FINANCIAL DEVELOPMENT, ENERGY CONSUMPTION AND ENVIRONMENTAL QUALITY IN DEVELOPING COUNTRIES

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ABSTRACT

This study aims to analyze the impact of financial development on greenhouse gas emissions in the case of developing countries, considering the spillover effects due to energy consumption. For this purpose, static and dynamic panel threshold regression models were used. The evidence obtained from the 2003-2019 period data shows that financial development has a significant threshold effect on emissions. How this effect works depends on the distinction between financial institutions and financial markets. In contrast to financial market development, in countries where the financial institution development index is above 0.356, the forces that increase emissions have been observed to weaken.
Keywords: Climate change, financial market, regulation.
JEL **Classification:** G10, G20, Q54, Q58.

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DESARROLLO FINANCIERO, CONSUMO DE ENERGÍA
Y CALIDAD AMBIENTAL EN PAÍSES EN DESARROLLO

RESUMEN

El presente estudio analiza el impacto del desarrollo financiero sobre las emisiones de gas de efecto invernadero en países en desarrollo, considerando los efectos de derrame debidos al consumo de energía. Para tal propósito, utilizamos modelos de regresión de panel dinámico con umbral. La evidencia que obtuvimos con datos para el periodo 2003-2009 muestra que el desarrollo financiero tiene un efecto de umbral significativo en las emisiones. La forma en que opera este efecto depende de la distinción entre instituciones financieras y mercados financieros. En contraste con el desarrollo del mercado financiero, se ha observado que en países donde el índice de desarrollo de las instituciones financieras es mayor que 0.356, las fuerzas que incrementan las emisiones se debilitan.
Palabras clave: cambio climático, mercado financiero, regulación.
Clasificación JEL: G10, G20, Q54, Q58.

1. INTRODUCTION

Our world is facing problems caused by climate change, especially in recent decades, and the main cause of this problem is greenhouse gas (GHG) emissions. The Paris Agreement, which entered into force in 2016, aims to reduce emissions as soon as possible and to offset the released and captured GHGs by the second half of the 21st century. Economic and environmental researchers are also trying to contribute to this issue by using various methods and samples on the factors affecting GHG emissions. This intensive research has not ignored the possible impact of financial indicators. In fact, it can be seen that there are two opposing views on how financial development affects emission levels. According to the first view, financial development can increase energy consumption and hence emissions by removing credit constraints (Shahbaz *et al.*, 2016; Paramati, Mo, and Huang, 2021). Although this effect will occur directly in households, it runs in parallel with the increase in output in firms. According to the second opposite view, as financial development increases, opportunities for research and development and the use of environmentally friendly technologies will increase, so positive effects on environmental quality can be expected (Al Mamun *et al.*, 2018; Gill, Hassan, and Haseeb, 2019; Vo and Zaman, 2020). The results of empirical studies examining the relationship between financial development and GHG emissions are also mixed. Therefore, there is still a need for new empirical analyses that complement the shortcomings of the existing literature.

A striking shortcoming of previous studies is that the idea that financial development affects emission levels via energy consumption, while often emphasized, has not been empirically tested for developing countries. While financial development can have a significant impact on the level and composition of energy consumption (Sadorsky, 2010; Al Mamun *et al.*, 2018; Mukhtarov *et al.*, 2020), the level and composition of energy consumption determines the level of emissions. For this reason, it is important to show these effects using nonlinear models. Zeqiraj, Sohag, and Soytas (2020) is the only study that examines the effects of financial development considering the indirect effects due to energy consumption. However, the study focused on European Union (EU) countries and did not consider the distinction between financial markets and financial institutions. Moreover, a specific threshold for the financial development indicator was not calculated.

