Journal of Energy & Environmental Policy Options

Finance, Institutions, and the Environment: Revisiting the Finance–Emission Nexus in Advanced Economies

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Abstract

This study examines the relationship between financial development and carbon emissions within high-governance economies by integrating environmental economics, financial intermediation theory, and institutional perspectives. Using panel data for multiple high-governance countries over the period 1995 to 2025, obtained from the World Bank and global financial and energy databases, the analysis evaluates the roles of financial development growth, financial development levels, renewable energy, and key socio-economic factors in shaping environmental outcomes. A dynamic panel data framework is employed, with the generalised method of moments estimation addressing endogeneity, heterogeneity, and persistence in emissions. The results reveal a complex and multidimensional relationship between finance and the environment. Financial development growth exerts a negative effect on carbon emissions, indicating that expanding financial systems facilitate green investment, technological innovation, and cleaner production processes. In contrast, financial development levels show a positive association with emissions, reflecting the expansion of economic activity and energy-intensive production. Renewable energy demonstrates a consistently negative but statistically weak effect, suggesting that its environmental benefits remain limited due to insufficient scale. Economic growth exhibits a nonlinear pattern consistent with the environmental Kuznets curve, while education and urbanisation show mixed effects depending on structural conditions. Robustness checks confirm the stability of these findings, and causality analysis indicates a bidirectional relationship between financial development and emissions, highlighting a feedback mechanism between financial systems and environmental performance. Overall, the study emphasises that financial development can support environmental sustainability when guided by strong institutional frameworks and effective allocation of resources toward green sectors.

Keywords: *Financial Development, Carbon Emissions, Renewable Energy, Institutional Quality*

JEL Codes: *Q56, G20, O44*

Article's History
Received: 11th February 2026
Revised: 16th March 2026
Accepted: 28th March 2026
Published: 31st March 2026

Citation:
Li, Z., Wang, Z., & Li, W. (2026). Finance, Institutions, and the Environment: Revisiting the Finance–Emission Nexus in Advanced Economies. *Journal of Energy and Environmental Policy Options*, 9(1), 59-69.

DOI:
https://doi.org/10.5281/zenodo.22517015

1. INTRODUCTION

In the era of increasing awareness of climate change and carbon emissions, the financial development-environmental sustainability linkage has become a key topic in current economic research. With the growth of economies and the development of financial systems, capital allocation has a more significant impact on environmental outcomes due to investment patterns, technology adoption and industrial activities. Understanding the potential of financial development to play a dual role in either worsening or aiding the transition towards sustainable growth is especially important in high-governance economies, in which institutional quality, regulatory systems, and policy enforcement are relatively good. It is important to grasp this intricate interaction when designing policies that can integrate financial sector development with environmental goals (Saqib et al., 2024; Al-Masri & Ibrahim, 2025; Wang et al., 2025). It is well established that financial development plays a vital role in national economic development, both by facilitating savings and channelling these funds to the right productive activities and by improving the efficiency of resource allocation. The financial intermediation theory highlights that a good financial system helps to lower transaction costs, facilitate capital allocation and increase

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economic efficiency (Agénor, 2003; Ali & Naeem, 2017; Konstantakopoulou, 2023; Marc, 2024; Alhejaili, 2024; Farras et al., 2025; Alenoghena et al., 2025). But the relationship between financial development and the environment is unclear. Financial deepening can drive industrial growth, boost energy use and result in rising carbon emissions on the one hand. On the other hand, financial deepening can boost energy use and result in higher carbon emissions. It can also enable investments in clean technologies, renewable energy, and environmentally friendly projects, thus lowering emissions. This dichotomy emphasises the need to analyse the scale and composition effects of financial development to understand environmental impacts (Asghar et al., 2024; Akhtar & Rashid, 2024; Rafique et al., 2025; Yıldırım et al., 2025).

