

Financial Development and Environmental Sustainability: The Role of Renewable Energy in Non-Oil Exporting Emerging Economies

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Abstract

Financial development is frequently viewed as a means of inspiring investment, technological innovation and infrastructure development, which in turn can drive sustainable economic transition. However, the impacts on the environment of the growth of financial systems are not clear, especially in emerging economies where increased economic activity is still reliant upon fossil fuels. The study analyzes the direct relationship between financial development and environmental sustainability as well as the indirect route via the adoption of renewable energies, based on the theoretical concepts of sustainable finance, energy transition and the Environmental Kuznets Curve (EKC), which are also discussed using panel data from emerging countries over the period of 1995-2022. The study employs the Feasible Generalized Least Squares (FGLS) method, and concludes that financial development has a positive impact on CO₂ emissions, thus confirming that financial expansion remains to a large extent focused on traditional, carbon-intensive economic activities. The control variables also suggest that economic and structural factors are also significant in explaining environmental outcomes in emerging economies. Contrary to the view that renewable energy acts as a linker between

financial development and environmental sustainability, renewable energy significantly lowers CO₂ emissions, however, it does not mediate the relationship between financial development and environmental sustainability. Rather, its incorporation reinforces the estimated effect of financial development, suggesting a suppression, rather than mediation effect. The results indicate that the level of renewable energy use is too low to counteract the environmental impacts created by financial development. The study suggests that green financial regulation needs to be strengthened, and that green finance instruments should be expanded, green finance mechanisms for renewables should be improved, and environmental issues should be incorporated into policies for the financial sector.

Keywords: Financial Development, Renewable Energy, Environmental Sustainability, Emerging Economies, Sustainable Finance, Carbon Emission

1. Introduction

Over the past few decades, achieving economic development while being environmentally sustainable has become one of the biggest challenges today's world is facing all over the globe. Since the beginning of industrialization, urbanization, globalization and the liberalization of financial markets, the economic development has been greatly accelerated, particularly in emerging economies, but this accelerate economic development has also been accompanied by an increase in environmental degradation and greenhouse gas emissions (Stern, 2004; IPCC, 2022; Crippa et al., 2019). The emerging economies are producing a lot of CO₂, as they use a fossil fuel-based industrialization and high energy demand. Policymakers are therefore more and more worried about identifying development strategies, which can support both economic growth and decrease the environmental deterioration. This focus has been financial development, on the basis of its possible effects on economic performance and environmental quality. The economic activity benefits from financial development as it makes financial intermediation more efficient, accumulation of capital easier, investment opportunities larger and technological innovation more probable. Good financial systems allow companies to obtain outside financing, boost production efficiency and promote expansion of industrial activity. The environmental impacts of financial development are still unclear, however. The importance of financial development in the development of environmental sustainability has been supported by several studies, which show that financial development can support the funds for financing green technologies, energy-efficient production processes and renewable energy projects (Ji & Zhang, 2019; Godil et al., 2020; Kousar et al., 2020; Adewuyi &

Awodumi, 2021). Yet, this fact is also supported by the other countries' studies, which show that in the long run, financial liberalization positively impacts industrialization, energy consumption, and in turn, carbon dioxide emissions, as a result of increased dependence on fossil fuels (Omri et al., 2015; Nawaz et al., 2016; Adams & Klobodu, 2018; Shen et al., 2021; Shahbaz et al., 2020). The different results suggest that the impact of financial development on the environment is strongly related to financial resource allocation as well as to the structural aspects of national economies, not to financial expansion. The importance of financial development as a path to sustain environmental issues has been steadily recognized in the field of renewable energy. Investments in solar, wind, hydroelectric, biomass, and geothermal energy lead to a lessen reliance on conventional fossil fuel sources and help build cleaner production processes and decrease carbon emissions. The Energy Transition Theory thus asserts that working financial markets can aid this transition by directing long-term capital towards renewable energy projects and green technological innovations (Anton & Nucu, 2020; Asongu et al., 2022; Fidrmuc et al., 2024). But there have been mixed findings from empirical studies. While some studies report financial development to be important in promoting renewable energy sources, others have found that financial institutions have a strong preference to invest in conventional energy sectors because they are short-term profitable and pose lower risk (Saadaoui, 2022; Shahbaz et al., 2022; Iskenderoglu et al., 2021). This has resulted in many emerging economies not realizing the positive environmental effects of financial development.

In order to fill the gap between the above-mentioned inconsistencies, the aim of this study is to examine the effects of financial development and the environment in emerging economies with the condition of utilizing renewable energy. Previous studies in this field have focused on the direct finance–environment relationship and direct effect of renewable energy on environment while this research focuses on renewable energy as a mediator between the direct finance–environment relationship. It claims that, although renewable energy is helping to improve the environment, it is not doing enough to mitigate due to the continued dominance of carbon intensive sectors in terms of financial resources. Although there is more investment in renewables, financial development remains to be positively correlated with carbon emissions. This study provides a contribution to the growing literature on sustainable finance, specifically by emphasizing the role of green financial systems and their contributions to environmental sustainability in the long term, as suggested by policy makers (Acheampong et al., 2020; Gyamfi et al., 2022; Sayed et al., 2024).