To address this gap in the literature, we used a panel threshold regression to test the moderating effects of financial development. In addition, the relationships were tested with both static and dynamic models and the results were compared. The second important shortcoming in the literature relates to the financial development indicator used. Many different variables such as broad money supply and credit to the private sector relative to Gross Domestic Product (GDP) have been used as indicators of financial development. However, in this study, the current financial development index published by the International Monetary Fund (IMF) was used, which addresses financial development in a comprehensive manner rather than in a single dimension. The index includes information on the depth, accessibility and efficiency of financial markets and institutions. Third, because the index breaks down the development of financial institutions and markets, we were able to examine the effects of different types of financial development separately. This allowed us to answer the question of whether the effects of different indicators are different. Fourth, we conducted second-generation stationarity tests, allowing for the cross-sectional dependence before regression. In this way, we were able to obtain more robust results. Finally, we consider the example of developing countries, which has received relatively little attention. As economies develop, the share of the financial market increases, and the composition of financial systems changes in favor of the stock market. Zeqiraj, Sohag, and Soytas (2020) pointed out that the financial system in developed countries is mainly based on the stock market, while in developing countries it is based on the banking sector. Therefore, it is important to consider these countries as a separate sample as their financial structures differ significantly from those of developed countries.

In the context of these objectives, the remainder of the study is organized as follows. Section 2 reviews the relevant literature. Section 3 presents the methodology. Data and empirical results are given in Section 4. Section 5 provides conclusions and policy implications.

2. LITERATURE REVIEW

The question of how financial development affects environmental quality has been frequently discussed in the literature. There are two opposing views on this issue. According to the first view, financial development will promote the emergence and growth of firms by removing credit and liquidity constraints, so that emissions will increase in line with the increase in production and energy demand. Sadorsky (2010) pointed out that financial development reduces financial risk and borrowing costs, increases transparency between borrowers and lenders, and thus leads to an increase in fixed investment and energy consumption. Financial development can also lead consumers to purchase energy intensive goods by facilitating borrowing, and, it can also increase energy demand by lowering the cost of starting new businesses and hiring new workers. According to the second view, financial development will increase the use of research and development and investment in clean technologies (Paramati, Mo, and Huang, 2021), thereby reducing the amount of emissions.

The selection of key variables for financial development is a critical issue. It is noteworthy that various indicators of financial development have been used in the literature. Broad money supply, private sector credit, and stock market development and index performance are among the most widely used indicators. For example, Shahbaz *et al.* (2013a; 2013b) used domestic credit to the private sector as an indicator of financial development. Using data from Malaysia, Shahbaz *et al.* (2013a) examined the impact of financial development on emission levels. They considered both the quadratic and cubic terms of financial development to examine their non-linear effects. The results of the cointegration test indicate that the relationship between financial development and environmental degradation is N-shaped. In a similar study, Shahbaz *et al.* (2013b) examined the nonlinear relationship between financial development and emissions in the case of Indonesia. The results of the study suggest a U-shaped relationship between the variables. Later, Gill, Hassan, and Haseeb (2019) reexamined the impact of financial development on environmental degradation in Malaysia. The results of the Autoregressive Distributed Lag (ARDL) approach revealed that financial development mitigates emissions and has a moderating role on the environmental Kuznets curve by inducing the inflexion point earlier. Charfeddine and Khediri (2016) confirmed the existence of a U-shaped relationship between financial development and emissions in the United Arab Emirates. Rahman *et al.* (2020) examined both the linear and nonlinear effects of financial development on emissions in Lithuania. Using the ARDL bounds testing approach, they found empirical evidence for the existence of a U-shaped relationship between financial development and emissions. Tahir *et al.* (2021), on the other hand, argued that financial development stimulated the quantity of emissions in South Asian economies.

In contrast to the aforementioned studies, Vo and Zaman (2020) used broad money as an indicator of financial development. They argued that there is a negative relationship between financial development and carbon emissions for 101 developing and developed countries. The method they used was a dynamic Panel Generalized Method of Moment (GMM), but they assumed the impact of financial development is linear.

Some studies such as Zhang (2011), Abbasi and Riaz (2016), and Zeqiraj, Sohag, and Soytas (2020) focused on the role of stock market development. In investigating the impact of stock market development on carbon emissions in China, Zhang (2011) used both stock market capitalization and stock market efficiency as indicators of financial development.