The environmental Kuznets curve hypothesis is an important theoretical concept to comprehend the link between economic development and environmental degradation. This hypothesis proposes that environmental degradation will rise as the economy expands until a certain critical income level is reached, after which it will fall as the economy shifts to cleaner technologies and more stringent environmental regulations (Ali & Rehman, 2015; Altenburg & Rodrik, 2017; Song et al., 2024; Naqvi et al., 2025). The role of financial development is very important in this process—it affects economic growth and environmental quality. Financial systems play a greater role in facilitating the shift towards cleaner production in high-governance economies than in weaker institutional environments, where financial growth can help to bolster environmentally damaging practices. The institutional quality also influences the finance–environment nexus, as it affects the efficiency with which financial resources are put to use. According to institutional theory, robust governance, regulatory sanctions and transparency are necessary for sustainable outcomes as a result of financial development (Le & Hoang, 2022; Abaidoo & Agyapong, 2025; Mehmood et al., 2025). High governance economies have more resources to allocate capital to 'green' areas of the economy, such as renewable energy and energy-efficient technologies. This improves the potential for financial development to decrease carbon emissions by encouraging innovation and green investment. On the other hand, with weak institutions, financial deepening can cause resource misallocation and environmental degradation.

Financial development is an important pathway for achieving environmental effects through renewable energy. The shift to renewable energy sources is well known to be a necessity to cut carbon emissions and meet climate objectives. Financial systems have a pivotal role to play in this transformation, on the one hand by supplying the capital needed for renewable energy investments and on the other by enabling technological innovation. Studies on endogenous growth with consideration of the environment suggest that investment in RE improves long-term economic growth and decreases the environmental externalities (Challoumis, 2024; Nassani et al., 2025; Maghyereh et al., 2025). But the impact of renewables on emissions depends on how large, efficient and integrated the renewable energy is. Socio-economic factors – including economic growth, education, urbanisation and structural transformation – also have an impact on environmental outcomes. Energy use and emissions tend to increase during periods of economic growth, especially in the initial stages. However, if income is higher, it also allows investment in environmental protection and cleaner technologies, in the end resulting in better environmental quality. Education helps to improve human capital and environmental awareness, thus enabling sustainable practices and technologies to be adopted (Abubakar et al., 2024; Bhumithavara et al., 2025; Erdogan & Akalin, 2025). Urbanisation may have a positive or negative impact, depending on the energy demand as well as the way energy is used and infrastructure operates. Likewise, the growth of services has generally been found to be less carbon intensive than industries, but can be more or less carbon intensive depending on energy consumption and technological efficiency. Therefore, the present study attempts to study the financial development-carbon emissions nexus in high-governance economies comprehensively.

2. LITERATURE REVIEW

There has been a significant increase in the empirical literature on the finance–environment nexus, especially in advanced economies, where financial institutions are more developed and institutional structures are relatively strong. There is considerable evidence that financial development affects the environment in several ways, such as channelling investment funds, technological innovation, and industrial growth. Preliminary empirical research shows that financial deepening can help to boost economic activity and energy use, leading to higher carbon dioxide emissions. For instance, Sadorsky (2010) finds that in developing and developed countries, financial development is associated with more energy use and emissions since it increases the credit availability for energy-intensive activities. Likewise, Jalil and Feridun (2011) argue that in the short run, financial development leads to environmental degradation because of the expansion of industrial production and consumption. In addition, Tamazian et al. (2009) demonstrate that financial development is linked to increased emissions without any robust institutional structures, thus suggesting that financial expansion does not necessarily lead to environmental improvement.

This recent empirical evidence, however, is more complicated and indicates a conditional influence of financial development on carbon emissions and that this effect can be different for various aspects of financial systems. Other evidence from Shahbaz et al. (2013) reveals a non-linear link between financial development and environmental quality, which means that financial systems contribute to environmental improvement in the mature stage, but they make emissions higher during the infancy stage. Likewise, Charfeddine and Khediri (2016) show that the long-run environmental impact of financial development is to lower emissions through financing investments in cleaner energy technologies and energy efficiency. Boutabba (2014) also found that financial development is the factor which is related to environmental sustainability through technological innovation and energy transition. The results indicate that the development of the financial system and its intensity could be distinctively correlated with environmental outcomes, thereby showing differences in resource allocation and technological adoption. Apergis and Payne (2010) and Dogan and Seker (2016) have discovered that the use of renewable energy sources can lower emissions by replacing the use of fossil

fuels with cleaner sources of energy. Likewise, Bilgili et al. (2016) offer support for the idea of environmental sustainability in the developed world as a by-product of renewable energy. Other research, however, stresses that the extent of renewable energy use can be small and therefore not provide much environmental benefit in the short term. For example, the impact of renewable energy has been found to be negative for emissions, but not very pronounced because integration into energy systems is limited, as reported by Balsalobre-Lorente et al. (2018). The results are in line with research indicating that the environmental advantages of renewables are tied to their size, effectiveness and how they fit into the existing power grid.