2. Literature Review

Financial development and sustainability of the environment is one of the most controversial relations in environmental economics. Financial development provides an avenue for capital accumulation, technological progress, and economic expansion, but its environmental consequences are quite broad across countries, depending on institutional arrangements, the energy structure, and financial resource allocation. The previous studies basically found positive effects of developed financial systems on environmental quality as it allows investing in cleaner production technology, energy efficient infrastructure and innovations that are environmentally friendly (Jalil & Feridun, 2011; Ganda, 2019). From this point of view, efficient financial markets alleviate capital constraint, spur technology diffusion and quicken the shift towards low carbon economic activities. But emerging evidence shows that such positive environmental results are not guaranteed or easily attained, especially in the emerging economies where the growth of the financial sector may be associated with funding of traditional industrial production rather than green investments. Thus, financial development may not only accelerate the economic growth but also lead to environmental deterioration via greater energy consumption and carbon emission (Omri et al., 2015; Riaz et al., 2016; Fang et al., 2018).

This incongruity has been the result of directing the research focus away from direct impacts toward mechanisms of financial development that influence environmental sustainability. Of these mechanisms, one most often proposed is the passing on by renewable energy. Financial markets are likely to have the most potential to mobilise long-term funds for renewable energy infrastructure and technological innovations. Empirical evidence has shown that financial system and capital market development in general supports renewable energy adoption by alleviating financing constraints for renewable energy projects, which tend to be larger in scale (Anton & Nucu, 2020; Asongu et al., 2022; Fidrmuc et al., 2024). But these data are not necessarily uniform. Financial institutions' involvement in fossil-fuel based industries is also backed by other researchers that fossil-fuel based industries are more profitable with lower investment uncertainty in the short-term as compared to renewable energy technologies (Saadaoui, 2022; Shahbaz et al., 2022). This implies, that achieving the uptake of renewables goes beyond simple market expansion, and that financial systems are proactively enabling sustainable investments in the institutions, regulatory frameworks and environmental governance. Recent literature has increasingly recognized that one needs to modify the entire

economic system to meet environmental sustainability requirements of renewable energy systems. The increase of renewable energy generation and the continued provision of significant budget support for carbon-intensive industries makes for only modest gains for the environment since fossil-fuel energy use remains the primary driver of overall energy use. This is particularly evident in many developing countries with substantial investments in renewable energy, but not yet sufficient to fully supplant conventional fuels. The use of renewable energy resources in absolute terms, however, shows a positive contribution to environmental sustainability, and the relationship between renewable energy and the financial development-environmental quality is not a strong one. Current financial systems are generally conservative in sustaining the current financial models of industrial expansion and energy consumption, instead of redirecting financial development towards a more environmentally sustainable process. Thus, the conflicting empirical results from past research can be attributed more to the quality of financial development than to its level. The main impetus for the current research is that although renewable energy is a fundamental pillar of sustainable development, it has failed to effectively reduce environmental effects of financial development in emerging economies, and there is a need to develop new green financial policy and increase financial resources dedicated to clean energy investments.

3. Theoretical Foundation

This study examines the relationship between financial development, renewable energy, and environmental sustainability, in the context of the Environmental Kuznets Curve (EKC) hypothesis and Energy Transition Theory. According to the EKC hypothesis, environmental degradation rises in the early stages of the industrialisation and expansion of a country's economy since the production and use of energy cause it to emit more carbon (Grossman & Krueger, 1995). With the growth of economies, however, technological improvement, improved institutions and stricter environmental laws promote clean production and polluter abatement (Stern, 2004). Although this is a theoretical possibility, there is still a multitude of emerging economies that are exceedingly dependent on fossil fuels and a financial system that continues to prop up carbon-based industries rather than green investments (Adams & Klobodu, 2018). Likewise, Omri et al. (2015) suggest that an expansion of finance can lead to environmental deterioration if finance is channeled into energy-intensive industries. Within this context, the Energy Transition Theory suggests that the shift towards an energy transition based on renewable energy is critical for sustainable development. This process should be

boosted by the establishment of efficient financial networks, improving access to financing for investments in renewable energy, green technologies (Anton & Nucu, 2020). Nevertheless, empirical studies suggest that traditional sectors still enjoy a priority in the investment financial companies in many emerging economies because their profitability is higher and the risk of investment is lower (Saadaoui, 2022). The result is expansion of renewable energy but not to a level that can play a significant role in reducing the environmental impacts of financial development. Therefore, this paper suggests that along with economic growth, there is a need for smart allocation of financial resources in investments in renewable energy and in low carbon economic transition, for achieving environmental sustainability.

4. Conceptual Framework

This study suggests that financial development (FD) will directly impact environmental sustainability (ES) and will indirectly impact environmental outcomes (ENV) via renewable energy (REN). Theoretically, financial development leads to greater availability of capital and investment opportunities, which helps to grow renewable energy investments and to improve the environment. To be effective in enhancing the environment, however, financial resources need to be allocated to different areas, such as environmental protection. However, in many developing countries, money is locked in and tied up in carbon-intensive industries. But financial development- environmental sustainability is not a direct link, rather renewable energy is a medium between financial development and reduction of carbon emission, which is not strong in the relation. Thus, the conceptual framework includes the direct impact of the financial development on environmental sustainability but also indirectly via renewable energy.

