Effects of Financial Development on Sustainable Economic and Environmental Development:
A Case of Emerging Economies

Lili Wang[1], Jun Pang[2], Soocheol Lee[3]

Abstract

While financial development contributes to economic growth, it also requires attention to the environmental impact of its operations. This study explores the impact of financial development on economic growth and carbon emissions from 2001–2018 using pooled regression, fixed effects model, random effects model and threshold model for a sample of 13 emerging economies. The results show that financial development has a statistically positive long-term impact on economic growth. The results of the threshold model show that with trade openness as the threshold variable, the impact of financial development on economic growth and carbon emissions shows a three-stage nonlinear relationship, in which the coefficient of the impact of financial development on carbon emissions becomes larger and larger. Financial development promotes the decoupling of the economy from carbon emissions. Moreover, the economic promotion effect of financial development in most emerging countries offsets the negative impact of pollution on the environment.

Keywords: Trade openness; Financial responsibility; Carbon emissions; Multiple models;

1. Introduction

Since the global financial crisis, the role of financial development in the economic development process has been receiving widespread attention from scholars and policy makers. Although financial development is a key part of the process of economic growth and social progress, most scholars believe that financial development can also have a critical impact on environmental quality, especially on the evolution of carbon emissions. Whenever a financial crisis occurs, an inflection point in carbon emissions occurs (Shahbaz, Li et al. 2022). For example, carbon emissions fell by 1.4% after the financial crisis in 2008 and rebounded by 5.1% in the recovery

[1] Ph.D., School of Ecology and Environment, Renmin University of China, Beijing 100872, China.
[2] Professor, School of Ecology and Environment, Renmin University of China, Beijing 100872, China.
[3] Professor, Faculty of Economics, Meijo University,

process. Therefore, it is a difficult task to learn the lessons of the financial crisis to better make finance work for the economy and the environment.

Financial development is the continuous improvement of financial efficiency brought about by the expansion of the scale of financial transactions and the sophistication of the financial industry. Theoretically, financial development helps to achieve the accumulation and concentration of capital, and can help to realize modernized large-scale production and operation and realize economies of scale (Lahiani, Mefteh-Wali et al. 2021). In addition, financial development enables companies and governments to adopt environmentally friendly technologies that can reduce carbon emissions, which can motivate companies to adopt environmentally sustainable projects, thereby improving environmental quality and reducing carbon emissions.

Despite its relevance to the economy and carbon emissions, financial development is vulnerable to external shocks. Since the outbreak of the financial crisis in the United States in September 2007, financial markets have been in a state of turmoil, triggering a chain reaction on a global scale (Wang, Wang et al. 2021). More and more countries are fearful of the continued rise of the financial crisis and are becoming more cautious about their international trade strategies. In other words, there is a direct relationship between international trade development and financial development. Trade in imports and exports actually facilitates or hinders the financial development of the host country by changing the demand-side and supply-side factors of financial development under closed conditions (Wang, Padmanabhan et al. 2022). More specifically, there may be non-linear effects of the finance-economy and finance-carbon emission relationships at different levels of trade in different countries, which have received little attention in existing studies.

At present, the world economic situation is changing rapidly, and the role of emerging economies in the global economy is increasing. One of the prominent changes in the global economy since the 21st century has been the proliferation of emerging market economies. The British Economist first established the BRICS as an emerging country, followed by the Next-11 in 2006. Based on the outstanding performance of emerging economies, there is growing recognition that emerging economies are becoming a source of stability for the world economy at a time when developed economies are suffering from financial crises (Khan, Khan et al. 2021). Additionally, the pace of carbon emissions is accelerating in most emerging economies compared to developed economies. The remarkable growth of emerging economies has raised serious concerns about global environmental sustainability, and there is an urgent need to explore ways to reduce greenhouse gas emissions while maintaining economic growth. However, to our knowledge, no cross-country studies have investigated the link between financial development and economic and environmental quality in emerging economies.

This study makes the following contributions to the existing literature. First, it is a study to investigate the economic and environmental impacts of financial development and to assess the economic and environmental sustainability of financial development within a single framework.

This is because financial crises have a threat to rapid economic growth and to environmental sustainability. Second, given the intertwined relationship between trade and financial development, the omission of any single factor may lead to inconsistent findings. In this study, we use import and export trade as threshold variables while controlling for population, capital and renewable energy share as control variables, to explore the non-linear relationship between finance-economy and finance-carbon emissions under different trade levels. Finally, few studies have been conducted for the emerging countries proposed by Goldman Sachs. The financial development of emerging economies should not be underestimated, and this study examines the relationship between financial development, economic growth, and carbon emissions among these emerging countries. Emerging countries are attempting to promote economic growth while mitigating environmental degradation, and an integrated analysis would be better suited to present valuable insights to policymakers in emerging countries.

The rest of the paper is organized as follows. Section 2 presents the literature review, followed by an overview of the methodology and data in Section 3. Section 4 presents the empirical results and discussion, and Section 5 presents the conclusions and policy implications.

2. Literature review

The literature shows that financial development is significantly associated with both economic growth and environmental quality. Because, financial development is important for economic growth, it has a significant impact on environmental quality.

2.1 Impact of financial development on carbon emissions

Considering the significant correlation between financial development and environmental quality, scholars have conducted many studies at different national, regional and global levels. However, the literature has not yet reached a consensus on the impact of financial development on environmental quality, and this debate remains open. That is, financial development may have a positive, or negative, impact on carbon emissions.

First, the impact of financial development on carbon emissions is explored at the national level. Moghadam et al. investigated the impact of financial development and trade on environmental quality in Iran and the autoregressive distributed lag (ARDL) model showed a positive impact of financial development on carbon emissions, i.e., financial development accelerates environmental degradation (Moghadam and Dehbashi 2018). Similar positive effects were obtained for (Madhu, Sehrawat et al. 2015) for India, (Shahbaz, Shahzad et al. 2016) for Pakistan, (Maji, Habibullah et al. 2017) for Malaysia, and (Ahmad, Khan et al. 2019) for China. There are also studies for a particular country showing the negative impact of financial development on carbon emissions. Shahbaz et al. explored the determinants of carbon emissions in France, where financial development reduced carbon emissions and thus improved the environmental quality in France

(Shahbaz, Nasir et al. 2018). Lahiani et al. controlled for the effects of economic growth and energy consumption to examine the impact of financial development on carbon emissions in China, and the findings suggest support for financial development in China to reduce carbon emissions while maintaining economic growth (Lahiani 2020).

At the regional level, Lahiani surveyed 46 sub-Saharan African countries (Lahiani 2020), Koengkan et al. surveyed Latin American & Caribbean countries (Koengkan, Santiago et al. 2019), and Adams et al. surveyed 26 African countries (Adams and Klobodu 2018) and they identified financial development as an important determinant of environmental degradation. Abdouli et al. explored the Middle East (Abdouli and Hammami 2020), Paramati et al. explored the G20 countries (Paramati, Mo et al. 2017), Seetanah et al. explored the BRICS countries (i.e. Brazil, Russia, India, China and South Africa) (Seetanah, Sannassee et al. 2018), and Chen et al. investigated the Belt and Road region (Saud, Chen et al. 2020), and the conclusions they obtained showed that financial development suppresses carbon emissions.