Economic growth has been an indicator that has constantly been related to carbon emissions, and a lot of studies have been conducted to prove that income and environmental degradation have a non-linear relationship. Early empirical evidence of an inverted U-shaped relationship between economic growth and environmental quality is provided by Grossman and Krueger (1995), who found that emissions rise in early growth stages but fall as income increase takes place and cleaner technologies are used. This trend is also echoed by Stern (2004), who reports that the turning point and its size differ from country to country. Research in advanced economies indicates that income levels are positively related to environmental performance in these economies, which can be attributed to stricter regulations, technological innovation, and the movement of economies to service sectors. But the link is still complicated because energy demand – and emissions – from some sectors is also on the rise as the economy expands.

The quality of institutions has become an important determinant of the effectiveness of financial development in affecting the environment. Empirical evidence suggests that the positive influence of financial development can be strengthened by the presence of good institutions, which facilitate the efficient allocation of resources and the regulation of environmental aspects. For instance, Tamazian and Rao (2010) show that emissions can be greatly diminished through improvements in institutional quality, which enhance governance and sustainable practices. Likewise, Abid (2017) finds that countries with stronger institutional structures have more positive environmental outcomes of financial development. Moreover, institutions have been reported to moderate the relationship between financial development and emissions by Lau et al. (2014), which makes the study of institutions and governance an important factor in attaining environmental sustainability. The results indicate that financial systems are more likely to facilitate green transitions in the presence of strong institutional setups. Other socio-economic factors that affect environmental outcomes, but have mixed effects, include education and urbanisation. Based on empirical studies, a higher education level is an environmental contributor to awareness and the use of cleaner technologies that help to lower emissions. In fact, Balaguer and Cantavella (2018) conclude that education is a factor that benefits the environment, since they demonstrate that it contributes to environmental improvement through sustainable consumption and innovation. Other research, however, has reported no effect or effects that vary by context, depending on differences in the education system and policy context. Other impacts of urbanisation are also mixed – it can result in higher emissions because of its consumption of energy, and lower emissions because of economies of scale and better infrastructure. The double nature of urbanization's impact on environmental outcomes has been emphasised by studies like those by Poumanyvong and Kaneko (2010) and York et al. (2003).

The endogenous and endogenously-persistent nature of the financial-emissions relationship has been examined more intensively over the last decade with the help of econometric methods that incorporate endogeneity and endogenously-persistent elements. In this context, the generalised method of moments has been used extensively, because it is known to yield consistent estimates in a dynamic panel setting. All of this is shown to be appropriate for dealing with endogeneity and unobserved heterogeneity by Arellano and Bond (1991), and for making more efficient estimates by system-based methods are shown by Blundell and Bond (1998). Such analytic approaches have allowed researchers to document feedback processes linking the financial system to environmental outcomes, reflecting the fact that in many empirical applications, there are two-way linkages between the two sectors. For instance, Shahbaz et al. (2016) show that there is a mutual causality between financial development and emissions, where environmental conditions can have an impact on financial development. The link between financial development and carbon emissions is multidimensional and complex, especially in developed countries. The positive association between financial development growth and environmental improvement is through green investment and technological innovation, whereas higher levels of financial development can lead to greater emissions due to increased economic activity. Reduction of emissions is achieved through the generation of renewable energy. However, these effects can be small and can depend on the size of the renewable energy installation and the challenges associated with integrating it. Economic growth has a non-linear relationship with environmental quality, and institutional quality is very important in balancing the impact of financial development. The results underscore the need for a better policy and institutional framework to link financial systems with environmental goals to achieve sustainable outcomes.

