




FINANCIAL DEVELOPMENT, ENERGY TRANSITION, AND CARBON EMISSIONS IN ARAB ECONOMIES

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ABSTRACT

This paper investigates the role of financial development in accelerating the energy transition and reducing carbon dioxide emissions in Arab countries over the period 2000–2022. The study uses a panel autoregressive distributed lag model, estimated via the pooled mean group approach, to examine the long-run and short-run effects of financial development, foreign direct investment, economic growth, carbon dioxide emissions, and political stability on renewable energy consumption. The results show that financial development has a negative and statistically significant long-run effect on renewable energy consumption, indicating that domestic financial systems in Arab countries remain weakly oriented toward green investment. Conversely, foreign direct investment and economic growth positively support the transition toward renewable energy, while political stability has no statistically significant effect. These findings suggest that financial deepening alone is insufficient unless it is supported by green finance instruments, stronger regulatory incentives, and climate-oriented economic policies. The paper is relevant to researchers, policymakers, financial institutions, and energy regulators.

1 INTRODUCTION

In recent decades, the global energy system has undergone a structural transformation in the ways energy is produced and consumed, driven by mounting climate pressures, the intensification of global warming, and the growing commitments of countries under multilateral climate agreements, particularly the 2015 Paris Agreement. This transformation has reinforced the strategic importance of renewable energy as an alternative

to fossil fuels, especially for economies seeking to reshape their development models toward more sustainable and diversified pathways. However, achieving such a transition requires a set of enabling conditions, including resilient energy infrastructure, a stable institutional environment, and an effective financial framework capable of mobilizing resources toward clean-energy innovation.

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Within this context, financial development has emerged as a critical driver of energy transition through its role in mobilizing domestic savings, expanding access to finance, reducing the cost of capital, and stimulating investment in low-carbon projects. As financial systems become deeper, more efficient, and more stable, their capacity to finance the structural shift toward sustainable energy models is expected to increase. Recent economic literature has therefore emphasized the channels through which financial development may affect energy-sector performance, either directly through green finance or indirectly through economic growth and technological progress (Beck et al., 2007; Zhang et al., 2024).

Despite this theoretical momentum, the Arab region remains largely underrepresented in rigorous empirical research on this topic, although it constitutes a distinctive case characterized by abundant fossil-fuel resources, growing renewable-energy commitments, and highly heterogeneous financial systems. These systems range from traditional bank-dominated structures to emerging capital markets, raising important questions about their ability to support the energy transition effectively, particularly in contexts marked by institutional fragility or weak regulatory incentives.

Accordingly, this study addresses the following central research question: To what extent does financial development contribute to accelerating the energy transition and reducing carbon dioxide emissions in Arab countries? To answer this question, the study tests three hypotheses: financial development has a significant long-run effect on renewable energy consumption; foreign direct investment and economic growth support the energy transition; and political stability is positively associated with the transition, although its effect depends on the presence of an effective institutional framework.

The study estimates the dynamic effect of financial development on renewable energy consumption (ENRR) and carbon dioxide emissions (CO₂) in a sample of eleven Arab countries over the period 2000–2022. It adopts a flexible econometric framework that captures short- and long-run causal interactions among financial, economic, environmental, and institutional variables, including foreign direct investment (FDI),

economic growth (GDPG), and political stability (PS). Its contribution lies in its comparative regional focus on an empirically underexplored area and in its use of a dynamic Panel ARDL model estimated through the PMG approach, supported by CS-DOLS and System-GMM robustness checks.

The paper is organized as follows. The first section presents the theoretical background and defines the core concepts of energy transition, financial development, and green finance. The second section reviews the relevant empirical literature and identifies the research gap. The third section presents econometric analysis, discusses the results, and interprets the findings in light of economic theory and previous studies.

2 REVIEW OF THE SCIENTIFIC LITERATURE

Figure 1 maps the reviewed literature according to four analytical dimensions: key studies, research themes, empirical contexts with methods, and main findings. Overall, the literature shows that the relationship between financial development and the energy transition is neither linear nor uniform. Rather, its direction depends on the type of financial development examined, the institutional setting, the structure of the energy system, and the methodological framework adopted.

