocorrelation limited. Descriptive statistics for the variables are presented in Table 1 below.

Table 1: Descriptive Statistics.

Variable	*N*	*Mean*	*SD*	*Min*	*Max*
log (CO_2 per capita)	1,015	1.080	1.290	−2.710	3.780
Government Effectiveness (GOV)	1,015	0.265	0.937	−2.170	2.310
Financial Development Index (FD)	1,015	0.408	0.238	0.075	0.955
log (Energy Use per capita)	1,015	7.370	1.030	4.730	9.970
Trade Openness (Trade/GDP, %)	1,015	84.900	56.200	22.100	383.000

Notes: Core Controls sample. N = 1,015 observations, 85 countries, 2009–2020. CO_2 and energy use are log-transformed. GOV = Government Effectiveness Estimate (World Bank WGI, scale −2.5 to +2.5). FD = Financial Development Index (IMF, normalized 0–1). log (CO_2) = natural log of CO_2 emissions per capita (metric tons). log (Energy) = natural log of energy uses per capita (kg of oil equivalent). Trade/GDP = trade openness ratio (%). Statistics computed on the estimation sample after listwise deletion of missing observations.

Per capita CO_2 emissions (metric tons) were used as the dependent variable. Data was obtained from the World Bank's World Development Indicators database. Natural logarithmic transformation was applied in the regression analysis to reduce asymmetric distribution and heteroskedasticity. The main explanatory variable, the Financial Development Index, is a composite indicator combining the depth, reach, and efficiency dimensions of financial institutions and markets, and is normalized between 0 and 1. Higher values correspond to advanced financial development. The composite structure of the index allows it to capture the financial system in a multidimensional way, compared to alternative measures that only consider banking system credit volume. In the panel threshold model, the Government Effectiveness Estimate (GEE) from the World Bank's World Governance Indicators (WGI) is used as the moderator variable. This indicator measures the quality of public services, civil service capacity, the level of commitment to national policies, and the reliability of their implementation. The indicator is expressed on a standardized scale between -2.5 and +2.5, with higher values indicating more effective governance. The sample mean is positive at 0.265, while the wide distribution of the standard deviation (0.937) suggests that the sample contains significant heterogeneity in terms of institutional quality (Table 1). Two key control variables predicted in the literature were included in the analysis. Per capita energy consumption (oil equivalent kg) is used to capture energy intensity, a key determinant of emissions. Trade openness is measured as the sum of exports and imports as a percentage of GDP, and both control data are compiled from the World Bank database.

Four specifications using different control set combinations were estimated: a model without control variables, Sub-1 including only trade openness; Sub-2 including only energy consumption; and the Basic Controls model including both control variables. This multiple specification strategy serves as a robustness test to demonstrate that the findings are independent of a particular control set choice.

4. EMPIRICAL FRAMEWORK

Standard panel models, which assume a linear effect of financial development on CO_2 emissions, are not sufficiently flexible. Hansen (1999, 2000) developed the panel threshold regression model to explain such situations. The threshold regression used in this study allows testing whether this effect differs below and above a certain threshold value. In other words, the hypothesis that the effect of financial development exhibits a structural break depending on the level of institutional quality is directly tested.

The basic model is specified as follows:

$$\log (CO_2it) = \alpha i + \lambda t + \delta \cdot GOVit + \beta 1 \cdot FDit \cdot \mathfrak{B}\,(GOVit \leq \gamma) + \beta 2 \cdot FDit \cdot \mathfrak{B}\,(GOVit > \gamma) + \beta X \cdot Xit + \varepsilon it$$

Here, i represents the country, t the year; αi represents the country fixed effect, λt the year fixed effect; GOVit represents the governance efficiency estimate; FDit represents the financial development index; Xit represents the control variables; (·) represents the indicator function; γ represents the threshold parameter; and β1 and β2 represent the FD coefficients (beta_low and beta_high) in low and high governance regimes, respectively. In practice, the FD variable is included in the model only through regime-specific terms; the main FD variable is not included separately in order to avoid the perfect multicollinearity problem, as stated in Hansen (2000).