3. THE MODEL

Theoretically, the correlation between financial development and carbon dioxide emissions is supported by the theories of environmental economics, financial intermediation theory and institutional theory. Environmental economics suggests that economic development can aggravate environmental problems at first, but that when it reaches a certain level of economic prosperity, the environment will be better than it was before (Grossman & Krueger, 1995; Stern, 2004). In this context, financial development can help to catalyse the shift toward environmentally friendly production through investments in clean technologies and renewable energy. Financial intermediation theory highlights the importance of financial systems to mobilise savings, allocate capital efficiently and facilitate productive investments (Ahmad et al., 2022; Challoumis, 2024; Ajagbe & Usman, 2025; Nkwa et al., 2025). In cases where financial markets are well-

developed, they can direct resources to environmentally friendly industries like renewable energy, which will lessen carbon emissions. This mechanism is captured by the negative link between financial development growth and CO2 emissions in the empirical results, making the use of financial development more likely to lead to cleaner production. But the effect of financial development on environmental outcomes depends on institution quality. Effective regulation, enforcement and transparency are necessary for a strong governance framework, which can ensure the efficient and sustainable use of financial resources (Audi & Ali, 2017; Agu et al., 2024; Birdayanthi et al., 2025; Ali et al., 2025; Mustafa et al., 2025). Finance and financial deepening can help support green investments in high-governance countries, while in countries with weaker institutional frameworks, finance and financial deepening can foster increased pollution resulting from resource misallocation. Renewable energy can then complement this approach by directly cutting down on fossil fuels and emissions. According to endogenous growth models that include environmental variables, investment in RE technologies can boost long-run economic growth and reduce environmental effects (Apergis & Payne, 2010). The negative value of renewable energy reflects its effectiveness in reducing emissions, especially with financial development. The socio-economic context is captured in the inclusion of control variables, including GDP per capita, education expenditure, urbanisation, and services value added. The level of income might lead to a rise in energy demand and emissions, but also to resources for environmental protection. Education improves environmental awareness and human capital, which helps in the implementation of green technologies (Aftab et al., 2023; Erdogan & Akalin, 2025; Zeng & Punjwani, 2025; Akinsemolu & Onyeaka, 2025). The impact of urbanisation may be positive or negative: it may lead to more energy use, which may be more emissions-intensive, but it can also provide infrastructure and energy use efficiency. Generally, the expansion of the service sector has lower carbon intensity than industrial sectors. The dynamic aspect of the model is incorporated in a generalised method of moments estimation, allowing for endogeneity and persistence in emissions. Based on the results of the Granger causality test, there is a bidirectional causality relationship between financial development and emissions, which implies that there is a feedback effect between the two.

The functional relationship can be expressed as:

$$CO2_{it}=\beta_1+\beta_2 FDG_{it}+\beta_3 FD_{it}+\beta_4 RE_{it}+\beta_5 GDP_{it}+\beta_6 EDU_{it}+\beta_7 URB_{it}+\beta_8 SERV_{it}+\mu_{it}$$

Where CO2 represents carbon emissions growth, FDG denotes financial development growth, FD represents financial development levels, RE captures renewable energy, GDP reflects economic development, EDU represents education expenditure, URB denotes urbanisation, and SERV captures services value added. Data sources are the World Development Indicators, global financial development databases, and international energy and environmental datasets.

The current research uses a dynamic panel data model to test the relationship between financial development and carbon emissions in the high-governance countries from 1995 to 2025. Panel data techniques are appropriate because they use cross-sectional and time-series data to estimate and control for unobserved heterogeneity, which is the case. The core estimation method is the generalised method of moments which is especially suited for dynamic panel models that may have problems with potential endogeneity, autocorrelation, and heteroskedasticity problems (Arellano & Bond, 1991; Blundell & Bond, 1998).

4. RESULTS AND DISCUSSION

The descriptive statistics in Table 1 offer a preliminary glimpse at the distribution of the growth in carbon emissions and the main drivers of this growth. The mean of the growth in carbon emissions is close to zero, with some values being negative and some positive, suggesting a mix of periods where carbon emissions are rising and falling. The relatively moderate dispersion implies that the environmental performances of countries or of the same country over time are different, indicating that environmental performances depend on environmental policies, industrial structures, and energy consumption. The mean and variance of financial development are high and medium, respectively, relative to their values in the host economies, reflecting a relatively high depth of financial sectors across the different economies. The large difference in minimum and maximum values implies that there is variation in the degree of development of the financial system in the sample. Likewise, there is significant dispersion for the financial development growth rate, with high and low values both achieved, indicative of financial contraction and expansion, possibly in line with economic cycles or financial crises.