A first strand of research examines the role of financial inclusion and financial depth in promoting clean energy. Sohail et al. (2024), using a Panel NARDL approach for BRICS economies, show that disaggregated financial inclusion indicators can accelerate the clean-energy transition and contribute to reducing carbon emissions. Similarly, Parashar and Jaiswal (2025), relying on System GMM for a sample of emerging economies, find that financial access, depth, and efficiency improve energy equity, energy security, and environmental sustainability. These studies suggest that financial development can support the energy transition when it expands access to capital and channels financial resources toward sustainable energy uses.

A second group of studies focuses on financial innovation, digital finance, and technological progress. Zhang et al. (2024), using evidence from China, demonstrate that financial innovation and

environmental regulation significantly enhance renewable energy generation and accelerate the energy transition. Liu et al. (2023) further show that digital financial development contributes to reducing pollution and carbon emissions through green technological innovation. Benfica and Marques (2024), in the Latin American context,

confirm that technological and financial development can improve energy-transition efficiency, although the magnitude of this effect differs across countries. This strand indicates that finance becomes more environmentally effective when it is linked to innovation, regulation, and clean technology diffusion.

Key studies	Theme	Context (with method)	Main results
Sohail et al. (2024)	Financial inclusion and clean energy transition	BRICS economies (2004–2022) [Panel NARDL]	Promotes clean energy and lowers CO ₂ emissions in BRICS.
Zhang et al. (2024)	Financial innovation and renewable energy	China, 31 provinces (1990–2021) [MMQR, 2SLS, Wasteland cointegration]	Financial innovation and regulation boost renewable energy transition.
Jackson and Jackson (2025)	Macroeconomic and financial dynamics of energy transition	United Kingdom of global implications [SHC-IO model]	Rapid transition may cause instability; gradual transition is safer.
Parabhar and Jairwal (2025)	Financial access, depth and energy sustainability	18 emerging economies (1995–2020) [System GMM]	Financial access, depth and efficiency improve energy sustainability.
Harvey et al. (2024)	Digital payments, financial development and energy transition	Africa (2008–2019) [System GMM, dynamic threshold model]	Threshold effect between finance, digitalization and renewable energy.
Benfica and Marques (2024)	Technology, finance and energy transition efficiency	Latin America [DFA, fractional regression model]	Technology and finance improve transition efficiency, with heterogeneity.
Petrović and Lobanov (2022)	Financial development and CO ₂ emissions	24 advanced and developing countries [Panel cointegration with structural breaks]	Finance can raise CO ₂ when it supports carbon-intensive sectors.
Subhan et al. (2023)	Renewable/non-renewable energy, finance and CO ₂ emissions	India (1971–2019) [NARDL, wavelet coherence]	Finance raises CO ₂ by boosting non-renewable energy use.
Li (2023)	Financial markets and clean technology investment	Global sample (1990–2018) [SYS-GMM]	Financial markets support clean-tech and renewable expansion.
Liu et al. (2023)	Digital finance and pollution-carbon reduction	China (2011–2019) [Fixed effects–mediation analysis]	Digital finance reduces pollution and CO ₂ through green innovation.
Prempeh (2023)	Financial development and renewable energy consumption	Ghana (1990–2020) [ARDL, VECM, FMOLS, DOLS, CCR]	Finance supports renewable energy when institutions are strong.
Zhao and Yang (2020)	Financial development and CO ₂ emissions (regional evidence)	Chinese provinces (2011–2018) [PCA, FMOLS, DOLS, PVAR]	Finance can reduce CO ₂ , but effects vary across regions.
This study (2025)	Financial development, energy transition and CO ₂ (Arab region)	11 Arab countries (2000–2022) [Panel ARDL (PMG) and CS-DOLS and System-GMM]	In Arab countries, effects depend on institutions, FDI, growth and political stability.

Figure 1. Comparative Mapping of the Scientific Literature on Financial Development and Energy Transition

Source: Prepared by the author.