In addition to the national and regional levels, some scholars have explored the relationship between the two variables at the global level. Jiang et al. explored the impact of financial development on carbon emissions at the global level and showed that financial development in emerging markets and developing countries can significantly increase carbon emissions (Jiang and Ma 2019). Acheampong et al. conducted a study on a combined 83-country. The results showed that the non-linear and moderating effects of financial market development on carbon emissions vary across countries at different stages of financial development (Acheampong, Amponsah et al. 2020).

The literature argues that financial development harms the quality of the environment through various economic mechanisms. Jiang et al. argued that the financial system is an important source of financing for the expansion of existing operations and the development of new ones, which increase energy consumption, thereby increasing greenhouse gas emissions and negatively impacting environmental quality (Jiang and Ma 2019). In addition to the expansion of the financial system, financial development is associated with higher energy use. Financial development makes financing affordable and easily available to households and businesses, which may lead to higher carbon emissions and deterioration of environmental quality. The results of (Mukhtarov, Mikayilov et al. 2018) show that financial development increases energy use by individuals and businesses and deteriorates environmental quality. While Dhrifi et al. studied that financial development contributes to the absorption of foreign investments and promotes the development of energy-intensive enterprises, which has a negative impact on the environment (Dhrifi, Jaziri et al. 2020).

Meanwhile, some scholars have argued that there are mechanisms by which financial development contributes to environmental improvement. Zhang argues that the financial sector also provides better financial services that reduce carbon emissions by promoting technological progress and optimizing industrial structure (Zhang 2011). Also, financial development promotes

investment in environmental technological innovations that improve energy efficiency (called technology effects), reduce greenhouse gas emissions and promote environmental quality (Ji and Zhang 2019). Adams et al. argued that financial development reduces environmental degradation by creating more environmentally friendly production technologies. That is, by providing finance to small businesses so that they can invest in cost-effective and environmentally friendly renewable energy sources that will positively improve environmental quality (Adams and Klobodu 2018).

2.2 Impact of financial development on economic growth

Since the 1990s, various empirical studies have examined the relationship between financial development and economic growth, based on the seminal work of (King and Levine 1993). The relationship between financial development and economic growth has been extensively discussed in many studies. However, empirical results on this relationship are mixed.

Various empirical studies have tested the relationship between financial development and economic growth at the cross-country or national level. Evidence suggests that financial development plays an important role in stimulating economic development by encouraging savings, mobilizing investment, technological progress, promoting investment, and optimizing resource allocation. Tran et al. used data from Vietnamese firms to investigate the economic impact of financial development on local firms, and the empirical results confirmed the impact of financial development on economic growth (Tran, Herwartz et al. 2020). Ahulu et al. explored the impact of financial stability on economic growth in sub-Saharan African countries, showing that, all else equal, financial stability accounts for 71.8% of the variation in a country's economic growth (Ahulu, Maccarthy et al. 2021). Similarly, Nguyen et al. studied 22 emerging markets, during which they found a linear relationship between financial development and economic growth and that financial development in general has a positive impact on economic growth in emerging markets (Nguyen, Thai-Thuong Le et al. 2021). Pradhan et al. used a panel causality model concluded that financial development and innovation support long-term economic growth. To ensure sustainable economic growth, policy makers in OECD countries must pay attention to the creation of an integrated structure to study common improvement policies regarding activities that promote financial development, innovation and economic growth (Pradhan, Nath et al. 2021).

However, the positive impact of financial development on economic growth has been questioned by various scholars. This is mainly due to the fact that the global financial crisis has shown the negative impact of financial system failures. This negative impact may discourage savings, reduce investment, stimulate speculation, waste resources and lead to misallocation of scarce resources. Several empirical studies have also succumbed to establish the negative impact of finance on economic growth. Asteriou et al. explored a panel dataset of 26 EU countries (1990–2016) and showed that the impact of financial development on economic growth

was positive before the financial crisis and negative after the financial crisis (Asteriou and Spanos 2019). Moyo et al. examined the relationship between financial development and growth in southern african development community countries between 1990 and 2015 on the relationship between financial development and growth. In the long run, the financial development index and individual financial indicators have a negative impact on economic growth (Moyo and Roux 2020). Cheng et al.'s study covers panel data for 72 countries and the empirical results of dynamic generalized method of moments (GMM) estimation showed that financial development is always detrimental to economic growth regardless of national income levels, but this negative impact is greater in high-income countries (Cheng, Chien et al. 2021).

3. Materials and method

3.1 Data source

This study uses annual statistics, spanning 18 years (2001–2018). We use panel data for 13 emerging countries to analyze the impact of financial development on the economy and carbon emissions. The variables included in the analysis were selected based on the availability of data. The study obtained data from the World Development Indicators.

The explanatory variables are gross domestic product (GDP, 2015 constant dollars) and total carbon emissions (CO_2, in metric tons), used as indicators of economic development and carbon emissions.

The explanatory variable is the financial development (FD) indicator. This study uses the share of private sector credit to measure the level of financial development. According to the definition of the indicator in the World Bank database, private sector credit refers to the financial resources provided by financial firms to the private sector through loans, purchases of non-equity securities, trade credits and other receivables.

The threshold variable is trade freedom (TRA), this is the sum of exports and imports of goods and services measured as a share of gross domestic product. And there are three main control variables. Capital (K) is used for gross fixed capital formation (% of GDP); and population (P) is population growth (annual %); and renewable energy development (R) is the percentage of renewable energy consumption to total final energy consumption.

3.2 Econometrics model for economic growth

Two models are used in this study: Model I: FD-GDP; Model II: FD-CO_2 to achieve the research objectives. Based on the Cobb-Douglas production function, we developed an econometric model of financial development on economic growth-Model I, which is specifically expressed as equation (1).

$$GDP = f(FD,R,K,P) \tag{1}$$

Equation (1) reveals that economic development is a function of financial development (FD), renewable energy development (R), capital (K), and population (P). Equation (2) is written in the form of panel data.

$$GDP_{it} = \alpha + \rho_1 FD_{it} + \rho_2 R_{it} + \rho_3 K_{it} + \rho_4 P_{it} + \varepsilon_{it} \quad (2)$$

All variables are converted to natural logarithms. The above model is expressed in log-linear form as in equation (3).

$$\ln GDP_{it} = \alpha + \rho_1 \ln FD_{it} + \rho_2 \ln R_{it} + \rho_3 \ln K_{it} + \rho_4 \ln P_{it} + \varepsilon_{it} + \varnothing_i \quad (3)$$

Where, i = 1, ..., N denotes each country in the panel and t = 1, ..., T denotes the time period. α is the intercept, $\varnothing_i$ is the individual effect, and ε_{it} is the error term. ρ_1, ρ_2, ρ_3, ρ_4 are the parameter estimates of the control variables.