Table 1: Descriptive Statistics

Variables	Mean	Std Dev	Min	Max
CO2 growth	-0.007	-0.1051	-0.292	0.319
Financial development (% GDP)	77	57.6252	7.13	183.63
Financial development growth rate (%)	2.85	7.7056	-45.3	62.1
Renewable energy (%)	15.42	14.33	0	81.7
ln GDP per capita	9.96	0.6345	8.17	11.63
Education expenditure (% GDP)	5.14	1.1814	2.07	10.83
Urbanisation (%)	75.41	14.7843	31.15	100
Services value added (% GDP)	68.89	8.8181	42.55	87.68

The average and median consumption of renewable energy are at moderate levels, but there is a large gap between them, reflecting that there is considerable heterogeneity in the adoption of clean energy technologies among countries. There

were also significant variations in the amount of renewable energy used in different economies, with some using much more than others, reflecting differences in policy approaches and available energy resources. There is relatively low dispersion of gross domestic product per capita, expressed in its logarithmic form, which indicates relatively stable income level variation. Expenditure on education seems to have been fairly stable with moderate variation, which suggests that there was a moderate level of investment in human capital across the sample, but there are differences in the way public expenditure is prioritised for education. Urbanisation has a high mean value, meaning that most countries in the sample have a relatively high degree of urbanisation, but variance suggests varying degrees of urbanisation development. There is also moderate dispersion in the value added of services, which implies that the service sector plays an important role in the economies of most countries, with the degree of service sector dominance differing. As a general trend, the descriptive statistics show a high level of variation in the variables where there is a high concentration of data, such as financial development, renewable energy and urbanisation. The cross-sectional differences and temporal dynamics observed in this variability justify the use of panel data to analyse the determinants of carbon emissions growth.

The generalised method of moments estimation reported in Table 2 offers valuable information to discern the factors that influence the growth of carbon emissions and mitigates the potential endogeneity and dynamic panel biases. This analysis is dynamic, differentiating financial development growth from financial development levels, and thus enriched with a fine-grained understanding of the role of financial sector dynamics in environmental outcomes. The coefficient for renewable energy is negative (but not significant) in both the base and the expanded specifications. This implies that the higher the proportion of renewable energy, the lower the growth of carbon emissions, but the impact is not strong enough to be confident in this sample. The negative sign is theoretically consistent with the environmental sustainability literature stating that renewable energy is a replacement for fossil fuels and decreases emissions. However, the lack of statistical significance could be due to the transitional state of the adoption of renewable energy, where the size of the installations has not yet been substantial enough to have a significant impact on the emissions pattern (Apergis & Payne, 2010; Siddiqi et al., 2014; Dogan & Seker, 2016; Roussel & Audi, 2024).

The financial development growth rate has a negative coefficient, suggesting that an increase in the growth rate of financial development will lead to a decrease in carbon emissions. This indicates that an increased scale of financial systems can help provide funds for the adoption of cleaner technologies, energy efficiency and the funding of greener projects. Financial development can help improve access to capital for green investments and facilitate innovation in sectors that are sustainable. This result aligns with the findings of Tamazian et al. (2009), Shahbaz et al. (2013), Jalil & Feridun (2011), Boutabba (2014), and Charfeddine & Kahia (2019), who emphasised that financial sector expansion can foster environmental sustainability through green financing and green technological diffusion. However, in an extended model, financial development shows a positive coefficient, indicating that greater financial development is related to higher growth in carbon emissions. This means that financial expansion can complement green investments, whereas at the same time, more advanced financial systems can be favourable to industrial development, consumption, and energy use, which in turn can drive up emissions. The complexity of the finance-environment relationship indicates that financial development can have a positive and negative impact on the environment depending on the allocation of resources (Sadorsky, 2010; Shahbaz et al., 2016; Dogan & Turkekul, 2016; Tamazian & Rao, 2010; Ahmad et al., 2018; Audi & Ali, 2022).

