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CẤU TRÚC TÀI CHÍNH VÀ CHẤT LƯỢNG MÔI TRƯỜNG: VAI TRÒ CỦA MỨC THU NHẬP QUỐC GIA

Nguyễn Linh Chi[1]

Sinh viên K61B - K61 - Tài chính quốc tế

Trường Đại học Ngoại Thương Cơ sở II tại TP. Hồ Chí Minh

Hồ Thị Trà Giang

Sinh viên RM001- K48 - Quản trị rủi ro tài chính

Đại học Kinh tế TP. Hồ Chí Minh

Nguyễn Thị Mai

Giảng viên cơ sở II

Trường Đại học Ngoại Thương Cơ sở II tại TP. Hồ Chí Minh

Tóm tắt

Nhiều nghiên cứu đã tiến hành làm rõ mối quan hệ giữa phát triển tài chính và lượng khí thải CO2, nhưng có rất ít thông tin về cấu trúc tài chính, trong đó tập trung vào tài chính trực tiếp và gián tiếp. Nghiên cứu này đo lường tác động của cấu trúc tài chính đến lượng khí thải carbon ở 60 quốc gia trong giai đoạn 2004–2017. Nghiên cứu sử dụng phương pháp bình quân của phương sai và phân tích yếu tố chính (PCA) để xây dựng chỉ số cấu trúc tài chính và phương pháp system-GMM để ước lượng. Kết quả nghiên cứu cho thấy: thứ nhất, cấu trúc tài chính giúp giảm lượng khí thải carbon ở các nước có thu nhập cao nhưng không đáng kể ở các nước khác; thứ hai, tăng trưởng thu nhập làm thay đổi bản chất mối quan hệ giữa cấu trúc tài chính và lượng khí thải carbon; thứ ba, độ mở thương mại tăng lên góp phần giảm thiểu ô nhiễm. Các kết quả khám phá mang lại nhiều hàm ý chính sách để cải thiện môi trường. Cấu trúc tài chính cần được phát triển toàn diện về mọi mặt: thể chế tài chính, thị trường tài chính và các công cụ tài chính, đồng thời cần thúc đẩy phát triển tổng sản phẩm quốc nội bình quân đầu người để phát huy tác động thuận lợi của cơ cấu tài chính.

Từ khóa: cấu trúc tài chính, phát thải CO2, mức thu nhập, tăng trưởng, system GMM

[1] Corresponding author, Email: k61.2211315004@ftu.edu.vn

FINANCIAL STRUCTURE AND ENVIRONMENTAL QUALITY: DOES NATIONAL INCOME LEVEL MATTER?

Abstract

The extant literature has rigorously studied the relationship between financial development and CO2 emissions, but very little is known about financial structure, which focuses on direct and indirect finance. In this study, we examined the impact of financial structure on carbon emissions in 60 countries for the period of 2004–2017. Our investigation relied upon variance equal weighting and principal component analysis to construct financial structure index and system generalized method of moments for regression estimation. The empirical results are as follows: firstly, financial structure helps reduce carbon emissions in high-income countries, but insignificant in others; secondly, income growth changes the nature of relationship between financial structure and carbon emissions; thirdly, increased trade openness contributes to pollution mitigation. The revealing results suggested many policy implications to better environmental performance. Financial structure should be comprehensively developed in all aspects: financial institutions, financial markets and financial instruments. Along with that, increasing gross domestic product per capita cannot be neglected in order to promote the favorable impacts of financial structure.

Keywords: financial structure, CO2 emissions, growth, system GMM

1. Introduction

Investigations into the determinants of environmental quality have attracted immense attention from the academic world in recent years due to the ongoing high level of harmful gasses in the atmosphere, especially carbon emissions (e.g. Zafar et al. (2019); Mahmood et al. (2019); Acheampong & Boateng (2019); Habiba & Xinbang (2022)). By the year 2020, CO2 concentration in the atmosphere has accelerated to 48% above its pre-industrial level in 1750 (European Commission, 2023). Among all the factors contributing to that increase, human activities are the most significant, for people constantly burn fossil fuels to generate electricity, heat and cool buildings, as well as power vehicles **(**Charfeddine & Khediri, 2016). It is important to ensure environmental quality for the survival of humans through guarding the effects of economic activities. Financial indicators have been evaluated and proved to exert significant impacts on CO2 emissions (Bui, 2020; Khan & Ozturk, 2021; Sadorsky, 2010).