The results of the study showed that the size of the stock market has a relatively larger impact on carbon emissions than the efficiency of the stock market. Abbasi and Riaz (2016) similarly focused on the impact of stock market development. As a result of their study in Pakistan, they found that financial development reduces emissions only during periods of high liberalization. Zeqiraj, Sohag, and Soytas (2020) analyze the impact of financial development on renewable energy emissions in the context of EU member states for the first time. They used the interaction term of financial development and renewable energy to test the nonlinear effects. As a result of the cross-sectional ARDL approach, they showed that stock market development reduces emissions by increasing renewable energy consumption.

Some recent studies have derived indices as indicators of financial development. For example, Shahbaz *et al.* (2016) constructed a composite index of Pakistan's financial development using M2, M3, domestic credit, stock market capitalization, traded stock market value, and stock market turnover. Their results suggest that bank-based financial development is detrimental to the environment. Similarly, Rahman *et al.* (2019) constructed a composite index of Pakistan's financial development using domestic credit, broad money, commercial bank assets and liquid liabilities. As a result of the ARDL bounds test, they concluded that this index has a moderating role for the environmental Kuznets curve. Al Mamun *et al.* (2018) examined the relationship between financial development and energy in a panel framework using a sample of 25 OECD countries (Organisation for Economic Cooperation and Development). They constructed an index by considering the stock market, credit market, and broad money supply. The results of the study show that financial development promotes cleaner energy in OECD countries. Katircioglu and Taspinar (2017) constructed an index for Turkey using domestic credit, broad money, commercial bank assets and liquid liabilities. Their results show no significant moderating effect of financial development on the relationship between energy consumption and emissions.

It is worth noting that some recent studies use the IMF's financial development index. For example, Saud *et al.* (2019) examined the role of financial development in selected Central and Eastern Europe (CEE) countries on carbon emissions. They found that environmental quality decreased in six of the countries as financial development increased, while the opposite was true in four. Later, Paramati, Mo, and Huang (2021) examined the impact of financial development using the distinction between financial markets and financial institutions. As a result of the study which looked at OECD countries, it was found that financial development increased emissions. However, it ignored the nonlinear effects of financial development. In the case of G20 countries, Habiba, Xinbang, and Ahmad (2021) used the Durbin-Hausman panel cointegration approach to test the impact of financial development on emissions. They distinguished between stock market development and financial institution development. Their results show that stock market development was found to have a negative relationship with emissions in developed countries, but a positive relationship with emissions in developing countries. In addition, financial institution development has a positive relationship with emissions in developed countries, but no significant relationship with emissions in developing countries. Thus, the study highlights the importance of considering the subcomponents of financial development when examining environmental impacts. However, energy use was considered as an exogenous variable and its moderating role on the relationship between financial development and environmental quality was not considered. He, Gao, and Wang (2022) examined the impact of financial development on GHG emissions for 162 countries and found that the financial development positively affects the GHG emissions. They also tested the mediating effect of technical progress on the process and confirmed the existence of a dilution effect.

In another study using IMF indices, Li *et al.* (2022) focused on the impact of financial development in Brasil, Rusia, India, China, Sudáfrica (BRICS) countries and argued that financial development increases emissions. Although the study focused on developing countries and used dynamic regression, the nonlinear effects of financial development were once again ignored.

3. METHODOLOGY

Hansen (1999) developed a threshold regression method for static panels with individual-specific fixed effects. The observations are divided into two or more regimes with different regression slopes. The single threshold model can be represented as follows:

$$y_{it} = \mu_i + \beta_1' x_{it} I(q_{it} \leq \lambda) + \beta_2' x_{it} I(q_{it} > \lambda) + e_{it},\ e_{it} \sim iid(0, \sigma^2) \quad [1]$$

Where $\{y_{it}, q_{it}, x_{it}, 1 \leq i \leq n, 1 \leq t \leq T\}$ is an observed panel data set, I(.) is the indicator function, q_{it} is the threshold variable with an estimated threshold λ, μ_i is the fixed effect, and e_{it} is the error term.
Chan (1993) and Hansen (1999) argued that the value of the threshold can be estimated by minimizing of sum of squared errors:

$$\hat{\lambda} = \arg\min_{\lambda} SSE_1(\lambda) \quad [2]$$

In the final stage, the significance of the threshold effect is tested using the likelihood ratio test. The significance of the threshold effect is tested by testing the null hypothesis that the slope coefficients do not change between regimes.