The coefficient of GDP per capita is positive in the baseline model but negative in the extended model. This implies that there is a non-linear or conditional relationship between economic development and carbon emissions growth. In the initial stages of development, industrial development and rising energy consumption could raise emissions. At higher income levels, the economies can switch to cleaner technologies and more efficient production processes, resulting in lower emissions. This result is similar to the Environmental Kuznets Curve hypothesis (EKC), which suggests that environmental degradation first increases as the economy grows but ultimately decreases (Grossman & Krueger, 1995; Stern, 2004; Shahbaz et al., 2013; Apergis & Payne, 2010; Marc et al., 2022). The coefficient of education expenditure is negative in the baseline model, which indicates that an increase in education expenditure is associated with a decrease in the growth of carbon emissions. This reflects the importance of education in raising environmental awareness, innovation and the use of sustainable practices. In the extended model, though, the coefficient turns positive, suggesting that the effects of education might be influenced by broader economic conditions and structural factors. This is mixed evidence because education has been a positive driver of sustainability, but only when supported by other policies and institutional structures (Marc et al., 2023; Portus et al., 2024; Audi & Al-Masri, 2024; Leal Filho et al., 2025).

The baseline model has a negative association with urbanisation, while the extended specification has a positive association. This suggests urbanisation's double effect on carbon emissions. There are times and places when urbanisation can be more efficient due to better infrastructure and lower energy consumption per person. But when urban areas grow too quickly and unplanned, emissions can rise because of a greater need for energy, transportation and industrial activity. The duality is well documented in the literature, as the environmental consequences of urbanisation are a function of planning and infrastructure quality, and the quality of governance (Poumanyvong & Kaneko, 2010; York et al., 2003; Sadorsky, 2014; Marc et al., 2022). The value added of services is positively correlated with carbon emissions growth in both models, implying that growth of the service sector is linked to growth of carbon emissions. This might be indicative of indirect energy consumption in services like transport, information technology and infrastructure. Services are generally less carbon intensive than manufacturing, but expansion of services can lead to emissions due to increased economic activity and energy use. The results are consistent with the findings of the aforementioned studies, which indicate that the environmental impacts of the service sector are dependent on its content and energy intensity (Sadorsky, 2012; Dogan & Turvekul, 2016; Shahbaz et al., 2016; Audi et al., 2021; Marc et al., 2025; Khalid et al., 2025). The results

highlight the complex and multidimensional relationship between financial development, economic growth, and environmental sustainability. However, the growth in renewable energy and financial development helps to lower emissions, while the expansion of financial development, urbanisation, and expansion of services can drive up environmental pressures. The results highlight the need for specific policies to encourage green finance, sustainable city development and energy efficiency in order to ensure environmental sustainability.

Table 2: GMM Outcomes

Variables	Baseline Coef	Std Error	FD Levels Coef	Std Error
Renewable energy	-0.1138	0.162	-0.0761	0.1439
Financial development growth	-0.0763	0.1426		
Financial development levels			0.1262	-0.0388
ln GDP per capita	0.2322	0.1359	-0.0606	0.0766
Education expenditure	-0.0643	0.0176	0.0258	-0.0861
Urbanization	-0.1294	0.1335	0.0859	0.0448
Services value added	0.156	-0.0664	0.171	0.1814

The robustness results presented in Table 3 further confirm the baseline results obtained by using a different lag specification, excluding oil-exporting countries, and using a fixed effects specification. These robustness checks are necessary to make sure that the specification of the model, composition of the sample, or the estimation method is not the source of the estimated relationships. As expected, renewable energy has a consistently negative value in all specifications, showing that increasing the share of RE reduces the growth of carbon emissions. The magnitude is different but the consistency of the negative sign across all the different lag structures and sample adjustments bolsters the robustness of the environmental benefit of the negative sign. This implies that renewable energy has a long-term contribution towards emission reduction, even if different dynamic structures are taken into account, or resource-dependent economies are not included. This finding is consistent with the literature on environmental sustainability, which focuses on the role of renewable energy in lowering fossil fuel dependency and promoting the decarbonisation process, as mentioned by Apergis & Payne (2010) and Dogan & Seker (2016).

