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Financial Development and Sustainable Transition: Does Governance Matter?

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Abstract:

Purpose: *This study investigates whether financial development supports the transition toward renewable energy in Asian economies and, more importantly, whether the effectiveness of governance determines how financial development translates into sustainable outcomes.*

Design/Methodology/Approach: *Using a balanced panel of 18 Asian economies over 2004–2024, the study constructs a multidimensional Financial Development Index through principal component analysis (PCA), combining indicators of financial access, banking depth and capital-market development. Renewable energy consumption is used as the principal measure of sustainable transition. The empirical analysis employs two-way fixed effects with Driscoll–Kraay standard errors to account for country heterogeneity and common time shocks. The moderating role of governance is examined through the interaction between financial development and government effectiveness, complemented by marginal-effect and extensive robustness analyses.*

Findings: *The results reveal that the finance–sustainability relationship is strongly conditional on institutional quality. Financial development is negatively associated with renewable energy consumption at the reference level of governance, while its interaction with government effectiveness is positive and highly significant. Marginal effects show that the adverse association progressively weakens as government effectiveness improves and disappears at sufficiently high levels of institutional effectiveness. The central moderation result remains robust to alternative governance dimensions, timing structures, outcome measures, covariance estimators, country exclusions and the exclusion of economies reporting zero renewable-energy shares.*

Practical Implications: *The findings suggest that financial deepening alone is unlikely to guarantee a greener energy transition. Asian economies may obtain greater sustainability benefits from financial development when it is accompanied by credible policy implementation, effective regulation and stronger institutional capacity. Sustainable-finance policies should therefore focus not only on expanding the availability of capital but also on improving the institutional environment that shapes its allocation.*

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Originality/Value: *The study contributes to the finance–environment literature by shifting attention from whether financial development is inherently beneficial for sustainability to the institutional conditions under which it becomes beneficial. By integrating a multidimensional financial-development measure with governance moderation, the analysis identifies institutional–financial complementarity as an important mechanism shaping sustainable transition in Asia.*

Keywords: *Financial development; sustainable transition; renewable energy; government effectiveness; governance; Asian economies; principal component analysis.*

JEL Classification: *G20, O16, Q42, Q56, H11.*

1. Introduction

The transition from fossil-fuel-based energy systems towards cleaner and more sustainable alternatives has become a major policy priority across the world. Climate change, rising energy demand, volatility in fossil-fuel prices and concerns over energy security have increased the urgency of expanding renewable energy. This challenge is particularly important for Asian economies, where rapid industrialisation, urbanisation and population growth continue to place considerable pressure on energy systems. Although many Asian countries possess significant renewable-energy potential, progress towards a cleaner energy mix remains uneven.

The sustainable transition requires more than technological availability. Renewable-energy projects are capital intensive, involve high initial costs and often generate returns over long periods. Their development therefore depends heavily on the availability of affordable finance, the capacity of financial institutions to evaluate long-term projects and the ability of financial markets to mobilise investment. In this context, financial development may play an important role in accelerating renewable-energy adoption.

Financial development can promote sustainable transition through several channels. Well-developed financial institutions mobilise savings, reduce information asymmetry and provide credit to firms and infrastructure projects. Efficient financial markets allow renewable-energy companies to raise equity and long-term debt, while financial instruments such as guarantees and insurance help distribute investment risks. Financial development may also support research, technological innovation and the adoption of energy-efficient production systems.

However, the relationship between financial development and sustainable transition is not necessarily positive in all circumstances. Financial expansion may increase industrial activity, household consumption and demand for transport and electricity. When this additional demand is met through fossil fuels, financial development may

increase environmental pressure rather than support transition. The effect of finance therefore depends not only on the amount of credit or investment available, but also on the sectors and technologies to which financial resources are allocated.