3.3 Econometrics model for carbon emissions

An econometric model of carbon emissions-model II was developed to explore the effect of financial development on carbon emissions. Equation (4) shows that CO_2 is a function of financial development (FD), renewable energy consumption (R), capital (K), and population (P).

$$CO_2 = f(FD,R,K,P) \quad (4)$$

Equation (5) is written in the form of panel data, and equation (6) is written in the form of a log-linear equation representation.

$$CO_2 it = \alpha + \rho_1 FD_{it} + \rho_2 R_{it} + \rho_3 K_{it} + \rho_4 P_{it} + \varepsilon_{it} \quad (5)$$

$$\ln CO_2 it = \alpha + \rho_1 \ln FD_{it} + \rho_2 \ln R_{it} + \rho_3 \ln K_{it} + \rho_4 \ln P_{it} + \varepsilon_{it} + \varnothing_i \quad (6)$$

3.4 Estimation strategy

This study uses panel data, which are sample data consisting of multiple cross sections taken over a time series and sample observations selected simultaneously in these cross sections. Panel data can overcome the plague of time series analysis by multicollinearity and can provide more information, less cointegration, more degrees of freedom and higher estimation efficiency. The unit root test and cointegration analysis of panel data are the beginning of empirical evidence.

The main methods of unit root test for panel data are LLC test (La and Chu 2002), IPS test (A, B et al. 2003), Fisher-ADF test (Maddala and Wu 1999). And the method of cointegration test for panel data is mainly the Pedroni test proposed by (Pedroni 2004), the original hypothesis of this test are that there is no cointegration relationship, and the residual statistics are obtained from the panel data for the test.

And then, panel data regressions can be classified into three types: ordinary least square (OLS),

fixed effects (FE), and random effects (RE) models. In this study, F-test, Hausman test and Breusch-Pagan test are used to select the validity of panel data. The F-test is used to test which is better, the fixed effects model or the mixed regression model, and if the original hypothesis is rejected, the fixed effects model is better. The original hypothesis of the Hausman test is that the random effects model is better than the fixed effects. The original hypothesis of the Breusch-Pagan Lagrange multiplier test is that the OLS estimates are appropriate and supports the alternative hypothesis of random effects model.

In addition, we test the impact of financial development on the economy and carbon emissions in the context of global trade openness, and we introduce a threshold regression model to explore it (Hansen 1999). In this study, we use trade openness as a mediating variable to explore the impact of financial development on the economy to obtain Model III, and explore the impact of financial development on carbon emissions to obtain Model IV. The threshold regression model for the two regimes can be expressed as Equation (7).

$$y_{it} = \begin{cases} x'_{it}\beta_1 + e_i, q_{it} \le \gamma \\ x'_{it}\beta_2 + e_i, q_{it} > \gamma \end{cases} \tag{7}$$

Where, y_{it} is the explanatory variables economic development and carbon emissions, x'_{it} is the explanatory variables (financial development, renewable energy consumption, capital and population), and q_{it} is the threshold variable. The role of the threshold variable q_{it} is to divide the sample into different groups, with the threshold variable as the turning point for regime change, and the different institutions in the model are represented by the threshold variable being greater or less than a certain threshold value.

The advantage of the threshold model is for how to find the point of sudden structural change for regression analysis for large samples and panel data (Uddin, Pan et al. 2022). Threshold effect, is a phenomenon that occurs when one economic parameter reaches a specific value, causing a sudden shift to other forms of development in another economic parameter, known as sudden structural change.

The dummy variable $d_{it}(\gamma) = (q_{it} \le \gamma)$ is defined, where (.) is the indicator function, i.e., for $q_{it} \le \gamma$, (.) = 1, otherwise (.) = 0. In this way, the above set of equations can be expressed in a single equation as Equation (8).

$$y_{it} = x'_{it}\beta + x'_{it}\, d_{it}(\gamma)\theta + e_i, e_i \sim iid(0, \delta_i^2) \tag{8}$$

Where, $\beta = \beta_2$; $\theta = \beta_1 - \beta_2$. Corresponding to any threshold value γ, the estimate of each parameter can be obtained by finding the residual sum of squares $S_1(\gamma) = e_i(\gamma)' e_i(\gamma)$. The optimal threshold value $\hat{\gamma}$ should minimize $S_1(\gamma)$ among all residual sums of squares. We took each observation in the threshold variable as a possible threshold value, and the observation satisfying the equation $\hat{\gamma} = argmin S_1(\gamma)$ was determined as the threshold value. Once the threshold estimates are determined, then the other parameter values can be determined accordingly. In

addition to the single-threshold model mentioned above, there are also multi-threshold models such as double-threshold and triple-threshold. Since the principles are similar, they are not repeated here.

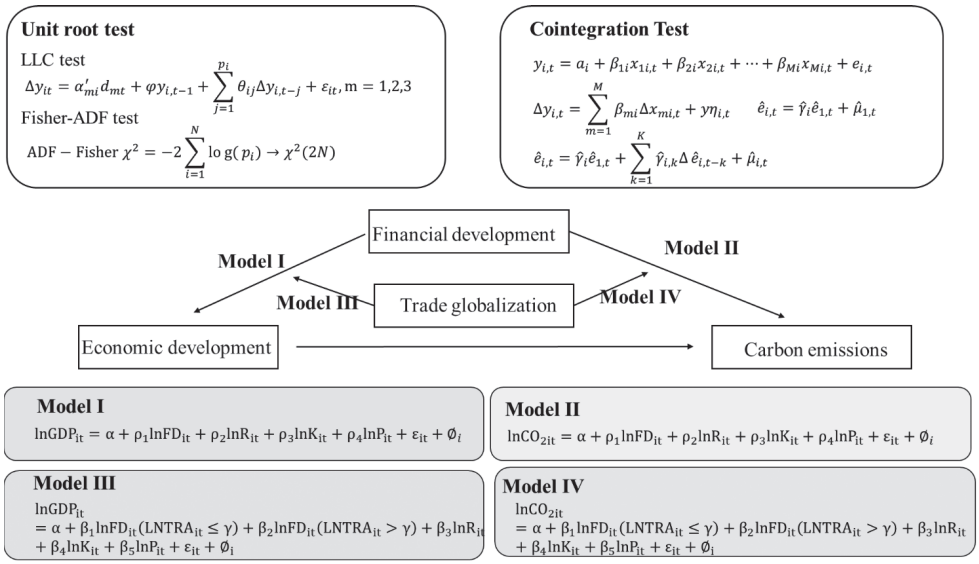

Figure 1. Logic of model construction

4. Empirical results and discussion

This study is on the world's emerging markets proposed by American economists-BRICS and Next-11. BRICS including Brazil, Russia, India, China, and South Africa were first proposed, and then 11 emerging markets with growth potential second only to BRICS, including Pakistan, Egypt, Indonesia, Iran, South Korea, Philippines, Mexico, Bangladesh, Nigeria, Turkey, and Vietnam were introduced. Due to the lack of financial data for Indonesia, Iran, and Turkey, this study focuses on the impact of financial development on the economy and carbon emissions in 13 emerging countries.