The threshold parameter γ is determined using the grid search method as the value that minimizes the sum of squares (RSS), as suggested by Hansen (1999). Threshold candidates are systematically searched within a defined range based on the observed distribution of the governance variable. For each candidate value, the Fixed Effects Least Squares (FE-OLS) estimator is applied; the value that minimizes the RSS is taken as the threshold estimate. Country and year fixed effects are included in the model to control for unobservable country-specific heterogeneity (i.e., institutional, geographical, and structural factors that do not change over time). This approach is directly compatible with the panel threshold regression framework and eliminates endogenity caused by unobserved country characteristics by estimating through the within estimator. Although the Hausman test does not reject the random-effects specification (t = 0.0058; p = 0.999), the fixed-effects approach is retained for both theoretical and methodological reasons. Hansen's (1999) panel threshold model is developed within a fixed-effects framework, and the purpose of the present empirical design is to control for unobserved country-specific heterogeneity, which is central in a cross-country study involving governance, financial development, and carbon emissions. In addition, fixed effects provide a more conservative approach in the presence of potentially omitted time-invariant country characteristics that may correlate with governance and financial development variables (Wooldridge, 2010).

The significance of the threshold parameter is assessed using the bootstrap likelihood ratio (LR) test, based on Hansen (1999). The null hypothesis states that the linear model is adequate — in other words, that there is no threshold effect. Under the null hypothesis, bootstrap samples are generated with B = 999 iterations, and the LR statistic is calculated in each iteration; the proportion of bootstrap samples exceeding the observed statistic gives the bootstrap p-value.

The 95% confidence interval for the threshold value is calculated using the LR inversion method proposed by Hansen (1999, 2000). In this method, all threshold candidates for which the LR statistic is below the critical value (7.35) are included in the confidence interval; thus, asymmetric intervals can be constructed, unlike the conventional symmetric approach.

The statistical significance of the coefficient difference between the two regimes is evaluated using the Wald test, which tests the null hypothesis H_0: β_low = β_high. The test statistic follows a chi-square distribution with one degree of freedom and is calculated based on the variance–covariance matrix of the regression coefficients. Standard errors of the coefficient estimates are calculated clustered at the country level to account for within-country autocorrelation in the panel.

The threshold equations estimated for the four specifications are structured as follows, differing in terms of the inclusion of control variables. Here, the goal is to observe the robust effect of governance under all conditions.

No Controls: $\log(CO_2it) = \alpha i + \lambda t + \delta \cdot GOVit + \beta 1 \cdot FDit \cdot \mathfrak{B}\,(GOVit \leq \gamma) + \beta 2 \cdot FDit \cdot \mathfrak{B}\,(GOVit > \gamma) + \varepsilon it$

Alt 1 — Trade Openness Only: $\log(CO_2it) = \alpha i + \lambda t + \delta \cdot GOVit + \beta 1 \cdot FDit \cdot \mathfrak{B}\,(GOVit \leq \gamma) + \beta 2 \cdot FDit \cdot \mathfrak{B}\,(GOVit > \gamma) + \beta T \cdot Tit + \varepsilon it$

Alt 2 — Energy Consumption Only: $\log(CO_2it) = \alpha i + \lambda t + \delta \cdot GOVit + \beta 1 \cdot FDit \cdot \mathfrak{B}\,(GOVit \leq \gamma) + \beta 2 \cdot FDit \cdot \mathfrak{B}\,(GOVit > \gamma) + \beta E \cdot \log(Eit) + \varepsilon it$

Core Controls: $\log(CO_2it) = \alpha i + \lambda t + \delta \cdot GOVit + \beta 1 \cdot FDit \cdot \mathfrak{B}\,(GOVit \leq \gamma) + \beta 2 \cdot FDit \cdot \mathfrak{B}\,(GOVit > \gamma) + \beta E \cdot \log(Eit) + \beta T \cdot Tit + \varepsilon it$

In the equations, T represents trade openness (Trade/GDP), and E represents per capita energy consumption. The financial development variable (FD) and the trade openness variable are not log-transformed; the governance variable (GOV) is exempt from log transformation because it can take negative values.

5. FINDINGS

Panel threshold regression estimation results are presented in Table 3. Table 2 includes the linear fixed effects model as the baseline comparison, while Table 3 presents the full coefficient tables for the threshold model across four specifications. In the discussion below, the findings are addressed in a sequence from the Uncontrolled specification to the Basic Controls model.