Earlier studies provide mixed evidence on this relationship. Brunnschweiler (2010) found that financial-sector development supported renewable-energy investment in developing and transition economies. Kim and Park (2016) showed that financial development facilitated the deployment of renewable-energy technologies by reducing financing constraints, particularly in countries with stronger capital markets. Similarly, Best (2017) found that finance could support a shift towards renewable energy, although its effect depended on whether capital was directed towards clean energy or fossil-fuel industries.

Evidence from Asian economies also suggests that finance can promote renewable-energy consumption. Ji and Zhang (2019) reported that financial development supported renewable-energy growth and the upgrading of the energy structure in China. Eren et al. (2019) found a positive long-run relationship between financial development and renewable-energy consumption in India.

More recent cross-country studies, however, indicate that the effect is not uniform. Raza *et al.* (2020) identified a nonlinear threshold effect, while Qamruzzaman and Jianguo (2020) reported asymmetric responses of renewable energy to changes in financial development. Sun *et al.* (2023) further showed that financial development had stronger positive effects in developed and emerging economies than in less-developed countries.

These differences suggest that financial development alone may not be sufficient to support sustainable transition. The effectiveness of finance may depend on the quality of the institutional environment in which financial decisions are made. Governance determines how policies are designed and implemented, how contracts are enforced and how public and private resources are allocated. Strong governance can reduce uncertainty, improve investor confidence and create conditions under which financial institutions are more willing to support long-term renewable-energy projects.

Governance is particularly relevant to renewable-energy investment because energy markets are highly regulated. Project developers depend on government approvals, electricity tariffs, grid access, environmental standards and long-term power-purchase arrangements.

Weak regulatory quality, ineffective public institutions and corruption can increase project costs and discourage investment. In contrast, government effectiveness, regulatory stability, rule of law and control of corruption can improve the commercial viability of renewable-energy projects.

This issue is especially relevant for Asia. The region contains advanced economies, large emerging markets and lower-income economies with relatively shallow financial systems. Asian countries also differ considerably in institutional quality, regulatory capacity, energy structure and dependence on fossil fuels. In some countries, financial development has supported renewable-energy investment and technological innovation. In others, credit expansion has remained concentrated in conventional industry and carbon-intensive infrastructure.

Despite the growing literature, several important gaps remain. First, most studies examine the direct effect of financial development on renewable energy without considering whether governance changes that relationship. Second, governance is frequently included only as a control variable rather than as a moderating factor. Third, many studies rely on a single measure of financial development, such as domestic credit to the private sector, which may not fully capture the depth, access and efficiency of financial institutions and markets. Fourth, evidence focusing specifically on a broad sample of Asian economies remains limited.

The present study addresses these gaps by examining the effect of financial development on sustainable transition in Asian economies and by explicitly testing the moderating role of governance. Sustainable transition is represented by renewable-energy consumption, while financial development is measured through a broader indicator of financial-system development.

Governance is included both as an independent explanatory variable and through an interaction term with financial development. The study provides evidence from Asian economies, which differ widely in financial structure, governance quality and energy dependence. Moreover, it offers policy implications by showing whether financial reforms alone are sufficient or whether improvements in governance are also necessary to accelerate the sustainable transition.

The remainder of the paper is organised as follows. Section 2 reviews the relevant literature and develops the research hypotheses. Section 3 presents the data, variables and econometric methodology. Section 4 reports and discusses the empirical results, while the final section concludes and presents policy implications.

2. Literature Review

2.1 Financial Development, Sustainable Transition and Governance

The concept of sustainable transition refers to the gradual transformation of economic, financial, technological and institutional systems away from resource-intensive and carbon-dependent activities towards cleaner, more resilient and socially sustainable alternatives. Within the energy sector, this transition involves replacing fossil fuels with renewable energy, improving energy efficiency, modernising electricity infrastructure and directing financial resources towards low-

carbon technologies. Because the wider concept is difficult to capture through a single empirical indicator, previous studies have commonly represented sustainable transition through renewable energy consumption, renewable electricity generation, the share of renewable energy in total final energy use, carbon intensity or green growth.