Detailed descriptive statistics of the variables were performed prior to the empirical analysis. The descriptive analysis of the selected variables is briefly presented in Table 1. The results show that the mean values of the series are 12.684 for carbon emissions, 27.039 for economic development and 3.820 for LNFD; 3.122 for LNK, 0.144 for LNP and 2.934 for LNR. The standard deviations are 1.369, 1.174, 0.767, 0.316, 0.699 and 1.162, respectively. In the statistical review, except for the mean and standard deviation, the kurtosis values only apply to carbon emissions and population growth rates and renewable energy share are above 3, indicating a long-tailed or higher peaks distribution, and all other values are below 3, indicating a short-tailed or lower peaks distribution. Next, the Jarque-Bera test statistics are important for exploring the normal

distribution of the series. The original hypothesis indicates that the distribution is normal. If the p-value is greater than 5%, it involves that the series is normally distributed. But the Jarque-Bera value indicates that the series is non-normally distributed.

Table 1. Detailed descriptive statistics of the variables

	$LNCO_2$	LNGDP	LNFD	LNK	LNP	LNR
Mean	12.684	27.039	3.820	3.122	0.144	2.934
Median	12.697	26.590	3.782	3.088	0.288	3.441
Maximum	16.149	30.233	5.061	3.796	0.986	4.486
Minimum	10.157	25.120	2.090	2.521	−3.503	−0.368
Std. Dev.	1.369	1.174	0.767	0.316	0.699	1.162
Skewness	0.736	0.610	−0.116	0.196	−1.939	−0.927
Kurtosis	3.141	2.718	2.162	2.147	8.767	3.172
Jarque-Bera	20.499	14.696	7.091	8.251	452.787	32.470
Probability	0.000	0.001	0.029	0.016	0.000	0.000

4.1 Multiple panel model analysis

The problem of pseudo-regression often occurs in regression analysis, and in order to avoid such problems, it is necessary to conduct prior tests for the smoothness of each variable. In this study, we have taken the practice of many scholars and selected the three common methods of LLC test, IPS test and ADF test to ensure the accuracy and reliability of the test results. The results of the panel unit root test in Table 2 reflect that all variables are non-stationary at the level; therefore, the original hypothesis will not be rejected. However, all variables are stationary at first-order difference and the significance level for rejecting the original hypothesis is 1%. In conclusion, the findings suggest that the variables are stable at the first-order difference. However, this situation suggests the possibility of a long-term association between the series.

In this study, the Pedroni cointegration test was applied to analyze the cointegration between the variables. Table 3 reports the results of the cointegration test for Model I (LNFD-LNGDP) and Model II (LNFD-$LNCO_2$). The alternative hypothesis is that there is no cointegration, while the original hypothesis is the existence of cointegration.

The results of Model I showed that out of seven statistics, four within-dimension statistics and two between-dimension statistics were statistically significant. The results demonstrate that the original hypothesis of no cointegration is rejected. This shows that LNFD, LNP, LNK, and LNR are cointegrated with LNGDP. In addition, the results of Model-II show that the five statistics are significant. Therefore, the results justify the rejection of the original hypothesis of no cointegration. This represents that the variables LNFD, LNP, LNK, and LNR are cointegrated with $LNCO_2$. This indicates that the two models have a long-run cointegration link between the variables.

Table 2. LLC, IPS and Fisher-ADF unit root test results

Test	Variables	Level		First difference	
Panel Ⅰ: Levin-Lin-Chu	$LNCO_2$	−3.277***	0.001	−8.403***	0.000
	LNGDP	−0.705	0.240	−4.783***	0.000
	LNFD	−3.841***	0.000	−5.364***	0.000
	LNK	−1.252	0.105	−6.572***	0.000
	LNP	−1.252	0.105	−6.572***	0.000
	LNR	−1.073	0.142	−8.770***	0.000
Panel II: Im-Pesaran-Shin	$LNCO_2$	0.496	0.690	−6.869***	0.000
	LNGDP	1.714	0.957	−4.156***	0.000
	LNFD	−2.322**	0.010	−5.243***	0.000
	LNK	−0.203	0.419	−5.181***	0.000
	LNP	−0.203	0.419	−5.181***	0.000
	LNR	0.216	0.586	−7.771***	0.000
Panel Ⅲ: Augmented Dickey-Fuller	$LNCO_2$	34.692	0.119	94.239***	0.000
	LNGDP	34.026	0.134	72.612***	0.000
	LNFD	45.597**	0.010	74.714***	0.000
	LNK	35.693*	0.098	80.168***	0.000
	LNP	35.693*	0.098	80.168***	0.000
	LNR	42.627**	0.021	106.484***	0.000

Note: *, **, *** denote significance level at 10%, 5% and 1%, respectively. $LNCO_2$, LNGDP, LNFD,LNK, LNP, LNR represent the logarithm of carbon emissions, economic development, financial development, capital, population, and the proportion of renewable energy, respectively.

Table 3. Pedroni residual cointegration test result

	GDP Model-I		CO2 Model-II	
Pedroni residual Co-integration test				
Alternative hypothesis: Common AR coefficients (within-dimension)				
Panel v-statistic	−0.310	0.622	2.914***	0.002
Panel rho-statistic	3.632	1.000	2.860	0.998
Panel PP-statistic	−0.344	0.366	−1.232	0.109
Panel ADF-statistic	−6.887***	0.000	−3.191***	0.001
Panel v-statistic (Weighted Statistic)	−2.495	0.994	−0.786	0.784
Panel rho-statistic (Weighted Statistic)	3.750	1.000	2.940	0.998
Panel PP-statistic (Weighted Statistic)	−2.513***	0.006	−3.161***	0.001
Panel ADF-statistic (Weighted Statistic)	−4.791***	0.000	−3.049***	0.001
Alternative hypothesis: Individual AR coefficients (Between-dimension)				
Group rho-statistic	4.961	1.000	3.958	1.000
Group PP-statistic	−2.562***	0.005	−4.039***	0.000
Group ADF-statistic	−5.175***	0.000	−3.683***	0.000

Note: *, **, *** denote significance level at 10%, 5% and 1%, respectively. Newey-West automatic bandwidth selection and Bartlett kernel.

After determining the long-run cointegration relationship between the variables, we can next proceed to use the model specification, assuming a ordinary least square (OLS) model, fixed effects (FE) model, and random effects (RE) model, to understand the effects of the variables on GDP and CO_2 and to select the best-fit and efficient model. The estimation results of each model are shown in Table 4.

In the regression analysis, we select the exact model to predict the regression by performing Chow test, Hausmann test, and Breusch-Pegan on both models. First, for Model I, Chow test is used to choose between the OLS model and the fixed effects model. Table 5 shows that the fixed effects model is appropriate because the p-values are less than the 5% significance level. Next, the Hausman model is applied to determine whether the panel data model is a fixed effect or a random effect, and the p-value is greater than 5%, the original hypothesis of fixed effects is not rejected. We then compare the OLS and random effects using Breusch-Pagan's LM test, the results of which indicate that the random effects model is appropriate at the 1% significance level. Similarly, for Model II-CO2, the small p-values in the F.test support the fixed effects model as the best choice. The larger Hausman statistic value indicates that the appropriate specification is the random effects model, while the smaller value of the LM test indicates that the random effects model is superior to the OLS model. Therefore, the random effects model is

Table 4. The results of OLS regression model, fixed effects model and random effects model.