A third strand addresses the macroeconomic and systemic risks associated with energy transitions. Jackson and Jackson (2025), through a stock-flow consistent input-output model, show that a rapid and poorly managed transition may generate macroeconomic and financial instability, while a gradual transition is more sustainable. This perspective is important because it highlights that the financial system is not only a source of transition finance but also a channel through which transition risks may spread across the broader economy.

Another important strand of the literature investigates the relationship between financial development and carbon emissions. This line of research is particularly relevant because it questions the assumption that financial deepening necessarily produces environmental benefits. Petrović and Lobanov (2022) find that financial development may increase carbon dioxide emissions when credit expansion and financial

resources are directed toward carbon-intensive sectors. In such cases, financial development strengthens conventional economic activities rather than supporting environmental transformation. Subhan et al. (2023) reach a similar conclusion in the Indian context, showing that financial development can increase emissions by stimulating non-renewable energy consumption and facilitating investment in pollution-intensive activities. These findings suggest that, in the absence of green regulatory frameworks, financial development may reinforce existing fossil-fuel-based production and consumption patterns.

In contrast, Zhao and Yang (2020) show that financial development can reduce carbon emissions in Chinese provinces, although the magnitude and direction of this effect differ across regions. Their findings indicate that the environmental impact of finance depends on local economic structures, regional energy profiles, and

the degree to which financial resources are allocated to cleaner technologies. Taken together, these mixed results confirm that financial development is not intrinsically green. Its environmental outcome depends on the direction of credit allocation, the structure of investment, the presence of environmental regulation, and the ability of financial institutions to support renewable energy and low-carbon innovation rather than carbon-intensive activities.

The literature also emphasizes the importance of regional heterogeneity in shaping the finance–energy transition nexus. Horvey et al. (2024), focusing on African economies, identify a nonlinear threshold relationship between financial development, digitalization, and renewable energy consumption. Their results suggest that financial development may support renewable energy only after reaching a certain level of maturity and when complemented by digital infrastructure. Li (2023) provides broader global evidence showing that financial market development can support clean technology investment and renewable energy expansion, particularly where capital markets are capable of mobilizing long-term funding for green projects. Prempeh (2023), using evidence from Ghana, similarly finds that financial development can stimulate renewable energy consumption when supported by sound institutional and policy conditions.

Overall, these studies show that the effect of financial development on the energy transition is strongly context-dependent. Finance can either accelerate renewable energy adoption or deepen carbon lock-in, depending on the institutional environment, the structure of the financial system, the quality of energy policies, and the availability of green financial instruments. This reinforces the need to examine Arab economies as a distinct empirical context, given their heavy dependence on fossil fuels, heterogeneous financial systems, and emerging commitments to renewable energy development.

3 METHODOLOGY

This study examines the dynamic effect of financial development on the energy transition in a selected sample of Arab countries over the period 2000-2022. The empirical analysis models the interaction between renewable energy

consumption and a set of financial, economic, environmental, and institutional determinants. The methodological framework is based on a dynamic panel specification that captures both long-run equilibrium relationships and short-run adjustments.

Table 1 summarizes the variables used in the empirical model, their corresponding symbols, the study period, and the official data sources from which they were obtained. The purpose of this table is to clarify the measurement structure of the study and ensure transparency regarding the construction of the dataset used in the subsequent dynamic panel analysis.

Table 1. Variables and Data Sources

Variable	Symbol	Period	Source
Renewable energy consumption	ENRR	2000-2022	World Bank, World Development Indicators
Financial development index	FD	2000-2022	International Monetary Fund, Financial Development Index Database
Foreign direct investment, net inflows (% of GDP)	FDI	2000-2022	World Bank, World Development Indicators
Real GDP growth rate	GDPG	2000-2022	World Bank, World Development Indicators
Carbon dioxide emissions per capita	CO ₂	2000-2022	World Bank / Our World in Data
Political stability index	PS	2000-2022	Worldwide Governance Indicators

Source: Prepared by the author.