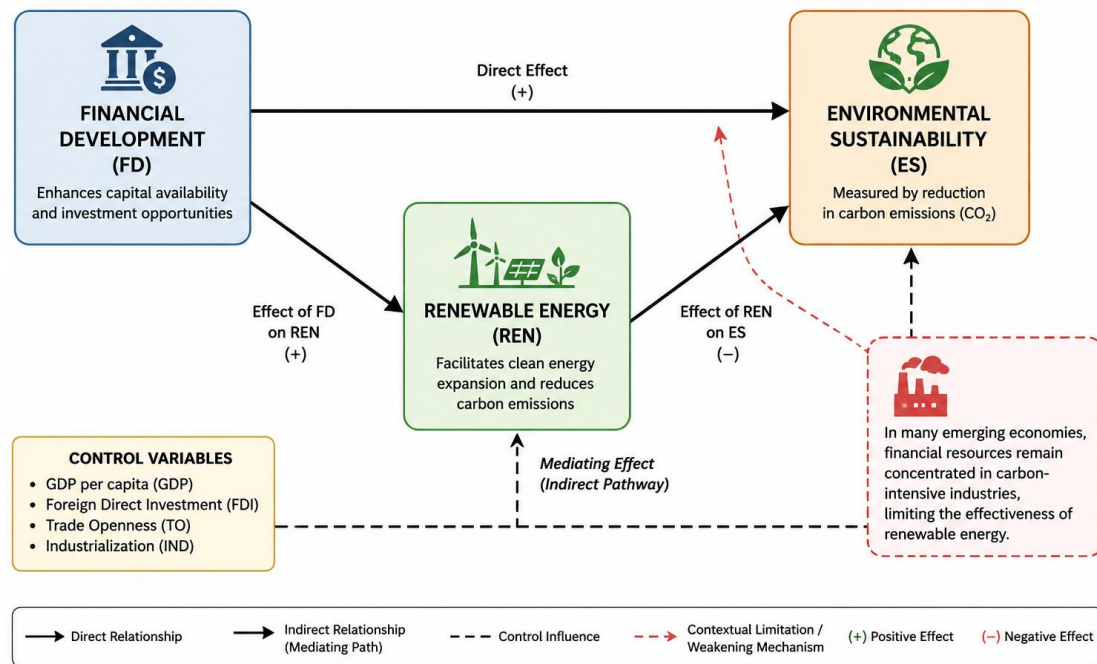


Figure 1: Conceptual Framework

4.1. Research Design

The design of this study is quantitative research with the aim of exploring the role of renewable energy to reduce environmental impacts in the development of finance in the emerging economy. The approach adopted is a panel data approach, which enables to incorporate cross-section and time-series variations, as well as country specific heterogeneity or flexibility (Baltagi, 2021). The study investigates direct link between financial development and environmental sustainability as well as indirect link between financial development and environmental sustainability through renewable energy, examining the mediating effect of renewable energy between financial development and environmental sustainability.

Based on above discussion and theoretical background the following equations are to be estimated and empirically analysed the Finance-environmental sustainability nexus directly and indirectly.

The mediation framework is assessed using three regression equations:

$$ES_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 FDI_{it} + \beta_3 IND_{it} + \beta_4 FDI_{it} + \beta_5 GOV_{it} + \varepsilon_{it} \dots (1)$$

$$REN_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 LBF_{it} + \beta_3 FDI_{it} + \beta_4 PCAP_{it} + \beta_5 HCAP_{it} + \varepsilon_{it} \dots (2)$$

$$ES_{it} = \beta_0 + \beta_1 GDPPC_{it} + \beta_2 GDPPC_{it}^2 + \beta_3 FND_{it} + \beta_4 REN_{it} + \beta_5 IND_{it} + \beta_6 FDI_{it} + \beta_7 GOV_{it} + \varepsilon_{it} \dots \dots (3)$$

4.2. Data Sources and Variables

Empirical analysis is based on the secondary panel data from different international sources like World Development Indicators (WDI), Penn World Table (PWT), etc. One of the most widely adopted metrics for environmental degradation is the amount of carbon dioxide (CO₂) emitted (Omri et al., 2015) which is also one way of measuring environmental sustainability. Financial development (FD) is regarded as independent variable, and the renewable energy consumption (REN) is regarded as the mediator. Based on the past empirical studies, GDP per capita, foreign direct investment (FDI), human capital (HCAP) and industrialization (IND) are used as control variables as they have significant impact on environmental quality (Shahbaz et al., 2020).

4.3. Estimation Strategy

Diagnostic tests are used before the estimation to assure validity of the panel data. Cross sectional dependence is discussed to test for the degree of dependence over countries, and then followed by tests of panel unit root to test for stationarity.

Empirical analysis is based on the Feasible Generalized Least Squares (FGLS) estimator is used in order to deal with heteroskedasticity, serial correlation and cross-sectional dependence often found in panel data (Greene, 2018). The mediation analysis is used to examine the potential mediation role of renewable energy between financial development and environmental sustainability. Renewable energy is expected to help reduce environmental degradation, but the mediating effect of renewable energy is lower since the financial development of emerging economies is not robust enough to fund predominantly carbon-intensive economic activities over green investments.

5. Results and Discussion

5.1. Descriptive Statistics

There are three models that have been used in this pathway in order to model the relationship between financial development and environmental sustainability. Results of the first model give the immediate effects of financial development on environmental sustainability. The

second model outcomes investigate the direct influence of financial development on renewable energy, as one of the possible drivers of sustainability. Lastly, the third model includes the mediation analysis, in which the indirect impact of financial development as a result of renewable energy is reported.