Later, Seo and Shin (2016) proposed a GMM approach based on the first difference transformation, where both the threshold variable and the regressors can be endogenous. They showed that the estimator obtained by this approach follows a normal distribution asymptotically. Moreover, unlike the least squares approach, asymptotic normality holds true irrespective of whether the regression function is continuous or not. Thus, standard inferences based on Wald statistics are possible.

A single panel threshold model following Seo and Shin (2016) is stated as:

$$y_{it} = \beta_1' X_{it} I(q_{it-k} \leq \lambda) + \beta_2' X_{it} I(q_{it-k} > \lambda) + e_{it},\ e_{it} \sim iid(0, \sigma^2) \quad [3]$$

Where $\beta_1' = (1, \beta_{1,1}, \beta_{1,2}, ... \beta_{1,k})$ and $\beta_2' = (1, \beta_{2,1}, \beta_{2,2}, ... \beta_{2,k})$ are parameter vectors in different regimes, $X_{it} = (y_{it-1}, y_{it-2}, \ldots, y_{it-k}, x_{it}, x_{it-1}, \ldots, x_{it-k})$ is the set of explanatory variables including the lagged term of the dependent variable, and I(.) is the identity function. We can also re-write the regression for single threshold as follows:

$$y_{it} = \begin{cases} \beta_{1,0} + \beta_{1,1} X_{it} + u_{1,it}, q_{it-k} \leq \lambda \\ \beta_{2,0} + \beta_{2,1} X_{it} + u_{2,it}, q_{it-k} > \lambda \end{cases} \quad [4]$$

The model can be extended if there is more than one threshold variable. Following Hansen (1999) and Seo and Shin (2016), we assumed that the threshold parameters are uniform.

4. EMPIRICAL ANALYSIS

4.1. Data

The sample covers the period 2003-2019 for 31 developing countries (Algeria, Argentina, Bangladesh, Brazil, Chile, China, Colombia, Ecuador, Egypt, India, Indonesia, Iran, Israel, Kuwait, Malaysia, Mexico, Morocco, Oman, Pakistan, Peru, Philippines, Qatar, Saudi Arabia, Singapore, South Africa, Sri Lanka, Thailand, Trinidad and Tobago, Turkey, United Arab Emirates, Vietnam) to provide a balanced panel without missing data. Greenhouse gas emissions (in kg per capita) denoted by *g*. The financial development index, financial institutions index and financial markets index are denoted by *fin_dev, fin_ins,* and *fin_mar*, respectively. The indexes are published by the IMF and focus on depth, access and efficiency. The indices vary between zero and one, and the higher the value, the higher the financial development.

Based on the Environmental Impact by Population, Affluence and Technology (IPAT) model (Ehrlich and Holdren, 1971) and the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model (Dietz and Rosa, 1997), the environmental impacts were measured using population, affluence, and technology. GDP per capita is used (*gdppc*) as the indicator of affluence, and total energy consumption per capita is used (*ener*) as the indicator of technology applied in the production process. The population density is denoted by *den*. Data on population and income variables are obtained from the World Bank's *World Development Indicators* database. Table 1 presents the descriptive statistics for the variables.