The linear fixed effects model (Table 2) does not account for the threshold structure and shows the average linear effects of FD and GOV. In the Basic Controls model, which includes energy consumption and trade openness variables, the FD coefficient is 0.307 and statistically significant only at the 10% level ($p = 0.093$). In the specification without control variables, the FD coefficient is 1.123 and is large and statistically significant ($p < 0.001$). A key finding is that the FD coefficient in the linear model represents an average that masks differences across governance regimes. As will be seen below, the threshold models separate this mean effect into two distinct regime-specific coefficients. The impact of financial development on emissions is therefore discussed in the context of the governance threshold.

Table 2: Linear Fixed Effects — Baseline Model.

Variable	*Coef.*	*SE*	*p*	*Coef.*	*SE*	*p*
	(1) Core Controls			**(2) No Controls**		
Financial Development (FD)	0.307*	0.181	0.0930	1.123***	0.294	0.0002
Government Effectiveness (GOV)	0.057	0.045	0.2035	0.206**	0.084	0.0163
log(Energy Use per capita)	1.109***	0.120	<0.001	—	—	—

Trade Openness (Trade/GDP)	0.000	0.001	0.5415	–	–	–
Observations	1,015			1,164		
Countries	85			97		
Within R^2	0.5663			0.0994		
Country & Year FE	Yes			Yes		

Notes: Dependent variable: log (CO_2 per capita). OLS with country and year fixed effects. Standard errors clustered at the country level. *** p<0.01, ** p<0.05, * p<0.10. The linear baseline is presented for comparison with the threshold model; it reflects the average effect of FD and GOV without accounting for threshold structure. In the Core Controls specification, the FD coefficient is only marginally significant (p=0.093), masking the regime heterogeneity revealed by the threshold model. Energy use per capita is the dominant predictor (p<0.001).

The models in which the threshold was estimated are shown in Table 3. As seen in Table 3.A, the estimated governance threshold is between -0.559 and -0.631 for all four models. This value is significantly below the middle of the WGI scale (-2.5 to +2.5). It represents economies where institutional quality is relatively weak, especially in developing countries. The confidence intervals for the threshold value differ according to the models. In the Uncontrolled and Lower 1 (Trade Only) specifications, the confidence interval is quite narrow at [-0.654, -0.521]. This indicates that the threshold is determined with high certainty in these specifications. Even though the confidence interval in the model with basic control variables extends to a wider range [-0.654, 1.251], narrow threshold intervals are observed in the models in general. However, as can be seen in Table 3.D, both the Wald test and the bootstrap test strongly support the existence of differences in coefficients between the regimes. The distribution of observations between regimes exhibits a striking asymmetry; observations in the high regime are numerous and generally account for between 74% and 79% of the total observations. In the Basic Controls specification, 799 observations, approximately seventy-nine percent of the sample, fall into the high-governance regime, while the remaining 216 observations fall into the low-governance regime.

When examining the regime coefficients, the *beta_low* coefficient in the low-governance regime is positive and statistically significant in all models. In the Uncontrolled specification, *beta_low* is estimated at 1.695 ($p < 0.001$); in Sub-1 with trade openness control, it is 1.823 ($p < 0.001$); in Sub-2 with energy control, it is 0.408 ($p = 0.047$); and in the Basic Controls specification, it is 0.506 ($p = 0.015$).

In the high-governance regime, the *beta_high* coefficient shows significant differences between models. In specifications including the energy consumption control variable (Basic Controls: $p = 0.121$; Sub-2: $p = 0.542$), *beta_high* is rendered statistically insignificant. In the Uncontrolled specification, which does not include energy controls, *beta_high* = 1.017 ($p < 0.001$), and in Sub-1, *beta_high* = 1.190 ($p < 0.001$), both of which remain smaller than *beta_low*. The inclusion of energy controls renders *beta_high* effectively non-significant, consistent with the mechanism by which financial development in highly governed countries impacts CO_2 through the transformation of the energy mix.

The inter-regime difference, *beta_diff* = *beta_high* - *beta_low*, is negative in all specifications, taking values of -0.678 in the Uncontrolled specification and -0.230 in the Basic Controls specification.

Table 3: Panel Threshold Regression Results.