The earlier literature primarily investigated the relationship between financial development and total energy consumption. These studies generally argued that an expanding financial system raises energy consumption by facilitating business investment, industrial development and household purchases of energy-using products.

For instance, Sadorsky (2010) found that financial development increased energy consumption in emerging economies. Financial expansion allowed households to acquire vehicles and electrical appliances while enabling firms to expand production capacity. Similarly, Islam *et al.* (2013) reported a long-run relationship among financial development, income, energy consumption and population in Malaysia.

Çoban and Topcu (2013) showed that the effect of finance on energy consumption varied across European countries depending on the structure and maturity of their financial systems. Although these studies did not explicitly focus on renewable energy, they established an important theoretical ambiguity.

Financial development may provide capital for cleaner energy, but it may simultaneously increase overall energy demand. The environmental outcome therefore depends on whether the additional demand is satisfied through renewable or non-renewable sources.

Furuoka (2015) extended this debate to Asian countries and found considerable heterogeneity in the relationship between finance and energy consumption. The study suggested that a single average coefficient may conceal differences associated with income, financial structure and national energy systems. This observation is particularly important for a Europe–Asia comparison because the two regions contain countries at markedly different levels of financial and institutional development.

One of the earliest direct examinations of finance and renewable energy was conducted by Brunnschweiler (2010). Using a sample of developing and emerging economies, the study demonstrated that a well-functioning financial sector supports renewable energy development by increasing the availability of investment capital.

Brunnschweiler's findings challenged the assumption that renewable deployment is determined mainly by resource endowments and energy prices. Instead, the study showed that countries with stronger financial intermediation were better able to exploit their renewable-energy potential.

A more detailed contribution was made by Kim and Park (2016), who investigated the deployment of renewable energy technologies across developed and developing economies. They found that financial development improved renewable-energy deployment by reducing external financing constraints. However, the effect was considerably stronger in countries with developed capital markets. Their results implied that renewable projects cannot rely exclusively on conventional bank lending; developed equity and bond markets are also needed to provide long-term and risk-bearing capital.

Best (2017) questioned whether additional financial capital necessarily supports renewable energy rather than fossil fuels. Analysing the allocation of financial capital between coal and renewable energy, Best found that the environmental effect of finance depended on the destination of investment. Financial development encouraged transition where capital was channelled towards renewable electricity, but it could reinforce dependence on coal where fossil-fuel industries remained economically and politically dominant. The study therefore shifted attention from the quantity of finance to its composition.

Ji and Zhang (2019) examined how financial development affected renewable energy growth and energy-structure upgrading in China. They found that financial development made a meaningful contribution to renewable energy expansion, although different components of the financial system produced different effects. The authors argued that financial institutions promote renewable energy by reducing capital shortages and supporting technological development. Their results are important for the Asian context, where bank-based financial systems continue to dominate many economies.

Evidence from India was provided by Eren *et al.* (2019), who identified a positive long-run relationship between financial development, economic growth and renewable energy consumption. Their findings suggested that economic growth alone does not guarantee renewable-energy adoption; financial development is needed to mobilise the capital required for cleaner infrastructure. However, because the study focused on one country, its conclusions cannot automatically be extended to institutionally diverse Asian economies.

Anton and Nucu (2020) examined 28 European Union countries over 1990–2015. They found that financial development significantly increased renewable energy consumption. Their study was particularly influential because it treated financial development as a multidimensional phenomenon rather than relying exclusively on domestic credit.

The results indicated that both financial institutions and financial markets could contribute to renewable-energy adoption, although their respective effects differed. The authors concluded that efficient financial intermediation lowers the cost of renewable investment and improves the capacity of firms and governments to fund

clean-energy projects. Vatamanu and Zugravu (2023) subsequently extended the European evidence by incorporating institutional quality into the finance–renewable energy relationship. Their analysis showed that financial development had a significantly positive effect on renewable energy consumption and that institutional quality was also important in facilitating the transition. The study demonstrated that finance operates more effectively when supported by credible government institutions, regulatory consistency and stronger public accountability.