Table 1. Descriptive statistics

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
g	527	10,172.23	10,854.75	862	62,035
den	527	390.915	1,265.82	7.710	7,965.878
gdppc	527	12,906.55	15,281.43	707.605	65,129.38
ener	527	41,723.92	55,145.84	1,262.086	261,332.7
fin_dev	527	0.405	0.150	0.097	0.793
fin_ins	527	0.424	0.154	0.159	0.764
fin_mar	527	0.371	0.186	0.002	0.895

Table 2. Test for cross-sectional dependence

	LM		LM adjusted		LM CD	
Indicator	**Stat.**	**p-value**	**Stat.**	**p-value**	**Stat.**	**p-value**
fin_dev	767.5	0.000	11.24	0.000	–0.061	0.951
fin_ins	737.9	0.000	8.888	0.000	0.623	0.533
fin_mar	775.4	0.000	11.84	0.000	–0.918	0.359

In the first step of our analysis, the series are tested for cross-sectional dependence using the Lagrange Multiplier (LM) test of Breusch Pagan (1980), the bias adjusted LM test of Pesaran, Ullah and Yamagata (2008), and the Cross-Sectional Dependence (CD) test of Pesaran (2004). Table 2 shows the results for all three indicators of financial development. The results of both the LM and LM adjusted tests indicate cross-sectional dependence of the residuals. Therefore, we tested the stationarity of the variables using the second-generation panel unit root test of Pesaran (2007).

The results of the Cross-Sectionally Augmented Dickey-Fuller (CADF) test (Pesaran, 2007) are shown in Table 3. From the table, it can be seen that some variables (*g, gdppc, ener*) are non-stationary at their level. These variables were transformed into stationary series by taking their differences. Stationary series were used in the following analyses.

4.2. Threshold analysis and empirical results

Next, the possible threshold effect of financial development was tested using static panel threshold regression. The results are reported in Table 4. The F-statistics are calculated as 18.79, 27.41, and 23.37 for different indicators of financial development. All of the indicators have a statistically significant threshold, and the results confirm the existence of a single threshold effect[1]. Therefore, the estimation of the coefficients based on two regimes seems reasonable.

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1 The double threshold effects were also tested. We do not report test results for double-threshold effects as we did not find any evidence of this in any of the models.

Table 3. CADF **unit root test results**

Variables		Z(t-bar)		p-value	
		Without trend	With trend	Without trend	With trend
g	Level	–0.435	–0.062	0.332	0.475
	1st difference	–5.689	–4.851	0.000	0.000
den	Level	–6.095	–5.989	0.000	0.000
gdppc	Level	5.065	7.048	1.000	1.000
	1st difference	1.587	0.523	0.944	0.699
	2nd difference	–5.779	–2.969	0.000	0.001
ener	Level	2.779	1.826	0.997	0.966
	1st difference	–3.695	–3.740	0.000	0.000
fin_dev	Level	–1.846	–2.062	0.032	0.020
fin_ins	Level	–1.705	1.391	0.044	0.918
fin_mar	Level	–1.586	–2.456	0.056	0.007

Note. Asterisks indicate significance levels: *p < 0.1, **p < 0.05, ***p < 0.01.

Table 4. The static models and the threshold effect

Threshold variable	Threshold no	F-statistics	p-values	Critical values			Threshold value
				1%	5%	10%	
fin_dev	Single	18.79**	0.033	25.761	16.014	13.183	0.464
fin_ins	Single	27.41**	0.047	42.348	26.090	19.665	0.356
fin_mar	Single	23.37**	0.047	39.154	22.452	16.351	0.531

Notes: 1/ Three hundred bootstrap replications are employed for each of the bootstrap tests. 2/ Asterisks indicate significance levels: *p < 0.1, **p < 0.05, ***p < 0.01.

Table 5 presents the coefficient estimates obtained from a static model with a single threshold. Each column shows the results of the model in which a different indicator of financial development is used as the threshold variable. In all models, as expected, there is a positive relationship between population density and the amount of emissions. Similarly, there is a positive relationship between GDP per capita and the amount of emissions. Since the sample studied includes developing countries, it can be assumed that this result is also in line with expectations. As the income level of the countries increases, the pollution level also increases, so they are in the increasing part of the environmental Kuznets curve (EKC).