	(1) No Controls	(2) Alt 1: Trade Only	(3) Alt 2: Energy Only	(4) Core Controls
Table 3.A: Governance Threshold Estimate				
Threshold (γ□)	−0.631	−0.631	−0.559	−0.559
95% CI (lower)	−0.654	−0.654	−0.654	−0.654
95% CI (upper)	−0.521	−0.521	0.307	1.251
N (low governance regime)	277	231	240	216
N (high governance regime)	887	851	816	799
Table 3.B: Regime Coefficients — Dep. var.: log (CO_2 per capita)				
β_low [FD × □(GOV ≤ γ□)]	1.695***	1.823***	0.408**	0.506**
Standard error	(0.391)	(0.392)	(0.203)	(0.204)
p-value	<0.001	<0.001	0.047	0.015
β_high [FD × □(GOV > γ□)]	1.017***	1.190***	0.121	0.277
Standard error	(0.281)	(0.281)	(0.197)	(0.177)
p-value	0.0005	<0.001	0.542	0.121
β_diff = β_high − β_low	−0.678	−0.633	−0.287	−0.230
Table 3.C: Direct Effect of Governance				

GOV coefficient	0.258***	0.210***	0.118*	0.081*
p-value	0.005	0.001	0.050	0.096
Table 3.D: Threshold Validity Tests (B = 999)				
Wald $\chi^2(1)$	6.309	7.646	7.432	7.032
Wald p	0.012**	0.006***	0.006***	0.008***
Bootstrap LR	11.727	28.944	15.787	30.330
Bootstrap p	0.037**	<0.001***	0.007***	0.010***
Table 3.E: Sample Information				
Observations	1,164	1,082	1,056	1,015
Countries	97	91	88	85
Period	2009–2020	2009–2020	2009–2020	2009–2020
Controls	None	Trade	Energy	Energy + Trade

Notes: Dependent variable: log (CO_2 per capita). Threshold variable: Government Effectiveness Estimate (GOV, World Bank WGI). Main variable: Financial Development Index (FD, IMF). Country and year fixed effects included in all specifications. Standard errors clustered at the country level. *** p<0.01, ** p<0.05, * p<0.10. β_low: effect of FD when GOV ≤ $\hat{\gamma}$; β_high: effect of FD when GOV > $\hat{\gamma}$. 95% confidence interval computed via Hansen (1999) LR-inversion method (critical value 7.35). Bootstrap p-values obtained with B = 999 replications under the null of linearity.

Looking at the threshold validity tests (Table 3.D), the Wald test results reject the null hypothesis H0: beta_low = beta_high for all four models. The chi-square statistic was 7.032 (p = 0.008) in the Uncontrolled specification and was found to be significant. In the model with the primary control variables, the statistic was 6.309 (p = 0.012) and was also significant. These results, obtained at the p < 0.05 level in all specifications, confirm that the difference in coefficients between the two regimes is statistically significant.

The Bootstrap LR test strongly rejects the null hypothesis regarding the adequacy of the linear model. Bootstrap p-values are 0.010 in the Uncontrolled specification, below 0.001 in Subset 1, 0.010 in Subset 2, and 0.035 in the Primary Controls specification. These results provide strong evidence of a statistically significant threshold effect in the governance variable. These results also indicate that the threshold model provides a better fit to the data than the linear specification.

The GOV coefficient is positive in all specifications: 0.258 in the model without control variables (p = 0.005), and 0.081 in the Basic Controls specification (p = 0.096). This positive relationship may be explained by the fact that high-income, institutionally strong countries already have a larger economic scale and consume more energy per capita. The main findings of the study are not in this level effect per se; rather, they lie in identifying how GOV transforms the FD–CO_2 relationship through a moderating mechanism.

The findings across the four models show considerable consistency, with the threshold located around -0.6. The estimated threshold corresponds to a level of governance quality typically observed in economies with relatively weak institutional structures. The negative value of beta_diff indicates that the effect of financial development on emissions weakens as governance quality increases. The Wald and bootstrap tests confirm that the difference between the two regimes is statistically significant. The main difference between the model specifications is observed in the significance level of beta_high; however, the beta_low coefficient is significant in all models. In regimes with low governance, financial development has a greater impact on emissions. Taken together, these findings strongly support the idea that the relationship between financial development and CO_2 emissions is nonlinear and subject to a threshold mechanism determined by the quality of governance.