The financial system is regarded as "the brain of the economy" (Mishkin, 2006) as it greatly contributes to the process of channeling funds from individuals with excessive revenues to those who lack budgets to fund their investments. To be specific, Levine et al. (1997, 2004) concurred that a developed financial system can influence the allocation of resources by fulfilling five fundamental functions: providing information about investment opportunities, monitoring corporate investments, facilitating trading and risk management, mobilizing savings and easing the exchange of goods and services. In short, a well-developed financial system helps address the problems of infamous market failures such as: asymmetric information and moral hazards. In this study, we differ from previous research in focusing on "financial structure" in the broad term of financial development, which primarily discusses the types of direct and indirect finance (Beck & Levine, 2002); and its potential effects on environmental quality in countries with different income levels. One of our major objectives is to construct a compound financial structure index constructed by variance-equal weight and principal component analysis, as mixed conclusions of the link between financial structure and CO2 emissions are due to the use of different indicators (Shahbaz et al., 2016). This study makes marginal contributions to policy-making process as integrating the roles of financial structure reform in environmental policies should take national income level into consideration.

The research is organized as follows: the second part provides a brief review of literature, the third part explains data collection, econometric models and estimation methods, the fourth part demonstrates experimental regression results and finally the authors come to the conclusion and propose policies in the fifth part.

2. Literature review

2.1. Financial structure

One of the most pioneering works by Raymond W. Goldsmith in 1969, "Financial Structure and Development", defined "financial structure" as the combination of financial instruments, markets and institutions in an economy. Despite his outstanding contribution to the evolution of national financial systems, Goldsmith has yet shed light on the merits of bank-based versus market-based financial systems. In the modern era, financial development captures more attention and there has been abundant research on financial development and its relationships with other disciplines. One noticeable line of thinking about financial development studies is its two different traits: (1) financial scale and (2) financial structure (Appiah-Otoo et al., 2023; Zhao et al., 2023). Financial scale is measured by stock market value traded to GDP or private credit to GDP. Financial structure concerns the proportion of direct finance (market-based) and indirect finance (bank-based) (Levine, 2002). Although financial scale has provided significant indicators in exploring the connection between environmental performance and financial development; however, recent studies have directed new focus on the structure of financial systems and emphasized its importance for policy makers concerning environmental issues both in the developed and developing economies (Ehigiamusoe et al., 2019; Yao & Tang, 2021; Zhao et al., 2023). The more developed financial intermediaries and markets in financial systems, the more effective in capital allocation (Greenwood & Jovanovic, 1990).

2.2. Measure financial structure

Beck et al. (1999) and Levine (2002) proposed a new comprehensive database to measure five aspects: (1) structure size, (2) structure activity, (3) structure efficiency, and (4) structure regulation of various financial institutions and markets across borders. The first proxy, Structure Size, represents the size of stock markets to that of banks. Structure Activity is a measure of stock markets' efficiency to that of banks. Structure Efficiency measures efficiency of stock markets. The last, Structure Regulatory, is an aggregate measure of regulatory restrictions on commercial bank activities. It is worth noting that there is a special conglomerate measure of financial structure called "Financial Aggregate", which is the first principal component of Structure Size, Structure Activity, and Structure Efficiency. While Structure Aggregate have been a frequent proxy in financial structure studies, Structure Regulatory have been rarely used due to data limit (Xu, 2022).