Table 1 gives the descriptive statistics of the variables that are used in the empirical analysis. The results reveal huge disparities between the emerging economies in terms of their financial development, their proportions of renewable energy consumption and their environmental sustainability. However, this variation is not unexpected, as the financial markets, the industrial structure, institutional quality and energy policies of emerging economies vary widely. The dependent variable is CO₂ emissions (in metric tons per capita): the minimum is 0.18 and the maximum is 13.32, the average is 4.66 and the standard deviation is 3.19 showing that there is a high degree of variation between the emerging markets in terms of environmental pressure. The level of financial development across countries and periods is very heterogeneous, with a mean of 3.13 and a standard deviation of 6.01, and values ranging from -40.26 to 106.43. Renewable energy (REN) use is on average 19.39%, and ranges between 0.40 and 64.90, with a standard deviation of 15.09, showing significant variations in the use of renewable energy among the sampled economies.

The control variables have an average GDP per capita of 8.61, and industrialization and governance have large cross-country variations. There is also significant variation in FDI, due to the differing levels of international capital flows, and labor force, human capital and physical capital are also very different between the economies sampled. The descriptive statistics show that overall financial development, renewable energy adoption and environmental conditions are heterogeneous, which is suitable for the analysis of relationships between them in emerging economies.

The correlation matrix is the same for Models 1 and 3 because they have the same dependent and control variables. The correlation matrix for Model 2, however, is different given that the dependent variable and the set of control variables are different. The descriptive statistics and the correlation results given here give an initial impression of the data and the interrelationships of the variables before the following econometric analyses are carried out.

The correlation matrix (Table 2 and 3) shows the relationships among variables suggested. The correlation between GDP per capita and CO₂ emissions is highly positive (0.6980), showing that an increase in economic development is at first linked to rising environmental degradation which corresponds to the rising part of the EKC hypothesis. Notably, there is also a moderate positive correlation between financial development and CO₂ emissions (0.399), suggesting that financial development could be tied to increased carbon-intensive industrial and infrastructure investments, but without a high correlation, other factors may also be at play. Governance is moderately positively correlated with emissions (0.4409); this may be due to the fact that countries with relatively strong institutions are also more industrialized and more economically developed, and hence there may not be an obvious linkage between improving governance and reducing emissions in short-term. In contrast, the CO₂ emissions and industrialization variables have a very low positive correlation of 0.0571, and the same holds true for the correlation between FDI and emissions of 0.0622. The results indicate that environmental impacts of industrial operations and foreign investment are not homogenous and could be related to technological growth, sectoral structure, regulatory quality and environmental policies.

Table 1: Summary of the data

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2	812	4.66	3.19	.18	13.32
GDPPC	812	8.61	.94	6.29	10.66
FND	812	3.13	6.01	-40.26	106.43
IND	812	29.89	7.53	13.41	49.64
GOV	812	-.32	.84	-2.81	1.26
FDI	812	3.13	6.02	-40.26	106.42
REN	812	19.39	15.09	0.4	64.9
LBF	812	67.8	154	486189	781
HCAP	812	2.53	0.55	1.34	3.77
PCAP	812	5567454	10.8	95988	102000

Table 2: Correlation matrix (Model 1 and 3)

Variable	CO2	GDPPC	FND	REN	IND	GOV	FDI
CO2	1.0000						
GDPPC	0.6980	1.0000					
FND	0.3986	0.5703	1.0000				
REN	-0.71	-0.58	-0.19	1			
IND	0.0571	-0.1388	0.0674	-0.1079	1.0000		
GOV	0.4409	0.4494	0.2385	-0.3173	-0.0155	1.0000	
FDI	0.0622	0.1150	0.0610	-0.0550	-0.0219	0.2060	1.0000

Table 3: Correlation matrix (Model 2)

Variable	REN	PCAP	HCAP	LBF	FND	FDI
REN	1.0000					
PCAP	0.005	1.0000				
HCAP	-0.31	0.007	1.0000			
LBF	0.02	-0.09	0.20	1.0000		
FND	-0.22	-0.02	0.21	0.14	1.0000	
FDI	-0.05	-0.007	0.09	-0.05	0.04	1.0000

5.2. Main Regression Results (Model 1)

Table 4 shows the result of effect of financial development on environmental sustainability. It is found that GDP per capita is positive and significant for CO₂ emissions in equation 1 indicates that with an increase of a unit in GDP per capita is accompanied by an increase of CO₂ emissions by 6.218 units. In addition, the significant negative coefficient of the squared term of GDP per capita further supports the Environmental Kuznets Curve (EKC) hypothesis, which suggests that CO₂ emissions firstly increase with the increase of the economic growth, but then decrease after reaching a certain income level. Other financial development measures are also positively and significantly related to emissions. All GDP terms are indeed positive and significant for EKC shape in equation 2 and coefficient of industrialization is positive and

significant as industrialization is a very energy intensive process in emerging economies as for every one percentage point increase in industrialization, emissions increase by 0.007933. Governance is also added to the model and has a statistically significant positive effect, with a 0.00628 increase in emissions corresponding to one increase in governance; this may be related to the fact that good governance translates into investments and industrial development, but not necessarily to better environmental protection. Lastly, equation 4 includes FDI and the signs and values of the GDP, GDP square, financial development, industrialization, and governance variables do not change. The findings reveal that FDI has a positive marginal impact on emissions and while this study offers support for the Pollution Haven Hypothesis, it also suggests that foreign investment can come into the carbon-intensive Industries or activities.