As shown in Table 1, the dependent variable is renewable energy consumption (ENRR), which is used as a proxy for the progress of the energy transition. The main explanatory variable is the financial development index (FD), which captures the depth, access, and efficiency of the financial system. Foreign direct investment (FDI) is

included as a channel of external finance and technology transfer, while real GDP growth (GDPG) reflects macroeconomic dynamism. Carbon dioxide emissions per capita (CO₂) are introduced as an environmental pressure variable, and political stability (PS) is used to account for the institutional capacity required to implement long-term energy policies.

3.1 Model Specification

The baseline long-run relationship is specified as follows:

$$ENRR_{it} = \alpha_i + \beta_1 FD_{it} + \beta_2 FDI_{it} + \beta_3 GDPG_{it} + \beta_4 CO2_{it} + \beta_5 PS_{it} + \varepsilon_{it}$$

where:

i refers to the country ($i = 1, \dots, N$), and

t refers to time ($t = 2000, \dots, 2022$).

$ENRR_{it}$ denotes renewable energy consumption in country i at time t ; FD_{it} represents financial development; FDI_{it} denotes foreign direct investment; $GDPG_{it}$ represents the real GDP growth rate; $CO2_{it}$ captures carbon dioxide emissions; PS_{it} denotes political stability; α_i represents country-specific effects; and ε_{it} is the error term. To capture short-run dynamics and long-run adjustment, the study adopts the Panel ARDL error-correction representation estimated through the Pooled Mean Group estimator:

$$\begin{aligned} \Delta ENRR_{it} = & \phi_i (ENRR_{i,t-1} - \theta_1 FD_{it} - \theta_2 FDI_{it} \\ & - \theta_3 GDPG_{it} - \theta_4 CO2_{it} - \theta_5 PS_{it}) \\ & + \sum_{j=1}^{p-1} \lambda_{ij} \Delta ENRR_{i,t-j} \\ & + \sum_{j=0}^{q-1} \delta_{1ij} \Delta FD_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij} \Delta FDI_{i,t-j} \\ & + \sum_{j=0}^{q-1} \delta_{3ij} \Delta GDPG_{i,t-j} \\ & + \sum_{j=0}^{q-1} \delta_{4ij} \Delta CO2_{i,t-j} + \sum_{j=0}^{q-1} \delta_{5ij} \Delta PS_{i,t-j} \\ & + \mu_i + \eta_{it} \end{aligned}$$

In this specification, ϕ_i denotes the first-difference operator. The parameter ϕ_i is the error-correction coefficient, which measures the speed at which deviations from the long-run equilibrium are corrected. A negative and statistically significant result confirms the existence of long-run convergence. The parameters represent the long-

run coefficients, while the parameters capture short-run effects. The PMG estimator is suitable because it allows short-run coefficients and adjustment speeds to differ across countries, while imposing homogeneity on the long-run coefficients

3.2 Sample

The sample includes eleven Arab countries selected based on data availability and statistical consistency over the period 2000-2022. The selected countries are distributed as follows: Qatar, the United Arab Emirates, and Kuwait from the Gulf region; Algeria, Libya, Tunisia, and Morocco from North Africa; Iraq, Jordan, and Lebanon from the Mashreq region; and Mauritania from the Arab Sahel.

3.3 Methodological Rationale

The use of the Panel ARDL-PMG approach is appropriate for this study for three reasons. First, it accommodates variables integrated at different orders, provided that none is integrated of order two. Second, it distinguishes between short-run country-specific dynamics and common long-run relationships, which is important given the heterogeneity of Arab economies in terms of financial structure, energy dependence, and institutional quality. Third, it provides a coherent framework for assessing whether financial development supports or constrains the energy transition over time. To strengthen the reliability of the findings, the analysis is complemented by robustness checks using CS-DOLS and System-GMM, which help address cross-sectional dependence, long-run endogeneity, and dynamic-panel bias.

4 RESULTS

This section presents and discusses the empirical findings obtained from the panel econometric analysis. The analysis proceeds in three stages. First, panel unit-root tests are used to examine the order of integration of the variables. Second, panel cointegration tests are conducted to verify the existence of a stable long-run relationship. Third, the long-run and short-run dynamics are estimated using the PMG-ARDL model, followed by robustness checks to assess the reliability of the results.