Model-I: Dependent variable LNGDP	Variable	Ordinary least square (OLS)	Fixed effect (FE)	Random effect (RE)
	LNFD	−0.0178	0.452***	0.449***
		(−0.06)	(−7.15)	(−7.14)
	LNP	−0.58	−0.217***	−0.217***
		(−1.77)	(−2.90)	(−2.93)
	LNR	−0.0859	−0.489***	−0.463***
		(−0.33)	(−6.75)	(−6.58)
	LNK	1.071	−0.452***	−0.431***
		(−1.12)	(−3.80)	(−3.64)
Model-II: Dependent variable $LNCO_2$				
	LNFD	0.355	0.401***	0.403***
		(−1.25)	(−7.42)	(−7.49)
	LNP	−0.585***	−0.201***	−0.204***
		(−4.50)	(−3.14)	(−3.21)
	LNR	−0.089	−0.561***	−0.548***
		(−0.34)	(−9.06)	(−9.02)
	LNK	1.072	−0.229**	−0.217**
		(−1.06)	(−2.25)	(−2.14)

Note: t statistics are in parentheses, and *, **, *** denote significance level at 10%, 5% and 1%, respectively.

Table 5. Selection of pooled regression model, fixed effects model and random effects model

	Test	P-value	Tested	Selection
Model-I	F.test	0.000	OLS/FE	FE
	Hausman	0.416	FE/RE	RE
	Breusch-Pegan	0.000	OLS/RE	RE
Model-II	F.test	0.000	OLS/FE	FE
	Hausman	0.613	FE/RE	RE
	Breusch-Pegan	0.000	OLS/RE	RE

the best choice.

Figure 2 shows the results of the coefficients of the random effects model. For model I, the effect of LNFD on the LNGDP is positive and significant, which implies that financial development stimulates economic growth, and the results are similar to the findings of (Ahulu, Maccarthy et al. 2021, Nguyen, Thai-Thuong Le et al. 2021). The coefficients of LNP, LNR and LNK are negatively significant, with the increase in the share of renewable energy having the largest negative impact coefficient on the economy. For the 13 emerging economies, the development of renewable energy does not contribute to their economies and can cause shocks to the economy. Chen et al. (2020) obtained similar conclusions, in contrast to Menyah and Wolde-Rufael (2010), whose study showed no economic impact of renewable energy.

For Model II, the regression results show that financial development also positively affects carbon emissions, i.e., with financial development leads to an increase in environmental pollution. This scenario suggests that the expansion of existing financial operations and the development of new ones increase the demand for energy as well as increase energy consumption, thus increasing carbon emissions. This finding is consistent with the empirical literature on the adverse effects of financial development on environmental quality (e.g., Godil et al. (2020); Xuan and Zaman (2020)).

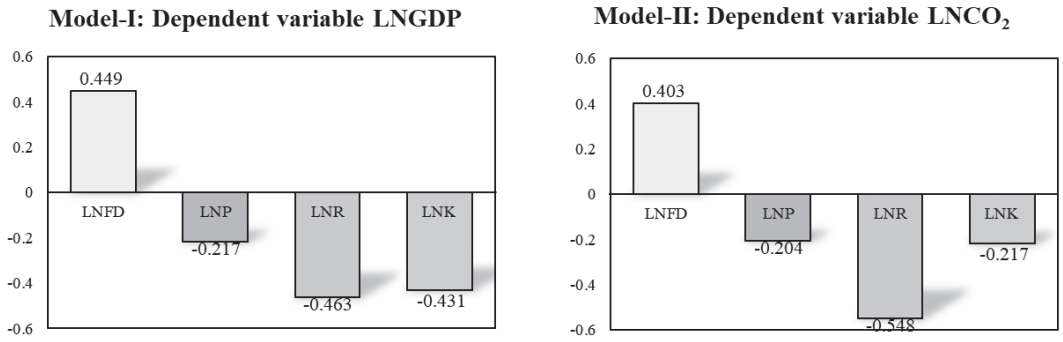

Figure 2. Coefficients of random effects model variables

The coefficients of LNP, LNR and LNK on $LNCO_2$ are negative. Renewable energy development would reduce environmental pollution in emerging countries. Interestingly, renewable energy development inhibits the economy and improves the environment, creating a paradox. And how to develop renewable energy in both favorable economic development and improve the environment is also a hot spot for many scholars to explore.

Moreover, the control variables for Model I and Model II are the same. From this, Model I and Model II can be compared horizontally. The coefficient of financial development on economic growth is 0.449, while the coefficient of impact on carbon emissions is 0.403. This indicates that financial development contributes more to the economy than financial development deteriorates the environment. For emerging countries, interventions in financial development are needed to align financial goals with sustainable development goals.

4.2 Trade threshold effect analysis

Under the perspective of trade globalization, the impact of financial development on economic growth (Model III) and the impact of financial development on carbon emissions (Model IV) are explored. As shown in Table 6, a double threshold model exists for Model III with estimates of 4.086 and 4.279 for the thresholds, corresponding to 95% confidence intervals [3.632, 4.584] and [3.880, 4.507]. The confidence intervals show a small difference between the upper and lower limits, indicating a small uncertainty in the thresholds.

There are two nodes and three stages of the impact of financial development on the economy with trade globalization. The coefficients of financial development are 0.333, 0.284 and 0.367, respectively. This indicates that financial development is a positive and statistically significant factor for economic growth at levels below or above the trade threshold. As trade development crosses the two thresholds in turn, the impact of financial development on the economy first decreases and then increases, even better than in the first stage. There are differences in the impact of national finance on economic growth at different stages of trade development in emerging countries.

First, trade openness affects the size of finance and thus stimulates economic development. On the one hand, trade openness can lead to an increase in the demand for external financing in the country or the region, thus expanding the scale of finance. Only companies with better financing status participate in international trade, rather international trade optimizes the financing status of companies, which in turn stimulates economic growth (Ashraf, Qian et al. 2021). On the other hand, trade openness can affect the supply of financial financing. Trade has led to a large number of foreign companies cooperating with local enterprises to build factories and provide advanced equipment and technology, further enhancing their own strength. Financial institutions can increase the number and types of financial resources supplied, which will have an impact on the scale of finance and the economy.