Table 4: Results of FGLS estimations

	(Equation 1)	(Equation 2)	(Equation 3)	(Equation 4)
VARIABLES	CO2	CO2	CO2	CO2
GDPPP	6.218***	4.640***	4.794***	4.957***
	(0.265)	(0.347)	(0.350)	(0.348)
GDPPC ²	-0.374***	-0.296***	-0.309***	-0.325***
	(0.0149)	(0.0208)	(0.0210)	(0.0208)
FND	0.0588***	0.0434***	0.0408***	0.0419***
	(0.00348)	(0.00541)	(0.00600)	(0.00607)
IND		0.00793***	0.00803***	0.00826***
		(0.000351)	(0.000356)	(0.000351)
GOV			0.00628**	0.00434
			(0.00298)	(0.00308)
FDI				0.00120***
				(0.000317)
Constant	0.0690***	-0.177***	-0.177***	-0.187***

	(0.00458)	(0.0131)	(0.0131)	(0.0128)
Observations	754	754	754	754
Number of id	29	29	29	29

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.3. Model 2

The second step of the analysis examines the effects of financial development and other important factors on renewable energy consumption. The results show that physical capital has a negative and statistically significant impact on renewable energy, whereas labor force and financial development have positive and statistically significant effects. The negative impact of physical capital implies that the physical capital stock in emerging economies might still be predominantly based on traditional and fossil-fuel-based technologies. Therefore, a rise in physical capital can continue to boost carbon-intensive production instead of promoting the use of renewable energy. The discovery underscores the need for a paradigm shift in infrastructure and investments to cleaner technologies. The positive and significant impact of financial development, on the other hand, suggests that a well-developed financial system can help to provide access to credit and investment resources needed for renewable-energy projects. This result is in line with Sadorsky (2010), who discovered a relationship between financial development and energy use in emerging economies, and later research that indicates that better financial conditions can facilitate investments and consumption of renewable energy. Labor force also has a positive and significant impact on renewable energy, indicating that a more robust and productive labor force can help drive renewable-energy development by boosting productive capacity and investment activity. Human capital is a high positive impact, highlighting the need for education, skills and technical knowledge, to enable the adoption and deployment of renewable technologies. A well-trained workforce can operate, maintain, and develop modern renewable-energy technologies. The result is aligned with the previous research that highlighted the importance of human capital for the promotion of the adoption of clean energy and the transition to renewable energy. Therefore, the findings indicate that investment in education and skills can be combined with financial development to enhance the technological capacity needed for the adoption of renewable energy. The coefficient of foreign direct investment (FDI) is positive, but statistically insignificant, with a

coefficient of 0.000244. This suggests that the impact of FDI is positive but not statistically significant for the sample for the adoption of RE. While FDI can bring in financial resources, technology and managerial skills, the small result implies that foreign investment may not necessarily go into renewable energy, but may also go into traditional energy and other carbon intensive industries. The overall findings from the analysis using the various models confirm the significance of financial development, labour force, human capital and the existing physical-capital structure in determining renewable-energy consumption. The positive impact of financial development and human capital suggests that improved financial systems and skills can help facilitate the transition towards renewable energy, while the negative impact of physical capital suggests that the current infrastructure, which is heavily reliant on fossil fuels, can be a constraint on this transition. The results are in line with previous research on renewable energy, such as Sadorsky (2010) that highlights financial development in emerging markets. Overall, the evidence indicates that the current fossil fuel-dominated capital structure of emerging economies is still a hurdle to adoption of renewables, and that financial development and human capital can help build the financial and technological ability to facilitate a gradual transition to less polluting fuels.

Table 5: Results of FGLS estimations

	Equation 1	Equation 2	Equation 3
VARIABLES	REN	REN	REN
PCAP	-0.0131***	-0.0109***	-0.0112***
	(0.00134)	(0.00182)	(0.00186)
LBF	0.802***	0.764***	0.801***
	(0.0501)	(0.0550)	(0.0545)
FND	0.0764***	0.0714***	0.0720***
	(0.00851)	(0.0110)	(0.0112)
HCAP		0.672***	0.641***
		(0.195)	(0.189)
FDI			0.000244

			(0.000237)
Constant	0.157***	0.126***	0.129***
	(0.0177)	(0.0230)	(0.0235)
Observations	754	725	725
Number of id	29	29	29

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.4. Mediation analysis

In order to analyze the mediation effect of renewable energy, three successive modelling steps for the estimation of the coefficient of financial development were adopted. The financial development has a positive and statistically significant direct effect on environmental sustainability in Model 1, suggesting that greater financial development leads to higher CO₂ emissions. Model 2 shows that financially developed has a positive and statistically significant effect on renewable energy, which is interpreted to indicate that financially developed promotes adopting of renewable energy. Incorporating renewable energy in the environmental sustainability model in Model 3 however strengthens the coefficient of financial development and increases relative to Model 1. This rise in the coefficient is not a decrease in coefficient; it is a suppression effect not a mediation effect.