Khan *et al.* (2020) used panel quantile regression to examine renewable energy, carbon emissions and financial development across a global sample. They found that the effect of financial development differed across the conditional distribution of renewable energy consumption. Finance did not produce an identical impact in countries with low and high levels of renewable-energy use. This finding supports the argument that the finance–transition relationship is heterogeneous and potentially nonlinear.

Le *et al.* (2020) examined renewable-energy financing across 55 countries. Their findings showed that financial development increased renewable-energy investment, but that the effect differed across financial institutions, financial markets and levels of economic development. The study reinforced the proposition that capital-market depth can be particularly important for large and long-term renewable projects.

Lahiani *et al.* (2021) also reported that the relationship between financial development and renewable energy was nonlinear and sensitive to the stage of development. Their findings suggested that financial expansion may initially raise conventional energy consumption before generating sufficient capital and technological capability to facilitate a cleaner transition.

Using a dynamic framework, Sun *et al.* (2023) examined the effect of multidimensional financial development on renewable energy consumption across 103 countries. They found that overall financial development promoted renewable energy consumption globally, but the positive effect was concentrated largely in developed and emerging-market economies. In the broader group of developing countries, the relationship was weaker and, in some cases, statistically insignificant.

The authors attributed this divergence to differences in capital-market maturity, regulatory capacity and renewable-energy infrastructure. Prempeh (2023) found that financial development contributed to renewable energy consumption, but the effect was influenced by economic structure and the broader investment environment. The study further reinforced the view that the environmental implications of finance should be assessed alongside industrialisation, globalisation and income growth.

Elzaki (2023) studied financial-development shocks and renewable energy consumption in Saudi Arabia. The analysis indicated that changes in financial indicators could influence renewable energy, but the response varied between the

short and long run. The findings suggested that expanding finance alone may be insufficient in economies where energy systems remain dominated by hydrocarbons. Recent evidence also highlights the importance of institutional and market conditions in determining whether sustainability-related information translates into meaningful financial outcomes.

Raza *et al.* (2026) examined ESG information across twelve Asia-Pacific markets and found substantial differences in ESG coverage across levels of market development. Their findings suggest that the financial relevance of sustainability information is shaped by differences in institutional development, regulatory frameworks, and disclosure practices, underscoring the importance of governance in supporting sustainability-oriented financial outcomes.

Overall, the global literature supports a qualified conclusion. Financial development can facilitate sustainable transition, but its effect varies with financial structure, economic development, environmental policy, technological capability and governance quality. However, the positive financing channel is only one side of the relationship. Several studies have shown that financial development can increase environmental pressure when credit expansion stimulates fossil-fuel consumption, industrial production and private consumption.

This reasoning also explains why the direction of the relationship can differ. In countries with stringent environmental regulation and established renewable-energy incentives, the technique and composition effects may dominate. In rapidly industrialising economies where fossil fuels remain relatively inexpensive and environmental regulation is weak, the scale effect may be stronger. Governance broadly describes the manner in which public authority is exercised and policies are formulated, implemented and enforced.

Marques *et al.* (2010) found that renewable-energy adoption in European countries was driven not only by economic and energy variables but also by political and policy conditions. They showed that the availability of renewable resources does not by itself ensure deployment; public policy is required to transform technical potential into actual energy production.

Marques and Fuinhas (2012) evaluated the effectiveness of public policies supporting renewable energy in Europe. They found that policy instruments produced differing results depending on national economic and institutional conditions. Their analysis suggested that policy adoption and policy effectiveness are separate issues: governments may announce renewable targets, but weak implementation can prevent those targets from being achieved.