Second, trade openness can promote efficient economic development by allocating more

Table 6. Results of threshold effects test for Model-Ⅲ and Model-Ⅳ

	Model-Ⅲ (Dependent variable LNGDP)	Model-Ⅳ (Dependent variable $LNCO_2$)
Threshold estimates (Threshold variable LNTRA)		
$\lambda 1$	4.086	4.279
$\lambda 2$	4.279	4.659
95% Confidence interval		
	[3.632, 4.584]	[4.264, 5.053]
	[3.880, 4.507]	[4.659, 5.093]
Impact of financial development		
$\beta 1$	0.333***	0.238***
	(－5.06)	(－4.17)
$\beta 2$	0.284***	0.311***
	(－4.32)	(－5.74)
$\beta 3$	0.367***	0.387***
	(－5.96)	(－6.67)
Impact of control variables		
LNK	－0.457**	－0.226***
	(－4.08)	(－2.37)
LNP	－0.560***	－0.507***
	(－5.45)	(－5.57)
LNR	－0.605***	－0.687***
	(－8.04)	(－10.52)
Observations	216	216

Note: t statistics are in parentheses, and *, **, *** denote significance level at 10%, 5% and 1%, respectively.

financial resources to the more productive sectors (Omri, Daly et al. 2015). According to the theory of trade liberalization, under the condition of free trade, if countries concentrate on the production with comparative advantage, the situation of each country will become better than before. Therefore, with the deepening of trade openness, the distortion of prices caused by national trade protection policies and monopolistic behavior will be gradually eliminated. The financial sector will allocate more funds to the sectors with higher production efficiency in order to improve returns, thus enhancing the allocation efficiency of the financial sector and efficiently promoting economic development.

Model IV also has a double threshold model with threshold estimates of 4.279 and 4.659, corresponding to 95% confidence intervals [4.264, 5.053] and [4.659, 5.093]. With the development of trade, the coefficients of financial development on carbon emissions are 0.238, 0.311 and 0.387, respectively. Overall, the impact of financial development on carbon emissions is significantly positive, and the development of finance does not improve the environment for emerging

countries. And with the gradual opening of trade, the coefficient of the impact of financial development on carbon emissions is continuously becoming larger. A related study by Dhrifi et al. found that financial development helps to absorb foreign investments and promote energy-intensive enterprises, which makes emissions rise, which has a negative impact on the environment (Dhrifi, Jaziri et al. 2020). The results of Mukhtarov et al. showed that in the process of financial deepening, private loans are more easily available people can buy more cars, washing machines and other household items, thus increasing daily carbon emissions. Financial development increases energy use by individuals and businesses and deteriorates the quality of the environment (Mukhtarov, Mikayilov et al. 2018).

Combining model III and model IV, the second threshold of model III and the first threshold of model IV are equal. When LNTRA＜4.279, the coefficients of financial development on the economy are 0.333 and 0.284, while the coefficient of financial development on carbon emissions is 0.238. This indicates that at this stage, financial development facilitates the decoupling of the economy and carbon emissions. The promotion effect of financial development on the economy is significantly higher than the pollution effect on the environment. When LNTRA4＞.279, the impact coefficient of financial development on the economy is 0.367, while the impact coefficients on carbon emissions are 0.311 and 0.387. when 4.＜279LNTRA＜4.659, the impact coefficient of financial development on the economy is higher than the impact coefficient on carbon emissions, and the economy and carbon emissions are still in the decoupling state. When LNTRA4＞.659, the impact coefficient of financial development on the impact on carbon emissions is greater. At this stage, the promotion effect of financial development on the economy does not offset the pollution to the environment, and the decoupling of the economy from carbon emissions is not achieved.

In general, financial development is critical to sustaining economic growth and prosperity

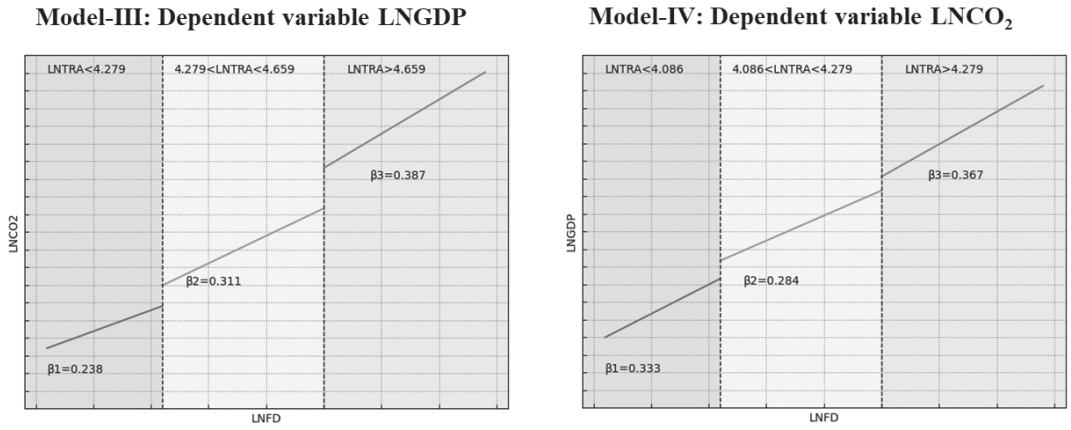

Figure 3. Threshold effects of financial development on the economy and carbon emissions under the influence of trade globalization

in emerging countries and therefore cannot be compromised. Considering the importance of financial development, the obvious solution is financial reform. Financial reform can help redirect financial resources to the introduction and diffusion of environmentally friendly products and technologies and the construction of alternative energy infrastructures that lead to sustainable growth. In other words, improvements to their financial systems and the promotion of green finance in emerging countries can lead to sustainable development.

According to the threshold, the countries are divided into years 2003, 2008, 2013, and 2018 (Figure 4). The countries Bangladesh, Brazil, China, India, Nigeria, Pakistan, and Russian Federation have been at LNTRA＜4.086 for the four years. This indicates that the financial development is favorable to decouple the economies of these countries from carbon emissions and that this effect is stable. While Vietnam is at LNTRA＞4.659, the economic boost from financial development does not offset the environmental pollution for Vietnam. For Korea and Mexico, the decoupling status of the economy and carbon emissions is changing as time advances and their trade evolves across different threshold values, but it is always favorable to decouple.