The results indicate that GDP per capita is still positive and significant, and its squared term is negative and significant, thus supporting the EKC hypothesis. The coefficient of renewable energy is highly important, and quite negative at -0.54 , indicating that for each unit of renewable energy, CO₂ emissions drop significantly. This suggests that reducing CO₂ emission levels is a significant contributor to environmental sustainability when more renewable energy is used. It reflects the ideas of Energy Transition, which implies that the use of more environmentally-friendly renewable energy rather than conventional fossil fuel energy can diminish the environmental costs of economic and industrial development. The generally strong positive effect of financial development, however, suggests that the uptake of renewable energy may be too late to compensate for the carbon-intensive outcomes of financial development in emerging economies. The financial development index also increases with the inclusion of renewable energy from 0.0419 to 0.0557 , this suggests that financial development

has a suppression effect and therefore both direct and indirect effects on environmental sustainability. The suppression effect suggests that financial development appears to have a stronger environmental benefit on CO₂ emissions when controlling for renewable energy, as part of this benefit is offset by the environmental costs of renewable energy. Therefore, the impact of financial development on environmental sustainability is not transmitted, but rather abated and/or obscured by renewable energy. Industrialization also increases CO₂ emissions, showing a positive and significant impact as a consequence of increased industrial activity, which puts a greater pressure on the environment. Moreover, governance is positive and significant in baseline model (Model 1), but insignificant in the fully specified model (Model 3), and FDI is positive and significant in both models which implies further environmental pressure with respect to foreign investment in the sample.

Table 6: Results of FGLS estimations

	Equation 1	Equation 2	Equation 3	Equation 4
VARIABLES	CO2	CO2	CO2	CO2
GDPPC	5.020***	3.794***	4.240***	4.365***
	(0.168)	(0.334)	(0.398)	(0.381)
GDPPC ²	-0.289***	-0.228***	-0.254***	-0.262***
	(0.00977)	(0.0194)	(0.0231)	(0.0221)
FND	0.0619***	0.0526***	0.0552***	0.0557***
	(0.00396)	(0.00534)	(0.00642)	(0.00685)
REN	-0.540***	-0.538***	-0.540***	-0.541***
	(0.00471)	(0.00953)	(0.0123)	(0.0118)
IND		0.00780***	0.00743***	0.00753***
		(0.000294)	(0.000377)	(0.000362)
GOV			0.00469**	0.00318
			(0.00232)	(0.00223)
FDI				0.000974***

				(0.000338)
Constant	0.0656***	-0.170***	-0.157***	-0.163***
	(0.00421)	(0.01000)	(0.0125)	(0.0131)
Observations	754	754	754	754
Number of id	29	29	29	29

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5.5. Does mediation exist in renewable energy Pathway?

Mediation exists if the coefficient value of FND is significant in model 1 and 2 but the coefficient value of financial development is small in magnitude in model 3 as compared to model 1.

Table7: Mediation Analysis of Renewable Energy in the Financial Development–
Environmental Sustainability Nexus

Variable	(Model 1) Dependent variable: ES	(Model 2) Dependent variable: REN	(Model 3) Dependent variable: ES
Financial development	(0.0419)***	(0.0720)***	(0.0557)***
Renewable energy			(-0.541)***

Renewable energy does not mediate the financial development-env. sustainability relationship. Instead, the results suggest a suppression effect: the positive impact of financial development on CO₂ emissions is more pronounced and more significant when renewable energy is added to the model. This finding can be explained by the dual nature of financial development in emerging economies. Financial development can help to expand the supply of credit and investment, which can drive growth, industrial production, infrastructure development and energy intensive activities. In such economies where production is still fairly carbon-intensive, more money could thus drive more carbon-intensive activities. This interpretation is in line

with the Environmental Kuznets Curve view, which posits that environmental pressures can rise in the early phases of economic development before technological progress, structural change and increased environmental regulation can bring about improvements in environmental quality.

Meanwhile, renewable energy offers an environmentally friendly pathway as increased consumption of renewables can lessen reliance on fossil fuels and thus decrease CO₂ emissions. There are also existing empirical studies that indicate that consumption of renewable energy is associated with lower emissions, while financial development could still be a source of environmental pressure in developing and emerging economies. The negative environmental impact of renewable energy is, however, not large enough in the present sample to counter the emission-generating impact of financial development. This could be due to the fact that renewable-energy transition is still in a relatively early phase in many emerging economies, where renewable-energy capacity and infrastructure, technological skills, and institutional frameworks are still developing. There is also some evidence from developing countries that financial development can stimulate the demand for renewable energy, but not necessarily enough to change the overall environmental impact of financial deepening. Thus, the suppression effect should not be taken as a sign of the deterioration of environmental sustainability due to renewable energy. Rather, it argues that renewable energy offers an alternative mitigating pathway, with the financial-development pathway still creating environmental pressures. The emission-reducing effect of renewables, therefore, exists but it is not strong enough to offset the positive relationship between financial development and CO₂ emissions in the emerging-economy sample. This view is also in line with recent studies, which indicate that financial development is associated with environmental impacts, depending on the use of financial resources and the direction of their use towards clean technologies and investment in renewable energies. Therefore, the results show that financial development should increasingly be channeled into green investment, infrastructure for renewable energy and cleaner technologies, to enable the growth of financial activity to serve environmental sustainability instead of harming it. This indicates that in the emerging countries, the traditional fossil-fuel industries are major beneficiaries of financial credit as a result of resource-curse and rent-seeking, which compromises environmental sustainability. These findings show that in the absence of a robust governance, financial development is damaging to environmental sustainability and renewables only reveal this latent impact but does not diminish it. Therefore, there is no mediation in Renewable energy pathway.