2.3. Financial structure - CO2 emissions nexus

In theory, financial structure has two kinds of impacts on environmental quality. The first strand of literature argues that financial structure contributes to environmental degradation. Myers & Majluf (1984) discussed corporate financing behaviors, such as internal sources of funds, and external financing like debt or equity. Enterprises that operate in industrialized business, especially those with high contamination degree and energy demand, have more advantages in meeting their financial obligations (Gokmenoglu, Amin, & Taspinar, 2015). If raising funds from debt is impossible, companies can seek equity from the public through stock shares. Nevertheless, in developing economies, where direct fundraising from stock markets is not straightforward due to weak regulations and slow income growth, loans from financial intermediaries like banks are much easier to seek for. (Wei & Kong, 2017).

The second strand of literature concerns that, if the ratio of indirect finance is greater than that of direct financing, the amount of CO2 emissions will reduce. One frequent channel that financial structure helps ameliorate environmental quality is technological development or research and development activities because CO2 emissions mainly come from fossil fuels consumption; to develop renewable energy is to reduce the use of fossil fuels. Technological development projects often seek funds in two ways: (1) through stock markets and (2) through loans and credits. If the second way is more preferred, it means that companies' eco-friendly projects are reliable enough to pass meticulous loans screening of banks, ultimately leading to emissions reduction (Tamazian et al., 2009).

Many empirical studies have explored the heterogeneous effects of financial structure on environment in different kinds of economies and with many methods, but there is no consensus in conclusions (Ehigiamusoe et al., 2019; Khan & Ozturk, 2021; Khezri, Karimi, Khan, & Abbas, 2021; Yao & Tang, 2021; S. Zhao et al., 2023). One perspective advocates that financial structure helps reduce CO2 emissions through green investments and environmental initiatives; but not applicable to all stages of economic development, particularly in advanced and emerging economies. Tamazian & Rao (2010) stated that in developed nations, fundraising for technology innovation projects is more efficient in both types of finance as investors have adequate and reliable information about enterprises and enterprises get access to financing at a lower cost; but this is not the case in developing countries, where regulations about stock markets are weak. Hence, financial structure in developed countries is more conducive to emissions mitigation. Other scholars, on the other hand, highlighted the harmful impacts that a well-developed financial system exerts on the environment. This is not because of industrial businesses but rather consumers' purchasing behaviors. Easier credit opportunities can lead to increasing consumption of energy-consuming products like automobiles and air-conditioning, which in turn increases CO2 emissions. It also enables companies to obtain cheap credits to expand business by installing new facilities, employing more labor, and building new plants; however, such activities increase the consumption of energy and resources (Sadorsky, 2011; Shahbaz et, 2017). Besides, the third view have postulated that the development in financial structure has an insignificant impact on carbon emissions (Ziaei, 2015).

In addition, Sadorsky (2011) and Shahbaz et al. (2016) mentioned that mixed results might happen due to the use of varying financial development indicators, which implies that biases in selecting measures lead to different ways that financial development and financial structure affect environment quality. As economic growth and other socio-economic conditions are distinct, the structure of the financial industry across countries shows different developing tendencies. Together with the origin definition of financial structure above, it is challenging to thoroughly capture all aspects of financial structure in one single indicator. Previous studies employ different proxies for financial development and financial structure such as: stock market value to private credit (Appiah-Otoo et al., 2023), stock market value to domestic credit (Yao & Tang, 2021), domestic credit to private sector by banks (Xu et al., 2021; Omri et al., 2021), liquid liabilities to GDP (Sadorsky, 2010), value of stock traded to GDP (Ehigiamusoe et al., 2019). Additionally, accelerating globalisation in these years has gradually changed the structure of financial systems, resulting in a higher degree of complexity and multi-dimensionality. From traditional prospects like market-based and bank-based, a wide range of other financial institutions such as insurance companies, securities firms, mutual funds, pension funds, investment banks have gained more importance to economic growth. Therefore, the financial structure index needs to be composed of multiple indicators that reflect its changing complexity.

3. Methodology

3.1. The construction of financial structure index

One of our primary objectives is to aggregate all subindexes into a composite index that still generalizes the development of each nation's financial structure. construct a comprehensive measurement of aggregate financial structure index (FSI). Similar to Beck et al. (1999)'s work, we built up FSI to cover three main aspects that almost every country's financial system structure includes: depository institutions, non-depository institutions and stock markets.