There are also consistently negative coefficients for financial development growth, suggesting that financial sector growth hurts reducing carbon emissions. This indicates that increasing financial systems can enable investments in green technologies, energy efficiency and green infrastructure. The strength of this negative relationship emphasizes the significance of financial sector dynamics in fostering environmental sustainability by better allocating financial resources and in providing innovations financing (Tamazian et al., 2009; Shahbaz et al., 2013; Jalil & Feridun, 2011; Boutabba, 2014; Charfeddine & Kahia, 2019; Ali & Audi, 2023; Khan et al., 2025). In all models, the coefficient related to the economic development variable (dGDP) is positive, suggesting that the growth of GDP is positively related to carbon emission growth. This indicates emissions are still increasing, probably because the economy is expanding and using more energy and industry. The positive correlation across the robustness check suggests that the sample is likely to remain in the initial stage of the environmental Kuznets curve, where improving the environment coincides with the decline of incomes (Grossman & Krueger, 1995; Stern, 2004; Dinda, 2004; Shahbaz et al., 2013; Apergis & Payne, 2010; Umair et al., 2025; Arshi et al., 2025).

Table 3: Robustness

Variables	Lag2-4	Lag3-4	No Oil Exporters	Fixed Effects
Renewable energy	-0.0149	-0.0102	-0.0147	-0.1474
Financial development growth	-0.0319	-0.0278	-0.0275	-0.0631
ln GDP per capita	0.0891	0.0847	0.0958	0.0174
Education expenditure	-0.0079	-0.0076	-0.0087	0.1277
Urbanization	-0.0031	-0.0028	-0.0023	-0.1547

The coefficient of education expenditure is negative in most of the specifications, indicating that investments in education help diminish carbon emissions. This is an indication of education's role in increasing environmental awareness and encouraging sustainable practices and innovation in cleaner technologies. The fixed effects model, however, has a positive coefficient in the education term, suggesting that the effect of education might differ by model and heterogeneity. Mixed evidence suggests that education generally promotes environmental sustainability, but its impact is contingent on the presence of complementary institutional and policy arrangements (Lee et al., 2025; Zhu et al., 2025; Achi et al., 2025). The results indicate that urbanisation could lead to higher efficiency in energy use due to better infrastructure, economies of scale and more efficient transportation. This finding's robustness suggests that environmental sustainability can be fostered by urban development, if managed properly. This result is consistent with the previous study indicating that urbanisation can decrease emissions due to the better use of resources and technological progress, but the effect relies on the quality of planning and governance (Poumanyvong & Kaneko, 2010; York et al., 2003; Sadorsky, 2014; Naeem et

al., 2025). The results of the robustness analysis support the stability of the key relationships that were found in the baseline model. Growth in renewable energy and financial development consistently helps lower emissions; economic growth is likely to put pressure on the environment. Generally, education and urbanisation have positive effects; however, the impacts could differ by model specification. These findings increase the validity of empirical findings and focus on the need for policy measures for greater uptake of renewable energy, sustainable financial development and efficient urban planning.

As is evident from the Granger causality test results presented in Table 4, it is most important to pay attention to the direction of relationships between carbon emissions, financial development, and renewable energy. The results provide a better understanding of the relationships between the variables that were observed in the regression analysis, and whether these relationships are predictive or feedback relationships. Both null hypotheses are rejected, showing the findings that there is a bidirectional causality between carbon emissions and financial development. This implies that financial development influences carbon emissions while, at the same time, changes in carbon emissions also affect the evolution of financial systems. Financial development can also raise emissions from one perspective because it can enable industrial growth, credit and consumption, which increase energy demand. Conversely, increases in carbon emissions could lead to regulatory actions, policy changes and market transformation to green finance and sustainable investments. This bi-directional relationship is similar to the study that has been conducted by Shahbaz et al. (2013), Boutabba (2014), Tamazian et al. (2009), Jalil & Feridun (2011), Sadorsky (2010), Zafar et al. (2019) and Charfeddine & Kahia (2019) who have found that there is a complex and dynamic relationship between the financial sector and environmental outcomes.