4.1 Panel Unit-Root Tests

Before estimating the dynamic model, the stationarity properties of the variables were examined using the Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) panel unit-root tests. The results indicate that all variables-carbon dioxide emissions (CO₂), real GDP growth (GDPG), financial development (FD), foreign direct investment (FDI), political stability (PS), and renewable energy consumption (ENRR)-are non-stationary at the level but become stationary after first differencing. This implies that the variables are integrated of order one, I(1).

Methodologically, this finding supports the use of a Panel ARDL framework, provided that none of the variables is integrated of order two, I(2). The ARDL approach is particularly appropriate in this context because it can accommodate variables with mixed orders of integration, I(0) and I(1), while allowing the estimation of both short-run dynamics and long-run equilibrium relationships. The stationarity results, therefore, provide a valid preliminary basis for proceeding with the cointegration analysis.

4.2 Panel Cointegration Test

After establishing the integration properties of the variables, the study applies the Pedroni panel cointegration test to determine whether a long-run equilibrium relationship exists among renewable energy consumption and its financial, economic, environmental, and institutional determinants. The results show that three out of the seven Pedroni statistics-namely, the Panel PP-statistic, Panel ADF-statistic, and Group ADF-statistic-are statistically significant at the 1% level.

These findings allow the rejection of the null hypothesis of no cointegration and support the existence of a stable long-run relationship among the variables. In substantive terms, this means that renewable energy consumption (ENRR), financial development (FD), foreign direct investment (FDI), political stability (PS), carbon dioxide emissions (CO₂), and real GDP growth (GDPG) move together over time within a long-run equilibrium structure. This result justifies the estimation of the PMG-ARDL model and confirms that the relationship under study is not merely short-term or incidental, but reflects a persistent dynamic interaction.

Table 2. Long-run estimates of the PMG-ARDL model

Variable	Long-run coefficient	Statistical significance	Economic interpretation
FD	-13.03	Significant at 1%	Domestic financial development does not appear to be directed toward renewable energy projects
FDI	0.33	Significant at 1%	Foreign direct investment supports technology transfer and stimulates renewable energy investment
PS	0.014	Not significant	Political stability alone is insufficient without targeted clean-energy policies
CO ₂	0.97	Significant at 1%	High-emission countries tend to increase renewable energy adoption as part of transition responses
GDPG	0.21	Significant at 1%	Economic growth expands the fiscal and investment capacity needed to finance renewable energy projects

Source: Prepared by the author.

4.3 Long-Run Estimates of the PMG-ARDL Model

The PMG-ARDL(1, 2, 2, 2, 2, 2) model was estimated to assess the long-run effects of the explanatory variables on renewable energy consumption. The long-run results are summarized in Table 2, which reports the estimated coefficients, their statistical

significance, and their economic interpretation. The purpose of this table is to provide a concise overview of how financial development, foreign direct investment, political stability, carbon emissions, and economic growth affect renewable energy consumption in the long run.

The most striking result reported in Table 2 is the negative and statistically significant coefficient of financial development. This finding suggests that

financial deepening in Arab countries does not automatically translate into greater renewable energy consumption. Instead, it may indicate that domestic financial systems remain largely oriented toward conventional sectors, including hydrocarbon-related activities, real estate, trade finance, and short-term credit, rather than long-term green investment. In this respect, the result supports the argument that finance is not inherently green; its environmental effect depends on the direction of credit allocation, the design of regulatory incentives, and the existence of dedicated green financial instruments.

Foreign direct investment has a positive and statistically significant effect on renewable energy consumption. This result suggests that external capital can contribute to the energy transition by facilitating technology transfer, improving project financing, and introducing cleaner production practices. In many Arab economies, where domestic green finance mechanisms remain underdeveloped, foreign investment may therefore play a compensatory role by providing access to technical expertise, advanced renewable-energy technologies, and international financing standards.