Table 1. Financial structure indicators

Individual factors
(1) Depository institutions (Banking system)
Liquid liabilities
Central bank assets
Deposit money banks assets to GDP
Private credit by deposit money banks and other financial institutions to GDP
(2) Nondepository institutions
Life insurance premium volume to GDP (%)
Non-life insurance premium volume to GDP (%)
(3) Financial markets
Stock market capitalization to GDP (%)
Stock market total value traded to GDP (%)
Stock market turnover ratio (%)
No. of listed companies per 10k population

Source: Authors' calculation (2024)

Because the literature does not reach consensus on a certain method of aggregating small indices into a compound index (Illing & Liu (2003); Svirydzenka (2016). We observed that there are two most common weighting methods: variance-equal weights (VEW) and principal component analysis (PCA). Illing & Liu (2003) mentioned that the difficulty in choosing weights is due to the lack of reference series upon which significant weights can be derived and examined. VEW overcomes this shortcoming by giving equal importance to each indice, but the assumption that all indices are normally distributed is the main drawback of this approach. To account for this problem, we decide to check the robustness of data by conducting the second method, PCA. Principal component analysis is an algorithm-based technique for reducing the multi-dimensionality of dataset while summarizing the large content with the most important component.

Firstly, we employ variance-equal weighting method to construct financial structure index (FSI). Before aggregating all individual indicators into a single aggregate index, all individual indicators need to be normalized so that they are on the same variance scale. The authors computed statistical normalization by applying the following formula:

$$Z_t = \frac{X_t - \bar{X}}{S}$$

Z_t is called standard normal distribution with zero mean and unit variance, N (0,1). X_t is the value of indicator at observed time t. $\bar{X}$ and S is the value of mean and standard deviation respectively of indicator x analyzed in the period t.

The final FSI is the arithmetic average of the depository institutions, non-depository institutions and financial markets. It is calculated by the following formula:

$$FSI = \frac{\sum_{i=1}^{3} s_i}{n}$$

where s_i represents the sub-indexes (depository institutions index, non-depository institutions index and financial markets index) and n refers to the number of sub-indexes in the final FSI. A positive value indicates improvement in financial structure and negative value indicates deterioration in financial structure.

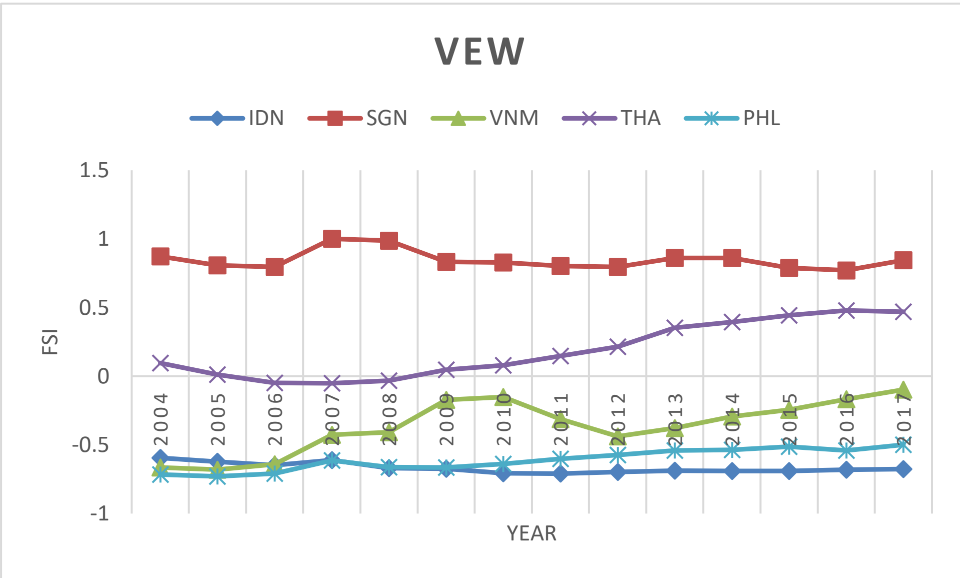

Figure 1. Financial structure index using VEW

Source: Authors' calculation (2024)