6. Discussion

The empirical results show that environmental degradation has a negative relationship with financial development, meaning that financial systems have not been progressing at a similar pace towards environmentally friendly investments. While capital development can increase capital availability, create more investment opportunities, and boost economic development, these gains have been realized, largely, in the soaring expansion of manufacturing, infrastructure, transportation and other energy-intensive industries. Consequently, finance is being used as a means to reinforce traditional business models that are reliant on fossil fuels, and, in so doing, they are worsening carbon emissions, rather than environmental issues. This finding is in line with the argument put forward by Adams and Klobodu (2018) that financial development can exacerbate environmental degradation if the financial markets focus on increasing economic growth rather than environmental sustainability. Similarly, Acheampong et al. (2020) highlight that environmental impact of financial development is more related to institutional quality and environmental governance than financial deepening. While the negative coefficient of renewable energy indicates that the cleaner energy is used, the more carbon emissions decrease, the mediation analysis shows that renewable energy is not yet a strong enough transmission channel to make financial development a more effective way of achieving environmental sustainability. This implies that investments in renewable energy continue to be a small part of the overall investment in the continued growth of fossil-fuel based industry. Fidrmuc et al. (2024) claim that traditional financial institutions are typically hesitant to make investments in renewable energy initiatives, due to their perceived high risk and low profitability compared to traditional energy sectors. Likewise, Saadaoui (2022) shows that the issue of financial development is not enough to speed up the uptake of renewable energy sources without the presence of supportive policies and institutional quality. The findings also indicate that structural inefficiencies in the finance–environment relationship are found in emerging economies, as well as in the absence of renewable energy potential. Financial systems appear to invest in the short term for short-term financial gain, rather than in the long term for environmental sustainability, limiting the contribution of renewables to the green transition. If green financial products and environmental policies are not well developed, financial market development can result in increased emissions of carbon, argue Shen et al. (2021). Likewise, Riaz et al., (2016) have found that improved financial efficiency is often associated with increased industrial production and energy consumption, and the economy progresses, causing the environmental effects to deteriorate. The results also support the

segmented nature of the relationship between finance and the environment evident in the conflicting findings with those of Anton and Nucu (2020) and Asongu et al. (2022). There is consensus in the studies that financial development is a driver of investment in the renewable energy and environmental improvement, but they are essentially all applied to the relatively stronger financial institutions and green investment systems of the economies they scope. On the other hand, many emerging economies are still under-resourced regarding the availability of good regulatory environments, the development of green financial markets, and the extent to which the fossil fuel dependence reduces the ability of renewables to compensate for environmental costs associated with financial expansion. This is corroborated by Iskenderoglu et al. (2021) who have found that financial development is not enough to drive the adoption of RE in emerging economies if it is not supported by efficient financial markets and institutions.

In conclusion, the results indicate that the adoption of renewable energy resources is still not enough to achieve environmental sustainability in financial development. But policy makers should focus on structural change, redirect more funding towards low-carbon industries, make green financial rules more effective and enforce more sustainable financial practices, and improve the institutional governance, rather than simply raise the capacity of renewable energy production. The effect of renewable energy to achieve long-term environmental sustainability will be further limited if the complementary reforms do not take place, as it will further support carbon-intensive activities in the economy. The finding is similar to the various themes of Gyamfi et al. (2022) which argue that more investment in renewables and general reorganization of financial systems are needed for more sustainable and environmentally oriented economic growth to be achieved.

7. Conclusion and Policy Recommendations

This study investigated the effect of financial development on the environmental impact in emerging economies using renewable energy as a mediator. The study uses the panel of 29 emerging nations (excluding oil exporting countries) over the period of 1995-2022. Financial development is regarded as one of the important factors for economic growth by allocation of capital and investment and technological development, the impact of financial development on environment is rather complicated. This study indicates that financial development still has a positive relationship with carbon emissions, implying that the development of the financial sector in emerging economy has mainly been used to back conventional industrial processes and not environmentally sustainable investments. These results further underscore the notion

that financial development – if not accompanied by suitable environmental policies – can allow for faster economic growth while eroding environmental sustainability (Omri et al., 2015; Fang et al., 2018; Shahbaz et al., 2020). The analysis also reveals the importance of the reduction of carbon emission in dealing with environmental degradation by implementing renewable energy. However, as would perhaps be predicted, renewable energy does not trigger the aforementioned financial development – environmental sustainability path. Renewable energy capacity has increased in most of the developing states, but has not yet been enough to offset the environmental impacts of a developing finance. It means that there is still a green way to the same traditional industries where carbon is still used, not to divert money towards the renewable energy industry, to change the financial landscape. This has resulted in the pace of transitioning to cleaner energy systems has not been sufficient to compensate for the environmental impact of growth in financial market. In conclusion, the results suggest that financial development is not sufficient in and of itself to ensure environmental sustainability. Instead, the environmental outcome of financial development just as with financial development itself depends largely on the direction of financial resources. The financial development will continue to reinforce fossil fuel-oriented traditional growth unless there is greater investment in "green finance" and "renewable energy infrastructure. Thus, there is a need for financial systems that are proactively pro-economically sustainable and environmentally friendly in the long-term.