Table 5 shows that financial development has a significant threshold effect on GHG emissions in all models. However, it works differently for different financial development indicators. Accordingly, a 1% increase in energy consumption in countries with a financial development index value of less than 0.46 increases the amount of emissions by 0.07%, while a 1% increase in energy consumption in countries with an index value greater than 0.46 increases the amount of emissions by 0.16%. Thus, as financial development increases, energy consumption in the sampled countries increases, and thus has an increasing effect on emissions. This effect is mainly due to financial market development. This is because when financial market development is above the threshold, it can be clearly

Table 5. The coefficient estimates of the static models

Dependent variable: ***gg***	**Threshold variable (*thv*)**		
	fin_dev	***fin_ins***	***fin_mar***
den	0.768*** (0.0437)	0.5996*** (0.0301)	0.768*** (0.0450)
gdppc	0.101*** (0.0353)	0.094*** (0.0238)	0.095*** (0.0339)
ener ($thv \leq \lambda$)	0.0696** (0.0340)	0.263*** (0.0279)	0.069** (0.0323)
ener ($thv > \lambda$)	0.159*** (0.0115)	0.099*** (0.0107)	0.161*** (0.0131)
R-square	0.280	0.293	0.282
F-statistics	102.61	169.19	110.03
F-probability	0.000	0.000	0.000

Note: Asterisks indicate significance levels: *p < 0.1, **p < 0.05, ***p < 0.01. White heteroscedasticity consistent standard errors are in parentheses. The number of repetitions of the bootstrap method is equal to 300.

seen in the third column that the coefficient of energy consumption is higher. The threshold effect of financial institutions works in the opposite direction. In countries where the financial institutions development index is above the threshold, the emission increasing effect of energy consumption weakens. This result can be interpreted to mean that the development of financial institutions encourages the use of clean energy. This could be due to the relatively large share of financial institutions in the financial system in developing countries.

Table 6 shows the results of some diagnostic tests. According to the test results of both Pesaran (2004) and Friedman (1937), there is no cross-sectional dependence between the residuals. According to the CADF test of Pesaran (2007), the residuals are stationary.

Subsequently, the models were tested with dynamic regressions to check their robustness. The results are reported in Table 7. The F-statistics are 18.87, 27.28, and 23.69 for models including the financial development index, the financial institutions index, and the financial markets index, respectively. The presence of a threshold effect at the 5% significance level was again confirmed in all models. Moreover, the threshold of the static and dynamic models for the financial development index and the financial institutions index are identical (0.4644 and 0.3561, respectively). The thresholds obtained for financial market development are also very close (0.5309 in the static model and 0.5340 in the dynamic model). Therefore, the next step was to estimate the coefficients based on the two regimes.

Table 6. Residual diagnostic tests of the static models

	Threshold variable					
	fin_dev		*fin_ins*		*fin_mar*	
Cross-sectional independence	**t-statistics**	**Probability**	**t-statistics**	**Probability**	**t-statistics**	**Probability**
Pesaran test	1.022	0.3068	0.153	0.8786	0.943	0.3457
Friedman test	22.710	0.8270	18.687	0.9463	23.684	0.7861
Stationarity	**Z(t-bar)**	**Probability**	**Z(t-bar)**	**prob**	**Z(t-bar)**	**Probability**
Pesaran CADF	−2.491	0.006	−4.497	0.000	−2.348	0.009

Table 7. The dynamic models and the threshold effect

Threshold variable	Threshold no	F-statistics	p-values	Critical values			Threshold value
				1%	5%	10%	
fin_dev	Single	18.87**	0.033	33.914	17.969	13.916	0.464
fin_ins	Single	27.28**	0.040	38.989	24.843	18.294	0.356
fin_mar	Single	23.69**	0.040	28.604	20.397	14.315	0.534

Notes: 1/ Three hundred bootstrap replications are employed for each of the bootstrap tests. 2/ Asterisks indicate significance levels: *p < 0.1, **p < 0.05, ***p < 0.01.

Table 8 shows the coefficient estimates from the dynamic panel threshold regressions. The coefficient of the lagged dependent variable is not statistically significant in any of the models. However, the coefficients for population density and GDP per capita are in line with the static model findings.