Secondly, for sensitivity analysis, we construct financial structure index by principal component analysis (PCA) to capture the first principal component that explains the greatest part of the combined movement of the variables used for the construction of FSI. To date, only a certain number of researches, including Adu et al. (2013), Shoaib et al. (2020), Zhao & Yang (2020), Lv & Li (2021) have employed a composite financial structure index constructed by PCA to examine its relationship with environmental quality but all stated that the conclusions are more valid and insightful. Figure 2 demonstrates the results of 5 selected Asian countries' FSI. It is clear that FSI by PCA shows almost the same trend with FSI by VEW in Figure 1.

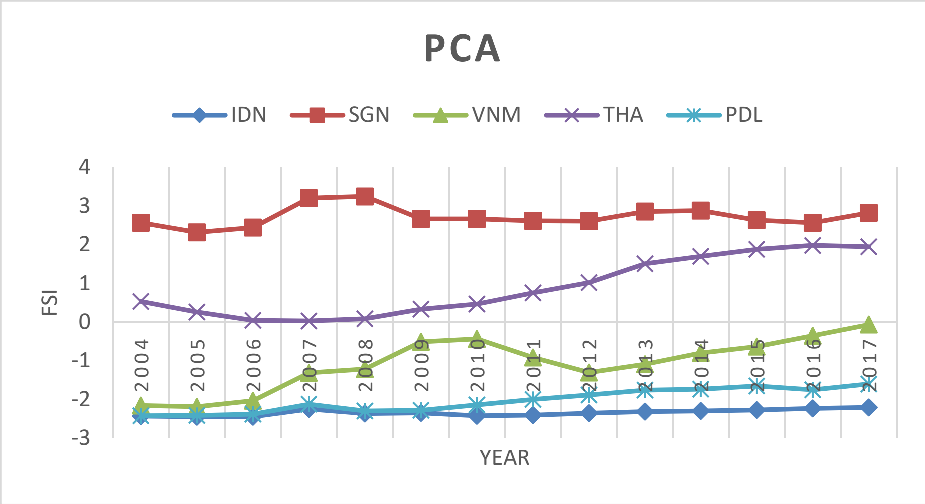

Figure 2. Financial structure index using PCA

Source: Authors' calculation (2024)

3.2. Data collection

This study uses an annual panel dataset of 60 countries during the period between 2004 and 2017 to disentangle the relationship between financial structure and CO2 emissions. The panel dimension was limited to secondary data availability. We collect data to measure financial structure from the Financial Development and Structure dataset proposed by Beck et al. (2000). Data for income inequality, human capital and coal consumption were adapted from Standardized World Income Inequality Database by Solt (2020), Penn World Table 10.0 and U.S. Energy Information Administration, respectively. Data for other variables, including CO2 emissions per capita, GDP per capita, trade, urban population, renewable energy consumption, was obtained from World Development Indicators by World Bank (2023).

3.3. Econometric modelling

To disentangle the relationship between financial structure and CO2 emissions, the research team carried out two regression models for direct and interaction effects, both are taken in logarithmic form. Based on the previous research of Khan & Ozturk (2021), we proposed the following econometric models:

$$CO2_{it} = \beta_0 + \beta_1 CO2_{it-1} + \beta_2 FS + \beta_3 GDP + \beta_4 TRADE + \beta_5 REC + \beta_6 COAL + \beta_7 UP + \beta_8 HC + \beta_9 GINI + \beta_{10} DUM + u_{it} \quad (1)$$

In Equation (1) we hypothesize the direct effect of financial structure on CO2 emissions. However, as mentioned earlier, the relationship between financial structure and environmental pollution is likely to differ across countries depending upon their macroeconomic features such as income level, trade openness and human capital. Then we add a multiplicative interaction term of financial structure and dummy variable income level that represents the relationship between financial structure and income level group. The resulting equation becomes:

$$CO2_{it} = \beta_0 + \beta_1 CO2_{it-1} + \beta_2 FS + \beta_3 GDP + \beta_4 TRADE + \beta_5 REC + \beta_6 COAL + \beta_7 UP + \beta_8 HC + \beta_9 GINI + \beta_{10} DUM + \beta_{11} FS * DUM + u_{it} \quad (2)$$

We describe model variables in Table 2.