The coefficient of carbon dioxide emissions is also positive and statistically significant. This result can be interpreted as evidence of a policy-response mechanism: countries facing higher environmental pressures may gradually increase renewable energy deployment to reduce dependence on carbon-intensive energy sources. However, this should not be interpreted as emissions directly causing sustainability; rather, high emissions may generate policy, social, and international pressure that encourages governments to incorporate renewable energy into their energy mix.

Economic growth also exerts a positive and statistically significant effect on renewable energy consumption. This finding indicates that higher growth can expand the fiscal and investment space required to finance renewable energy infrastructure. In economies where renewable energy projects require substantial upfront capital, macroeconomic expansion may improve the ability of both public authorities and private investors to support clean-energy initiatives.

By contrast, political stability has a positive but statistically insignificant coefficient. This suggests that institutional stability alone does not necessarily generate progress in renewable energy adoption. Political stability may provide a favorable general environment, but it must be translated into concrete policy instruments, such as renewable energy targets, green finance regulations, investment guarantees, feed-in tariffs, fiscal incentives, and transparent procurement mechanisms. Without such operational policy channels, institutional stability remains insufficient to drive the energy transition.

4.4 Error-Correction Mechanism and Short-Run Dynamics

The error-correction coefficient is negative and statistically significant at the 5% level, with an estimated value of:

$$ECT = -0.072$$

This confirms the existence of a long-run adjustment mechanism. The coefficient indicates that approximately 7.2% of deviations from the long-run equilibrium are corrected each year. Although the speed of adjustment is relatively slow, it is consistent with the structural nature of energy transitions, which typically require long planning horizons, large-scale infrastructure investment, institutional coordination, and gradual changes in the energy mix.

In the short run, most coefficients are statistically insignificant, except for a limited number of first-difference terms. This result indicates that changes in financial development, institutional conditions, and macroeconomic variables do not immediately affect renewable energy consumption. Such a finding is theoretically plausible because the impact of financial reforms and clean-energy policies usually materializes over longer horizons. Renewable energy projects are capital-intensive, require regulatory preparation, and often depend on long-term planning, grid integration, and institutional implementation capacity. Therefore, the weak short-run effects reinforce the interpretation that the finance-energy transition nexus in Arab economies operates primarily through long-run channels.

4.5 Robustness Checks

To assess the reliability of the baseline PMG-ARDL results, the study applies additional robustness checks using CS-DOLS and System-GMM estimators. The CS-DOLS estimator accounts for cross-sectional dependence and long-run endogeneity, while System-GMM helps address dynamic-panel bias and potential endogeneity arising from the persistence of renewable energy consumption and the interaction between financial development and economic performance.

The robustness results remain broadly consistent with the baseline findings in terms of signs and statistical relevance. This consistency strengthens the credibility of the empirical results and suggests that the estimated relationships are not driven by model-specific assumptions. In addition, the Hausman test supports the use of the PMG estimator rather than the Mean Group estimator, indicating that imposing long-run coefficient homogeneity is acceptable while allowing short-run heterogeneity across countries.

5 DISCUSSION OF THE FINDINGS

Taken together, the findings provide evidence that the relationship between financial development and the energy transition in Arab countries is conditional and structurally constrained. The negative long-run effect of financial development indicates that the existing financial architecture does not sufficiently channel resources toward renewable energy. This may reflect several characteristics of Arab financial systems, including the dominance of traditional banking, limited depth of green capital markets, weak environmental risk pricing, and continued preference for financing established carbon-intensive sectors.

The positive role of foreign direct investment and economic growth suggests that the energy transition in the region is more likely to advance when financial resources are combined with external technology, productive investment, and macroeconomic capacity. This finding is consistent with the view that renewable energy expansion requires not only domestic financial depth but also technological upgrading and stable investment conditions.

The positive association between carbon emissions and renewable energy consumption further suggests that environmental pressure can act as a catalyst for policy response. However, the effectiveness of this response depends on whether countries transform climate pressure into concrete renewable energy strategies. The insignificance of political stability reinforces this point: broad institutional stability is not enough unless it is supported by targeted regulations, green finance frameworks, and credible implementation mechanisms.