6. DISCUSSION OF THE FINDINGS

This research analyzes whether the connection between the development of financial system and carbon emissions varies relying on the stage of government effectiveness. Panel threshold model results show that the effect of financial development on CO_2 emissions has a non-linear relationship with governance quality. Specifically, the findings reveal that in countries where government effectiveness remains below a certain threshold, financial development significantly increases carbon emissions; however, this effect weakens when the threshold is exceeded. These results suggest that institutional quality can shape the link between financial development and the environment.

Numerous factors could explain this positive and high-magnitude affiliation amid financial development and emissions in low-governance systems. For instance, in low-governance systems, financial development might catalyze economic growth. However, in such systems, environmental protection might not be given adequate attention. For this reason, an increase in access to credit might lead to various activities such as increased production in industries, development of infrastructure, and consumption of energy. The fact that these activities are carried out mainly through fossil fuels means that there will be a rise in carbon emissions. This is in agreement with Shoaib *et al*. (2022), who specified that financial development may enhance carbon emissions if it is not integrated sufficiently with environmental policies. Abbasi and Riaz (2016) indicate that financial development might lead to an increase in carbon emissions because it increases economic activities.

Conversely, in nations with high government effectiveness, the impact of financial development on emissions decreases compared to countries with low government effectiveness. Effective government policies may persuade the financial sector to invest in clean technology, renewable sources of energy, and energy efficiency. Therefore, financial development may be expected to promote economic growth through clean production rather than carbon-intensive production. This argument is supported by the results obtained by Khan and Ozturk (2021), which indicate that effective institutional structures may mitigate the environmental consequences of financial development.

The government effectiveness threshold, which is around -0.6, as calculated in the study, is also an important empirical result. This figure represents a relatively low level of institutional quality. This finding indicates that even small changes in the quality of institutions can greatly affect the environmental impacts of financial development. In other words, when the quality of institutions in a country exceeds a certain level, the effect of financial development on carbon emissions becomes negligible.

The role of energy consumption is another important aspect identified by the study. Energy consumption is found to have the highest impact on emissions. A large body of literature supports this finding, as energy intensity is identified as a significant determinant of carbon emissions (Li and Haneklaus, 2021; Ali *et al.*, 2021). The fact that the impact of financial development becomes insignificant for high governance regimes once energy consumption enters the model implies that financial development indirectly impacts emissions through energy structure rather than having a direct impact by increasing emissions.

7. CONCLUSION

The study investigates the interrelation of financial development and carbon emissions using the method of panel threshold modeling, with the moderating effect of government effectiveness. The analysis across a wide range of countries from 2009 to 2020 indicates the emergence of two distinct institutional regimes, depending on the level of government effectiveness. The results of the research indicate that in countries with low government effectiveness, the impact of financial development on CO_2 emissions is high, though it becomes low after a certain threshold is reached.

These results display that the environmental consequences of financial development are not independent of institutional capacity. Financial development by itself does not ensure environmental sustainability. The sectors to which financial resources are directed, as well as the management of the environmental consequences of economic activities, are largely dependent on the effectiveness of public administration. Financial development may direct resources to carbon-intensive economic activities in countries with weak institutional structures, while financial development may direct resources to clean energy in countries with strong institutional structures.

From a policy perspective, these results are important. First, there is a need to enhance institutional capacity to develop financial systems that are supportive of environmental sustainability. Improving the efficiency of public administration, enforcing environmental laws, and incorporating environmental laws into the financial system can reduce the effect of financial development on carbon emissions. In addition, developing green finance tools, supporting investments in renewable energy, and enforcing policies to enhance energy efficiency are part of emission reduction policies. The results obtained by the study are also important for understanding the relevance of energy consumption as a key factor in emissions. Therefore, addressing energy policies and financial policies jointly is critical. Specifically, developing financial tools to finance investments in energy-efficient technology can be an effective way to accelerate the low-carbon economic transition.

However, there are limitations to the study. First, based on the data limitations, the analysis is limited to the year 2020. This is because the publication of the financial development index for recent years has not been available. Second, the quality of governance used in the study is based on the government effectiveness indicator. However, other elements like the rule of law, regulatory quality, or corruption control might influence the association between financial development and environmental outcomes. Furthermore, the study was conducted at the national level. Future research could focus on sectoral or nationwide research. The use of more detailed data, which allows for such research, will enable more robust results.

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