Table 2. Summary of variables

Type	Code	Explanation	References	Expectations
Dependent variable	lnCO2	CO2 emissions	Abbasi & Riaz, (2016); Anser et al., (2021); Park et al., (2018); Xu et al., (2021)	
Explanatory variable	FS	Financial structure captures composition of financial institutions and markets in each nation	Beck et al. (2000)	-
Interaction variable	FS*DUM	Relationship between financial structure and country income level	Authors' hypothesis	-
Control variable	GDP	GDP per capita	Habiba & Xinbang (2022); Zafar et al. (2019)	-
	TRADE	Export and import as % of GDP	Khan & Ozturk (2021); Shoaib et al. (2020).	+
	HC	Human capital measured by years of schooling	Mahmood et al. (2019)	-
	UP	Urban population percentage	Acheampong & Boateng (2019); Yao & Tang (2021)	+
	GINI	Comparison of cumulative proportions of the population against cumulative proportions of income they receive	(Bui, 2020; Zhang & Zhao, 2014)	+
	REC	Renewable energy consumption percentage	Anton et al. (2020); Zafar et al. (2019)	-

Type	Code	Explanation	References	Expectations
	COAL	Coal consumption percentage	Chandran et al. (2013); Magazzino et al. (2021)	+
	DUM	Dummy variable for income level, 1 for high-income group, 0 for the otherwise	Authors' hypothesis	+

Source: Authors' calculation (2024)

3.4. Estimation methods

The study performs Pooled OLS regression models within fixed effects by year and country, fixed-effects (FEM) models, random-effects (REM) models. In our equations, one year lagged value of dependent variable appears as independent; hence, we hypothesize $\boldsymbol{CO2_{it-1}}$ and UP are endogenous. To overcome endogeneity, we carried out and discussed the results of the system generalized method of moments (S-GMM) model as suggested by Ehigiamusoe et al. (2020) and Khan & Ozturk (2021).

For model fit, we applied F-test to determine whether FEM or POOLED OLS is consistent and Hausman test to determine whether FEM or REM is more suitable.

The study performs diagnostics tests for panel data models: multicollinearity test (VIF), heteroskedasticity (Wald test), autocorrelation (Wooldridge test).

4. Experimental results estimate the effects of financial structure on environment

4.1. Descriptive statistics

Table 3. Variables' statistics description

Variable	Obs.	Mean	Std. Dev.	Min	Max
CO2	840	6.464646	4.953518	0.2202442	27.54777
FS	840	-0.0001112	0.5964071	-0.8835423	2.040437
GDP	840	22165.92	22562.31	892.3821	112417.9
TRADE	840	89.1834	42.6109	22.10598	437.3267
HC	840	2.860881	0.5388143	1.467572	3.974208
UP	840	67.27956	18.97678	18.196	100
GINI	840	37.26667	8.681385	23.4	65.2
REC	840	19.12843	17.67802	0.1	81.67
COAL	840	2.453082	10.50978	7.76e-07	96.11871
DUM	840	0.5333333	0.4991849	0	1

Variable	Obs.	Mean	Std. Dev.	Min	Max
FS*DUM	840	0.1613572	0.4343926	-0.7493219	2.040437

Source: Authors' calculation (2024)

The properties of variables are illustrated in Table 6. The average of $CO2$ is 6.464646 metric tons per capita with a maximum of 27.54777 and a minimum of 0.2202442, indicating a significant gap between the highest and lowest pollution levels across countries. The mean of financial structure is -0.0001112, showing that the structure of financial systems in general is slightly undeveloped. It can be seen that the values of other variables have quite large differences between highest and lowest, indicating that there are distinct characteristics across countries. Also, the standard errors among variables differ greatly from each other; hence, considering possible heteroskedasticity, we take logarithm form of all variables in primary regressions, except for the dummy one.