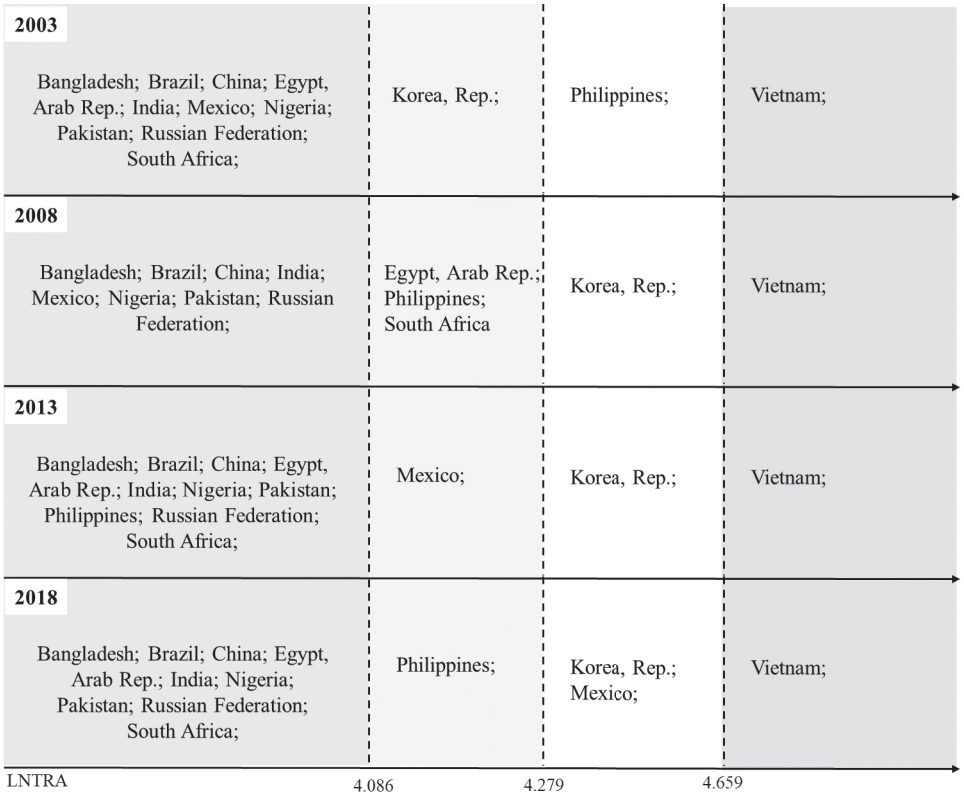

Figure 4. Classification of countries according to the threshold value

5. Conclusions and policy implications

Emerging economies are becoming a source of stability for the world economy. Because economic growth is accompanied by environmental threats, emerging countries face the challenge of trying to strike a balance between economic growth and environmental quality. In this context, the role of finance and trade is crucial as it is closely related to economic growth and environmental quality. This study empirically investigates the impact of financial development on the economy and carbon emissions of emerging countries from 2001–2018. It also explores the non-linear effects of financial development on the economies and carbon emissions of emerging countries under different levels of trade.

Our empirical results show, first, that the results based on the panel cointegration approach suggest that all series are long-run cointegration correlated. Second, the random effects model is the best choice. The random effects model shows that financial development has a statistically positive long-run effect on economic growth and carbon emissions. Third, the threshold model shows that the impact of financial development on economic growth and carbon emissions shows a three-stage positive relationship with the development of trade. The coefficient of the effect of financial development on carbon emissions is continuously getting larger. Fourth, when LNTRA $<$ 4.659, financial development facilitates the decoupling of the economy and carbon emissions. The boosting effect of financial development on the economy is significantly higher than the polluting effect on the environment. When trade crosses this threshold, the decoupling of the economy from carbon emissions is not achieved. Finally, the negative effects of pollution on the environment are offset by the boosting effect of financial development on the economy in emerging countries, except for Vietnam, during the study period.

Consistent with these results, the following policy implications are offered. Financial development and economic growth go hand in hand. The positive impact of financial development on economic growth shows that the policies, means and measures to support financial development are also supporting the economic growth of emerging countries. Thus, for the emerging countries in the study sample, expanding financial development appears to be an effective way to support economic growth. Due to the blindness and profit-seeking nature of financial capital, its role in guiding funds often cannot produce long-term effects, which requires the government to increase financial investment and strengthen direction guidance.

In order to decouple the economy from carbon emissions, emerging countries need to introduce and promote efficient and environmentally friendly products and technologies. To finance these technologies, improvements to their financial systems are needed. First, it is necessary to broaden the financing channels of green projects. The country needs to stimulate the development of green finance through various policy instruments, including: fiscal subsidies, policy preferences, etc., so as to mobilize investors and consumers' investment preference and consumption enthusiasm for green projects. Innovation in financial instruments can also play a

role in promoting the development of a green economy. Second, drawing on the experience of developed countries, the government has introduced green finance standards. As an emerging country, the general lack of attention to green finance, in the pursuit of sustained and steady economic growth, is facing economic pressure and environmental pressure at the same time. Designate financial standards with national characteristics, so that funds can be truly used in green projects. Finally, on the basis of maintaining the development of the total amount, financial supervision should also be strengthened to avoid risks caused by excessive financial efficiency. The state should formulate relevant institutional guarantees for a variety of green financial instruments, build a unified green financial regulatory agency that is in line with international standards, and promote the high-quality development of green finance.

Given the role of trade in financial development, there is a need to strengthen international cooperation in finance. The economy is globalized, and the new generation of technological changes is also global. Strengthen regional cooperation with other countries to create a favorable financial investment environment. It is necessary to actively guide international financial capital to come in and invest in key industries of national priority development, and cooperate with other countries to achieve win-win growth. In the process of opening up, the initiative of opening up should be grasped in real time, and the pace of financial opening up should be firmly controlled in our own hands. And in the process of opening up, we should protect our financial system with appropriate strength and in an appropriate way, and at the same time gradually improve the system to form competition internally and enhance competitiveness.

This study is limited to examining the impact relationship between financial development, trade, economy, and carbon emissions. In the future, financial development is more broadly conceptualized and researchers should examine the impact of finance from a global perspective in order to draw more general conclusions. In addition, future research should examine the impact of various social conditions (e.g., corruption, institutions, and aging) on economy and environment, which could provide insights into environmental sustainability. This analysis can then be extended to different panel regions, other developed economies and country-specific cases.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

References

A, K. S. I., M. H. P. B and Y. S. C (2003). “Testing for unit roots in heterogeneous panels.” Journal of Econometrics 115(1): 53–74.

Abdouli, M. and S. Hammami (2020). “Economic Growth, Environment, FDI Inflows, and Financial Development in Middle East Countries: Fresh Evidence from Simultaneous Equation Models.” Journal of the Knowledge Economy 11: 479–511.

Acheampong, A. O., M. Amponsah and E. Boateng (2020). “Does financial development mitigate carbon emissions? Evidence from heterogeneous financial economies.” Energy Economics 88: 104768.

Adams, S. and E. Klobodu (2018). “Financial Development and Environmental Degradation: Does political regime matter?” Journal of Cleaner Production 197 (PT.1): 1472–1479.

Ahmad, M., Z. Khan, Z. U. Rahman and S. Khan (2019). “Does financial development asymmetrically affect CO2 emissions in China? An application of the nonlinear autoregressive distributed lag (NARDL) model.” Carbon Management 9(6): 631–644.

Ahulu, H., J. Maccarthy and P. Muda (2021). “Financial Stability and Economic Growth Nexus: Evidence from Sub-Saharan Africa using Panel Data.” International Journal of Economics & Financial Issues 11: 11–18.

Ashraf, B. N., N. Qian and Y. Shen (2021). “The impact of trade and financial openness on bank loan pricing: Evidence from emerging economies.” Emerging Markets Review 47: 100793.

Asteriou, D. and K. Spanos (2019). “The relationship between financial development and economic growth during the recent crisis: Evidence from the EU.” Finance Research Letters 28: 238–245.

Chen, C., M. Pinar and T. Stengos (2020). “Renewable energy consumption and economic growth nexus: Evidence from a threshold model.” Energy Policy 139: 111295.