Overall, the results challenge the assumption that financial development automatically promotes sustainability. In the Arab context, finance appears to support the energy transition only when it is explicitly redirected through green financial instruments, environmental regulation, and investment incentives. Therefore, the key policy implication is that financial development must be reoriented from conventional financial deepening toward climate-aligned financial transformation.

6 CONCLUSIONS

This study provides a dynamic empirical assessment of the role of financial development in shaping the energy transition across eleven Arab countries over the period 2000–2022. The results show that financial development plays a decisive but conditional role in supporting renewable energy adoption. More specifically, the findings indicate that financial systems do not automatically operate as catalysts for clean-energy transition. Their impact depends on long-run interactions among financial, economic, institutional, and environmental factors.

The negative long-run effect of financial development suggests that financial deepening in Arab economies may remain insufficiently aligned with green investment priorities. In the absence of targeted regulatory incentives and sustainable finance instruments, financial resources may continue to flow toward conventional and carbon-intensive sectors. By contrast, foreign direct investment and economic growth appear to support renewable energy consumption, indicating that external capital, technological transfer, and macroeconomic capacity are important drivers of the transition process. The statistically insignificant effect of political stability

further suggests that institutional stability alone is not sufficient unless it is translated into concrete clean-energy policies and implementation mechanisms.

These findings reinforce the theoretical view that the relationship between finance and energy transition is complex, context-dependent, and potentially nonlinear. They also highlight the importance of local structural conditions in determining whether financial development contributes to environmental sustainability or reinforces existing carbon-intensive pathways. Unlike static or purely linear approaches, this study provides a dynamic framework that distinguishes between short-run adjustments and long-run equilibrium effects, thereby offering a more precise understanding of the mechanisms linking finance, renewable energy, and emissions in Arab economies.

The main contribution of this paper lies in reframing the finance–energy nexus as a developmental and transformative relationship. Financial development should not be treated merely as a source of capital accumulation, but as a policy channel that must be explicitly aligned with climate objectives. In this sense, the energy transition requires not only more finance, but better-directed finance.

Based on the empirical results, the study proposes several policy implications for Arab economies.

First, domestic financial systems should be reoriented toward green investment. This requires integrating sustainability criteria into banking regulations, credit allocation, and investment decisions, while encouraging banks and financial institutions to develop dedicated financing lines for renewable energy projects.

Second, Arab countries should develop sustainable financial instruments, including green bonds, climate funds, renewable-energy credit guarantees, and blended-finance mechanisms. These instruments can reduce investment risk, lower the cost of capital, and attract private-sector participation in clean-energy infrastructure.

Third, institutional incentives should be redesigned to support the energy transition. This includes reforming fossil-fuel subsidies, introducing carbon-pricing mechanisms where feasible, and providing fiscal incentives for firms investing in clean technologies and renewable-energy systems.

Fourth, climate considerations should be incorporated into national financial strategies. Governments and central banks should integrate climate-risk assessment into macroprudential regulation, public investment planning, and fiscal policy evaluation.

Fifth, innovation-oriented finance should be strengthened through digital finance, financial technology, crowdfunding platforms, and public–private partnerships. These mechanisms can improve access to clean-energy finance, especially in underserved regions and small-scale renewable projects.

Finally, stronger institutional coordination is required among ministries of finance, energy authorities, central banks, environmental agencies, and private financial institutions. Such coordination is essential to ensure policy coherence, improve regulatory credibility, and transform financial development into an effective driver of low-carbon transition.

Future research may extend this analysis in several directions. First, broader samples including other developing and resource-dependent economies could be used to compare the Arab experience with similar regional contexts. Second, future studies may incorporate additional institutional variables, such as governance quality, regulatory effectiveness, environmental policy stringency, and the role of green Islamic finance. Third, nonlinear and threshold models could be employed to test whether financial development begins to support renewable energy only after reaching a certain level of institutional or financial maturity. Finally, structural equation modelling and advanced dynamic-panel techniques may provide deeper insights into the causal channels linking finance, technology, institutions, and environmental performance.

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