4.2. Diagnostics results

Multicollinearity test (VIF) in Appendix 2 demonstrates that VIF for all variables in direct effect model (1) and interaction effect model (2) are below threshold 10, meaning that there is no multicollinearity in the dataset. Wald test result shows Chi-squared (60) = 2994.44 and Prob>Chi2 = 0.000 for model (1), Chi-squared (60) = 3013.55 and Prob>Chi2 = 0.000 for model (2), indicating that heteroskedasticity exists in the model. Wooldridge test result demonstrates that both two fixed-effects models have Prob.F = 0.000, lower than 5% significance level, meaning that models have autocorrelation issues.

Model fit results include: F-tests have p-value = 0.000, lower than 1%, showing enough statistical evidence to choose FEM over POOLED OLS; Hausman tests have p-value = 0.000, implying that FEM is more consistent than REM. However, the FEM model will show inefficient coefficient estimations because this model ignores the autocorrelation and heteroskedasticity problems (Hoechle, 2007). Moreover, to overcome endogeneity, we further compute Equation (1) and (2) using S-GMM model proposed by Blundell and Bond (1998).

4.3. Regression results estimating the effects of financial structure on environment

We compute and summarize results of S-GMM models in the following table:

Table 4. System-GMM results for two models

Variable	Direct effects model (1)	Interaction effects model (2)
ln$CO2_{it-1}$	0.94416***	0.98686***
	(39.13)	(34.78)
lnFS: financial structure	0.00260	-0.04527*
	(0.26)	(01.68)
lnGDP: gross domestic product per capita	0.02600	-0.10064**
	(1.28)	(-2.44)
lnTRADE: trade openness	-0.00614**	-0.01152***

	(-2.13)	(-3.67)
lnHC: human capital	-0.01681	-0.14609
	(-0.51)	(-1.13)
lnUP: urban population percentage	0.01302	0.05789
	(0.67)	(1.34)
lnGINI: income inequality	0.04943**	-0.05562
	(2.04)	(-0.69)
lnREC: renewable energy consumption	-0.01283	0.00732
	(-1.37)	(0.50)
lnCOAL: coal consumption	0.00509**	0.00433
	(2.10)	(1.64)
DUM=1 if it is high-income country, DUM=0 otherwise	-0.02048	0.25426**
	(-1.08)	(2.51)
FS*DUM		-0.06750*
		(1.90)
_cons	-0.27496	0.98926*
	(-1.13)	(-1.95)
Obs.	780	780
Instruments	58	56
Groups	60	60
Wald's Chi^2/R^2	838321.32	364706.57
Year effects	Yes	Yes
AR(1)	0.000	0.000
AR(2)	0.791	0.762
Sargan (p-value)	0.057	0.117
Hansen (p-value)	0.412	0.870

Source: Authors' calculation (2024)

Note: Standard errors shown in brackets are robust to heteroskedasticity.

*, **, *** represent significance at 10%, 5%, 1% level, respectively.

The result from the System-GMM model confirms the nonlinear relationship between financial structure and environmental quality. According to Arellano & Bond (1991), S-GMM estimation requires first-order autocorrelation and no second-order autocorrelation of residuals. The p-values show that at 10% significance level, there is a first-order autocorrelation AR(1) and there is no second-order autocorrelation AR(2). Hansen test has p-values greater than the 5% significance level, meaning there is no overidentification problem; and the number of instrumental variables (58) is less than the number of groups (60), showing that the model is appropriate.