Cheng, C. Y., M. S. Chien and C. C. Lee (2021). “ICT diffusion, financial development, and economic growth: An international cross-country analysis.” Economic Modelling 94: 662–671.

Dhrifi, A., R. Jaziri and S. Alnahdi (2020). “Does foreign direct investment and environmental degradation matter for poverty? Evidence from developing countries.” Structural Change & Economic Dynamics 52: 13–21.

Godil, D.I., Sharif, A., Agha, H., Jermsittiparsert, K. (2020). The dynamic nonlinear influence of ICT, financial development, and institutional quality on CO_2 emissions in Pakistan: new insights from QARDL approach. development, and institutional quality on CO_2 emission in Pakistan: new insights from QARDL approach. environmental science & pollution research international 27, 24190–24200.

Hansen, B. E. (1999). “Threshold Effects in Non-Dynamic Panels: Estimation, Testing, and Inference.” Journal of Econometrics 93(2): 345–368.

Ji, Q. and D. Zhang (2019). “How much does financial development contribute to renewable energy growth and upgrading of energy structure in China?” Energy Policy 128: 114–124.

Jiang, C. and X. Ma (2019). “The impact of financial development on carbon emissions: a global perspective.” Sustainability 11(19): 5241.

Khan, M. A., M. A. Khan, M. Ahmed and K. Khan (2021). “Environmental consequences of financial development in emerging and growth-leading economies: A multidimensional assessment.” Borsa Istanbul Review.

King, R. G. and R. Levine (1993). “Finance and Growth: Schumpeter Might Be Right.” The Quarterly Journal of Economics 108: 717–737.

Koengkan, M., R. Santiago, J. A. Fuinhas and A. C. Marques (2019). “Does financial openness cause the intensification of environmental degradation? New evidence from Latin American & Caribbean countries.” Environmental Economics & Policy Studies 21: 507–532.

La, F. and C. Chu (2002). “Unit root tests in panel data: asymptotic and finite-sample properties.” Journal of

Econometrics 108(1): 1–24.

Lahiani, A. (2020). “Is financial development good for the environment? An asymmetric analysis with CO2 emissions in China.” Environmental Science & Pollution Research 27(19): 7901–7909.

Lahiani, A., S. Mefteh-Wali, M. Shahbaz and X. V. Vo (2021). “Does financial development influence renewable energy consumption to achieve carbon neutrality in the USA?” Energy Policy 158: 112524.

Maddala, G. S. and S. Wu (1999). “A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test.” Oxford Bulletin of Economics & Statistics 61(S1): 631–652.

Madhu, Sehrawat, Giri, Geetilaxmi and Mohapatra (2015). “The impact of financial development, economic growth and energy consumption on environmental degradation.” Management of Environmental Quality An International Journal 26(5): 666–682.

Maji, I. K., M. S. Habibullah and M. Y. Saari (2017). “Financial development and sectoral CO2 emissions in Malaysia.” Environmental Science & Pollution Research 24: 7160–7176.

Menyah, K. and Y. Wolde-Rufael (2010). “CO2 emissions, nuclear energy, renewable energy and economic growth in the US.” Energy Policy 38(6): 2911–2915.

Moghadam, H. E. and V. Dehbashi (2018). “The impact of financial development and trade on environmental quality in Iran.” Empirical Economics 54(4): 1777–1799.

Moyo, C. and P. L. Roux (2020). “Financial development and economic growth in SADC countries: a panel study.” African Journal of Economic & Management Studies 12: 71–89.

Mukhtarov, S., J. I. Mikayilov, J. Mammadov and E. Mammadov (2018). “The impact of financial development on energy consumption: evidence from an oil-rich economy.” Energies 11(6): 1536.

Nguyen, H. M., Q. Thai-Thuong Le, C. M. Ho, T. C. Nguyen and D. H. Vo (2021). “Does financial development matter for economic growth in the emerging markets?” Borsa Istanbul Review.

Omri, A., S. Daly, C. Rault and A. Chaibi (2015). “Financial development, environmental quality, trade and economic growth: What causes what in MENA countries.” Energy Economics 48: 242–252.

Paramati, S. R., D. Mo and R. Gupta (2017). “The effects of stock market growth and renewable energy use on CO2 emissions: Evidence from G20 countries.” Energy Economics 66(aug.): 360–371.

Pedroni, P. (2004). “Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis.” Department of Economics Working Papers 20(3): 597–625.

Pradhan, R. P., T. Nath, R. P. Maradana and A. K. Sarangi (2021). “Innovation, Finance, and Economic Growth in OECD Countries: New Insights from a Panel Causality Approach.” International Journal of Innovation & Technology Management 18(11): 2150013.

Saud, S., S. Chen and A. Haseeb (2020). “The role of financial development and globalization in the environment: accounting ecological footprint indicators for selected one-belt-one-road initiative countries.” Journal of Cleaner Production 250: 119518.

Seetanah, B., R. V. Sannassee, S. Fauzel, Y. Soobaruth, G. Giudici, A. P. H. Nguyen and Trade (2018). “Impact of Economic and Financial Development on Environmental Degradation: Evidence from Small Island Developing States (SIDS).” Emerging Markets Finance 55: 1–15.

Shahbaz, M., J. Li, X. Dong and K. Dong (2022). “How financial inclusion affects the collaborative reduction of pollutant and carbon emissions: The case of China.” Energy Economics 107: 105847.

Shahbaz, M., M. A. Nasir and D. Roubaud (2018). “Environmental Degradation in France: The Effects of FDI, Financial Development, and Energy Innovations.” MPRA Paper.

Shahbaz, M., S. Shahzad, N. Ahmad and S. Alam (2016). “Financial development and environmental quality: The way forward.” MPRA Paper.

Tran, V. T., H. Herwartz, J. D. Haan, A. L. Hillman and H. W. Ursprung (2020). “The impact of local financial development on firm growth in Vietnam: Does the level of corruption matter?” European Journal of Political Economy 62: 101858.

Uddin, M. K., X. Pan, U. Saima and C. Zhang (2022). “Influence of financial development on energy intensity subject to technological innovation: Evidence from panel threshold regression.” Energy 239: 122337.

Wang, C.-H., P. Padmanabhan and C.-H. Huang (2022). “The impacts of the 1997 Asian financial crisis and the 2008 global financial crisis on renewable energy consumption and carbon dioxide emissions for developed and developing countries.” Heliyon 8(2): e08931.

Wang, Q., S. Wang and X.-t. Jiang (2021). “Preventing a rebound in carbon intensity post-COVID−19-lessons learned from the change in carbon intensity before and after the 2008 financial crisis.” Sustainable Production and Consumption 27: 1841−1856.

Xuan, V. and K. Zaman (2020). “Relationship between energy demand, financial development, and carbon emissions in a panel of 101 countries:”go the extra mile “for sustainable development.” Environmental Science & Pollution Research 27(1): 23356−23363.

Zhang, Y. J. (2011). “The impact of financial development on carbon emissions: an empirical analysis in China.” Energy Policy 39: 2197−2203.