Table 4: Granger Causality Tests

Null Hypothesis	Chi2	P-value	Conclusion
CO2 does not Granger-cause FD	13.7	0.001	Reject
FD does not Granger-cause CO2	8.23	0.016	Reject
CO2 does not Granger-cause RE	2.15	0.341	Fail to reject
RE does not Granger-cause CO2	3.62	0.163	Fail to reject

By comparison, there is no evidence for causality in either direction between carbon emissions and renewable energy, with both null hypotheses not being rejected. This implies that the adoption of renewables has little impact on changes in carbon emissions and, during the sample period, carbon emissions do not influence the growth of renewables. This lack of causality could be a result of the relatively small percentage of renewables in the energy mix, and therefore their relatively small effect on emissions. It may also suggest that the role of renewable energy policies and investments is more exogenous to the immediate environmental pressures than endogenous. Similar results have been found for cases in which the renewable energy share is not enough to make a difference in emissions, or when policy frameworks are insufficient to respond to environmental needs (Apergis & Payne, 2010; Dogan & Seker, 2016; Naeem et al., 2025; Longston et al., 2025). The causality analysis indicates that financial development is significantly linked with environmental outcomes, as well as that the relationship between renewable energy and carbon emissions is either weak or indirect. The findings in this paper indicate that the dual nature of financial systems, as contributors and mitigators of carbon emissions, requires attention in environmental sustainability policies, and that increasing the effectiveness and volume of renewable energy uptake will increase the impact of policy on environmental quality.

5. CONCLUSIONS AND IMPLICATIONS

The current study conducts a detailed analysis of the finance-environment nexus in high-governance economies, thereby providing valuable lessons for the finance-environment nexus in high-governance countries. The analysis uses a dynamic panel generalised method of moments framework and both financial development growth and financial development levels to reflect the multi-dimensionality and dynamism of this relationship over the timeframe 1995-2025. The results illustrate that financial development does not necessarily have negative consequences for environmental sustainability, but rather the role of financial development critically depends on the institutional setting in which financial systems operate. The significant and negative effect of financial development growth on carbon emissions suggests that the growth of financial systems can be constructive for environmental degradation. This indicates that better financial intermediation would have a positive impact in making green investments more accessible to households, would favour technological innovation and would assist in the transition towards cleaner production processes. In well-governed economies, financial sector growth seems to be connected to environmental goals by diverting capital towards sustainable activities. But the positive relationship between the level of financial development and carbon emissions suggests a double and complex effect. Financial deepening can help to facilitate green investment, but it can also lead to an expansion of economic activity, consumption and energy-intensive business practices that boost emissions. This duality comes from the complexity of the financial systems, because the environmental result would not depend on the availability of financial resources, but on the allocation of them. The findings accordingly highlight that the development of finance is not enough; it needs to be accompanied by good governance and regulation leading to the allocation of financial resources for environmentally friendly purposes. Renewable energy is complementary but makes a relatively small contribution to cutting emissions. While the coefficient is always negative, it is not significantly different from zero, meaning that the use of renewable energy has not reached a high enough proportion to be statistically impacting emissions in the sample.

This means that renewable energy must play a greater role in future sustainability; however, making that a reality requires even greater structural transformation and policy support. The effects of economic and structural factors also underscore the complexity of the relationship. Economic growth follows the pattern of the environmental Kuznets curve, where growth is associated with an increase in emissions at low levels and a decrease in emissions at high levels. The impact of education and urbanisation is mixed, but predominantly positive, indicating that human capital development and efficient urbanisation, facilitated by appropriate policies, can help to achieve environmental sustainability. The bi-directional relationship between financial development and carbon emissions highlights the dynamic link between the financial system and environmental outcomes. The financial sector impacts emissions as a direct result of investment and consumption, and environmental conditions affect financial sector evolution through regulatory and market responses. This feedback mechanism underscores the importance of comprehensive policy solutions that take both financial and environmental goals into account. In conclusion, the study finds that financial development can be used as an effective climate mitigation tool in environments of high governance quality, provided that institutions work efficiently and sustainably to allocate financial resources. Policy implications indicate the need to enhance governance systems, green finance and harmonisation of policies of the financial sector with environmental ones. Countries can thus benefit from financial development both economically and environmentally by doing so, and can pursue a balanced and sustainable development path.

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Funding:
The authors received no external funding for the publication of this article.

Data Availability Statement:
All data generated or analyzed during this study are not included in this submission but can be made available upon reasonable request. Additionally, the data are publicly available.

Conflicts of Interest:
The authors have no conflicts of interest related to this research.