Similarly, the dynamic models confirm the existence of a threshold effect for all indicators of financial development. In countries where the financial development index and the financial market development index are above the threshold, the increase in energy consumption has an increasing effect on emissions. This effect is about 2.3 times larger than in low regime countries. Moreover, an increase in the financial market development index has a larger effect on energy consumption than an increase in financial institution development. This can be seen also in Figure A1 in Appendix. In contrast, in countries where the financial institutions development index is above the threshold, the increase in energy consumption has a smaller impact on the amount of emissions. The coefficient of the lower regime is about 2.65 times larger than the coefficient of the upper regime. These findings are consistent with the results of the static models. In other words, the coefficients of the static and dynamic models are quite similar both in sign and magnitude.

Table 9 presents some findings on diagnostic tests of dynamic models. Both test results of Pesaran (2004) and Friedman (1937) confirm that there is no cross-sectional dependency between residuals. Moreover, CADF test of Pesaran (2007) shows that the residuals are stationary.

Table 8. The coefficient estimates of the dynamic models

Dependent variable: *gg*	Threshold variable (*thv*)		
	fin_dev	*fin_ins*	*fin_mar*
g(–1)	–0.0221 (0.0578)	–0.0108 (0.0626)	–0.0302 (0.0572)
den	0.7792*** (0.0554)	0.6035*** (0.0437)	0.7980*** (0.0555)
gdppc	0.0959** (0.0369)	0.0917*** (0.0287)	0.0902*** (0.0366)
ener ($thv \leq \lambda$)	0.0696* (0.0342)	0.2642*** (0.0291)	0.0660* (0.0358)
ener ($thv > \lambda$)	0.1613*** (0.0126)	0.0996*** (0.0106)	0.1693*** (0.0133)
R-square	0.2807	0.2934	0.2880
F-statistics	81.71	133.54	89.74
F-probability	0.0000	0.0000	0.0000

Note: Asterisks indicate significance levels: *p < 0.1, **p < 0.05, ***p < 0.01. White heteroscedasticity consistent standard errors are in parentheses. The number of repetitions of the bootstrap method is equal to 300.

Table 9. Residual diagnostic tests of the dynamic models

	Threshold variable					
	fin_dev		*fin_ins*		*fin_mar*	
Cross-sectional independence	**t-statistics**	**Probability**	**t-statistics**	**Probability**	**t-statistics**	**Probability**
Pesaran test	1.076	0.2818	0.157	0.8753	1.082	0.2792
Friedman test	22.400	0.8391	18.361	0.9524	22.135	0.8491
Stationarity	**Z(t-bar)**	**Probability**	**Z(t-bar)**	**Probability**	**Z(t-bar)**	**Probability**
Pesaran CADF	–2.853	0.002	–4.667	0.000	–2.740	0.003

5. CONCLUSION

In this study, the relationship between financial development and GHG emissions was tested by considering the moderating role of energy consumption. The sample which includes the period 2003-2019 and 31 developing countries, was analyzed with static and dynamic panel threshold regressions. It was found that the threshold effects of the financial development index, financial institutions development index, and financial market development index cannot be rejected at a 5% level of significance. However, the magnitude of the coefficients in the lower and upper regimes varies according to the financial development indicator used.

In countries where financial market development is above the threshold (0.53), a 1% increase in energy consumption increases greenhouse gas emissions by 0.16%. Singapore is an outlier with a level of financial market development above the threshold in all sample years. Therefore, the increase in financial market development in this country has triggered the level of emissions through energy consumption more than in other countries when all years are taken as a basis. On the other hand, in 17 of 31 countries (Algeria, Argentina, Bangladesh, Chile, China, Colombia, Ecuador, Indonesia, Iran, Israel, Mexico, Morocco, Oman, Pakistan, Peru, Sri Lanka, and Trinidad and Tobago), the financial market development index is below the threshold value (0.53) in all years. In these countries, a 1% increase in energy consumption increases greenhouse gas emissions by 0.069%.