Estimation results from the System-GMM model for direct and interaction effects show different relationships between financial structure and carbon emissions. In model (1), financial structure has insignificant impacts on carbon emissions, but in model (2), financial structure is beneficial to environmental betterment. For every 1% increase in the development of financial structure, the amount of CO2 emissions decreases 0.04527 metric tons per capita, assuming other independent variables are constant. This huge gap in regression results is due to the interaction term of income level and financial structure, in that if only a country is classified as high-income, financial structure contributes to pollution mitigation. Our conclusion is in line with previous expectation and the strand of literature advocating beneficial influence of financial structure (Tamazian & Rao, 2010; Yao & Tang, 2021; Zhao et al., 2023). However, we discovered the potential effects of income level on the financial structure - CO2 emissions nexus. Income level of country have changed the relationship from insignificant to significant, positive to negative. We came up with three reasons for this result. First, by using an aggregate financial structure index, the study took into account as many aspects of financial systems as possible, instead of just banking sector or stock market. Second, with higher living standards and more excessive income per capita in high-income countries, residents are more likely to save money in bank accounts, sign life insurance contracts or make investment decisions, leading to more fundraising opportunities for expensive eco-friendly projects. Thirdly, a high-income country usually goes with a sophisticated financial system, as a result of an advanced economy. Renewable energy sources like solar or wind energy require large expenditures to build up stations; hence, if traditional direct finance like credits from banks is impossible, enterprises can turn to stock markets under forms of debt or equity.

Some control variables also affect level of pollution. In both models, trade openness shows significant influence, for every 1% increase in exports and imports, the decrease in CO2 emissions is 0.00614 metric tonnes per capita in model (1), 0.01152 metric tonnes per capita in model (2). This validates the results of Acheampong et al. (2020); Ahmad et al. (2020). GDP per capita is only significant in the interaction model (2) as GDP per capita is closely linked to income level classification. For every 1% increase in income growth, CO2 emissions decrease 0.10064 metric tons per capita, as long as other independent variables remain stable.

5. Conclusions and policy implications

Although many studies have investigated the effect of financial development on CO2 emissions, financial structure aspects and a compound financial structure index are rarely applied, especially under different contexts of income level. Thus, this study explores the effects of financial structure on environmental performance using system-GMM estimation methods. Moreover, to yield robust results, we also compute the financial structure index by two popular methods: variance-equal weighting and principal component analysis. The regression results revealed that the degree to which financial structure influences carbon emissions depends on the income level of countries. In high-income nations, financial structure seems to help ameliorate environmental quality. In other words, the relationship between financial structure and environmental pollution is not consistent among all countries in the sample, but rather elastic due to the high-income or middle-income group that a country is classified.

From drawn conclusions above, we proposed some implications to better environmental quality. First, the nonlinear interplay between financial structure and environmental quality found in countries of different income groups should be considered in forming policies that aim at environmental protection. Specifically, countries should invest more in the financial system in their effort to enhance environmental quality. A well-developed financial system provides the prerequisite investments for the initiation and adoption of advanced technology that are both energy-efficient and environmentally-friendly. Also, a nation with a strong financial system is more likely to allocate funds to finance green projects than those with weaker financial power, which in turn reduce the level of carbon emission emitted. As a result, policy makers should create the conducive environment and initiate strong legal frameworks that enhance the growth of the financial system so that it can improve the environmental quality. Considering countries with high-income level, an efficient policy should be the one that accelerates the growth of the financial system. In contrast, countries of upper-middle income or low-income level should utilize some initiatives such as tax benefits for the financial institutions to fund green projects.

Second, as the interaction between income level and financial structure reverses the trade-off between GDP and the environment, economic growth is conducive to pollution mitigation. Considering countries with income of the top level, an efficient policy should be the one that accelerates the growth of the economy together with the financial system. Therefore, strategies aimed at increasing domestic income should be considered if the nation is to achieve a well-developed financial system and later, a clean and healthy environment in the future.

Interestingly, openness to trade seems to reduce CO2 emissions. In fact, trade agreements can enhance the capacity for governments to tackle environmental issues (Ahmad et al., 2020). The promotion of international trade in commercial activities of environmental goods and services, notably through free trade agreements, can facilitate the exchange of eco-friendly products and the advancement of eco-friendly technologies in manufacture. In Asia, the Trans-Pacific Partnership Agreement, by providing access to green services and investments, is expected to assist developing countries to transfer to low-carbon industries and forward sustainable development, thereby joining hands in tackling global warming issues (Meltzer, 2014).

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