Based on the empirical evidence, there are a number of policy implications that could be drawn to enhance the contribution of financial development to environmental sustainability in emerging economies. Governments should revise green financial regulations to boost green bonds, climate financing, and sustainable lending and provide more funds for renewable energy and clean technologies. Tax incentives, renewable energy subsidies, concessional financing and public/private partnerships should be used to lower the risk of investing in renewable energy and increase the involvement of the private sector in renewable energy. Financial development can help environmental sustainability if coupled with suitable policy incentives. Financial institutions must also incorporate the integration of ESG criteria and climate related risks in the process of lending and investment for the transition of funds from the polluting industry to the clean sector. This can help to enhance the environmental efficiency of financial development as noted by Acheampong et al. (2020). Last but not least, the governments need to take an integrated approach in the areas of financial development, renewable energy, technological innovation and environmental protection. For financial development to

effectively promote green growth, more investment in R&D is needed, more stringent environmental policies are needed, and better institutional coordination is needed.

References

- [1] Acheampong, A. O., Adams, S., & Boateng, E. (2020). Financial development and environmental sustainability: Evidence from panel data analysis. *Environmental Science and Pollution Research*.
- [2] Adams, S., & Klobodu, E. K. M. (2018). Financial development and environmental degradation: Does political regime matter? *Journal of Cleaner Production*, 197, 1472–1479.
- [3] Anton, S. G., & Nucu, A. E. A. (2020). The effect of financial development on renewable energy consumption: A panel data approach. *Renewable Energy*, 147, 330–338.
- [4] Asongu, S. A., Agboola, M. O., Alola, A. A., & Bekun, F. V. (2022). Financial development and renewable energy consumption: Evidence from developing economies. *Renewable Energy*.
- [5] Ayobami, A., et al. (2024). Financial development, institutional quality and environmental sustainability: Evidence from Nigeria. *Environmental Science and Pollution Research*.
- [6] Baltagi, B. H. (2021). *Econometric analysis of panel data* (6th ed.). Springer.
- [7] Crippa, M., Oreggioni, G., Guizzardi, D., et al. (2019). *Fossil CO₂ emissions of all world countries*. European Commission, Joint Research Centre.
- [8] Fang, Z., Razzaq, A., Mohsin, M., & Irfan, M. (2018). Financial development and environmental quality: Evidence from China. *Environmental Science and Pollution Research*.
- [9] Fidrmuc, J., et al. (2024). Financial development and renewable energy transition: Evidence from EU and ASEAN countries. *Renewable and Sustainable Energy Reviews*.
- [10] Ganda, F. (2019). The environmental impacts of financial development in OECD countries. *Environmental Science and Pollution Research*, 26(7), 6758–6772.
- [11] Godil, D. I., et al. (2020). Financial development and environmental sustainability: The role of green innovation. *Journal of Cleaner Production*.
- [12] Greene, W. H. (2018). *Econometric analysis* (8th ed.). Pearson.
- [13] Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *Quarterly Journal of Economics*, 110(2), 353–377.
- [14] Gyamfi, B. A., et al. (2022). Sustainable finance and environmental sustainability in emerging economies. *Environmental Science and Pollution Research*.
- [15] Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change*. Cambridge University Press.

- [16] Iskenderoglu, O., et al. (2021). Financial development and renewable energy consumption in emerging economies. *Renewable Energy*.
- [17] Jalil, A., & Feridun, M. (2011). The impact of growth, energy consumption and financial development on the environment in China. *Energy Economics*.
- [18] Ji, X., & Zhang, Y. (2019). Financial development, green technology and environmental sustainability. *Journal of Cleaner Production*.
- [19] Kousar, S., et al. (2020). Financial development and environmental sustainability: The role of green investment. *Environmental Science and Pollution Research*.
- [20] Nawaz, M. A., et al. (2016). Financial development and environmental degradation: Evidence from developing countries. *Energy Policy*.
- [21] Omri, A., Daly, S., Rault, C., & Chaïbi, A. (2015). Financial development, environmental quality, trade and economic growth: What causes what in MENA countries. *Energy Economics*, 48, 242–252.
- [22] Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics*, 61(S1), 653–670.
- [23] Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94(446), 621–634.
- [24] Riaz, A., et al. (2016). Financial development, economic growth and carbon emissions: Evidence from emerging economies. *Environmental Science and Pollution Research*.
- [25] Roubaud, D., et al. (2018). Financial development, energy consumption and carbon emissions: Evidence from France. *Energy Economics*.
- [26] Saadaoui, Z. (2022). Financial development, institutional quality and renewable energy transition in MENA countries. *Energy Policy*.
- [27] Sayed, A., et al. (2024). Sustainable finance and environmental sustainability: Policy implications for developing economies. *Journal of Environmental Management*.
- [28] Shahbaz, M., et al. (2020). Financial development, renewable energy consumption and environmental quality: Evidence from emerging economies. *Energy Policy*.
- [29] Shahbaz, M., et al. (2022). Financial development and renewable energy consumption: Nonlinear evidence from the United States. *Energy Economics*.
- [30] Shen, Y., et al. (2021). Financial development and carbon emissions: Evidence from panel data analysis. *Journal of Cleaner Production*.
- [31] Stern, D. I. (2004). The rise and fall of the Environmental Kuznets Curve. *World Development*, 32(8), 1419–1439.

- [32] Wing-Keung Wong, W., et al. (2021). Financial development and carbon emissions: Evidence from Turkey. *Environmental Science and Pollution Research*.