The positive effects of financial development on environmental quality emerge through financial institutions. In fact, in developing countries, an important part of the financial system is constituted by these institutions instead of financial markets. In countries where the financial institutions development index is below the threshold value (0.36), 1% increase in energy consumption increases greenhouse gas emissions by 0.26%. On the other hand, in countries where the financial institution development index is above the threshold value (0.36), a 1% increase in energy consumption increases greenhouse gas emissions by only 0.09%. In 11 of 31 countries (Brazil, Chile, China, Israel, Kuwait, Malaysia, Oman, Singapore, South Africa, Thailand, and Trinidad and Tobago), the financial institution development index is above the threshold value in all years. Therefore, it can be argued that the development of financial institutions in these countries increases the use of clean energy resources.

Nevertheless, it is clear that the findings support that financial development has a positive effect on emissions. Therefore, it would not be right to expect a solution to emerge spontaneously through financial development without implementing active policies to reduce emissions in developing countries. For this reason, it is recommended that policy makers benefit from policies such as environmental taxes, standards, and emissions trading. In particular, environmental taxation will penalize polluters and contribute to the financing of budget deficits, which is a general financial problem in developing countries. ◄

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APPENDIX

Figure A1. Financial development and energy use

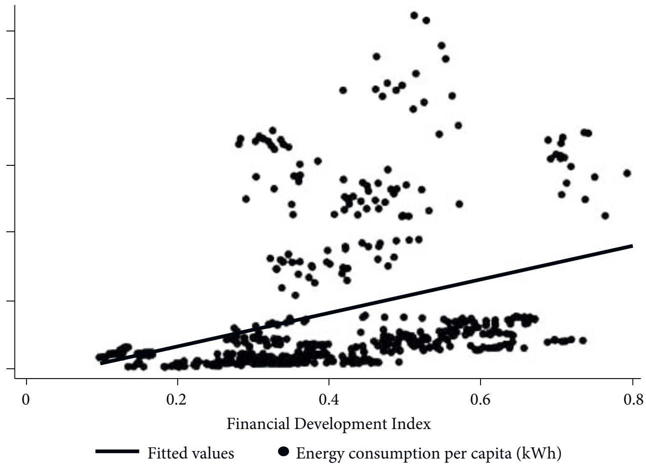
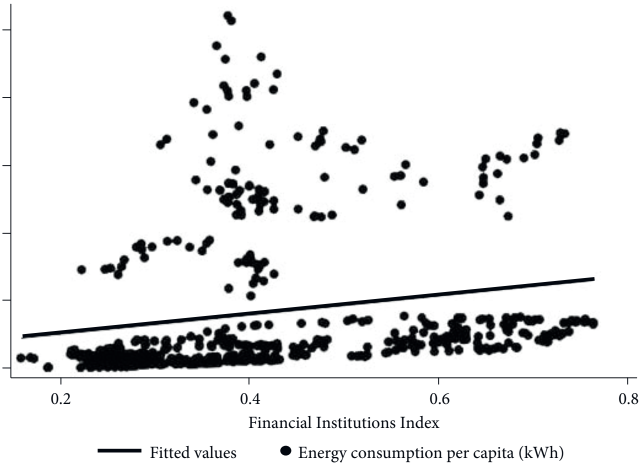
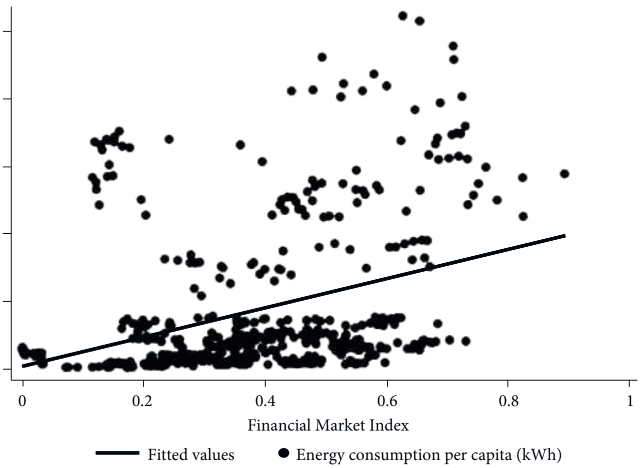


Figure A1. Financial development and energy use (concluded)





Sources: Data is obtained from IMF *Financial Development Indices*.