Cadoret and Padovano (2016) investigated the political drivers of renewable-energy policies. They concluded that political institutions, electoral incentives and government characteristics materially influenced the adoption and strength of

renewable-energy support. This contribution demonstrated that energy transition is a political-economy process rather than an exclusively economic response to technology costs. Uzar (2020) provided direct evidence on the relationship between institutional quality and renewable energy consumption across 38 countries. The study found that stronger institutional quality increased renewable energy consumption in the long run.

Haldar and Sethi (2021) examined institutional quality, renewable energy and carbon emissions in 39 developing countries. They found that institutional quality strengthened the environmental benefits associated with renewable energy. Rahman and Sultana (2022) analysed emerging economies and found that institutional quality, economic growth and exports significantly influenced renewable-energy consumption. According to the authors, institutions reduce investment uncertainty and improve the ability of governments to implement renewable-energy policies.

More recent evidence continues to emphasise institutional heterogeneity. Kolawole (2024) investigated finance, government revenue, institutional quality and sustainable energy supply in West African economies.

Financial development was found to be a significant determinant of sustainable energy supply, whereas institutional quality had an insignificant direct effect.

Chen *et al.* (2024) examined institutional quality as a threshold condition in the relationship between green innovation and energy efficiency across 72 countries. They found that green innovation improved energy efficiency more effectively after institutional quality exceeded a minimum level.

These studies collectively indicate that governance affects sustainable transition both directly and indirectly. However, the estimated effects differ across governance dimensions and country groups. Government effectiveness and regulatory quality may have relatively immediate effects on renewable investment, whereas voice and accountability or political stability may operate through longer political and social processes.

The separate examination of financial development and governance does not fully capture their interdependence. Financial systems operate within legal, political and regulatory institutions. Governance may therefore determine whether financial development produces sustainable or environmentally harmful outcomes.

Kassi *et al.* (2020) were among the earlier researchers to examine whether governance quality moderates the finance–renewable energy nexus across different world regions. Their findings showed that governance altered the effectiveness of financial development in supporting renewable energy. This was an important departure from models treating institutions only as an additive control variable.

Haldar and Sethi (2021) also provided indirect support for moderation. Their interaction analysis showed that institutional quality influenced the environmental effect of energy consumption in developing economies. The study implied that identical levels of renewable-energy use may generate different environmental outcomes depending on institutional effectiveness.

Ahmed *et al.* (2022) investigated financial development, institutional quality and sustainable economic growth in South Asian countries. They concluded that both finance and institutions were important for sustainable development. Although their dependent variable was broader than renewable-energy transition, the study suggested that financial development becomes more supportive of sustainability when accompanied by effective institutions.

Vatamanu and Zugravu (2023) provided more direct evidence from the European Union. They found that financial development and institutional quality both increased renewable-energy consumption. Their findings support complementarity between financial capacity and governance. Developed financial institutions were more effective in countries where regulation, government performance and accountability provided a credible environment for renewable-energy investment.

The interaction literature remains much smaller than the separate bodies of research on finance and institutions. Most studies examine either the direct effect of financial development or the direct effect of governance. Even studies incorporating both frequently enter them as separate explanatory variables without calculating the conditional marginal effect of financial development at different levels of governance. This is an important limitation. A positive coefficient for financial development and a positive coefficient for governance do not demonstrate that governance strengthens the financial effect. Establishing moderation requires an explicit interaction term between financial development and governance, followed by the calculation and graphical presentation of marginal effects.

2.2 Research Gap and Contribution of the Present Study

Several gaps emerge from the reviewed literature. First, most studies examine financial development and governance independently. Financial development is commonly treated as the principal explanatory variable, while governance is included only as a control. This approach does not test whether governance changes the effectiveness of financial development.

Second, many earlier studies measure financial development through domestic credit alone. This measure does not capture financial-market development or the access and efficiency dimensions of the financial system. A multidimensional financial-development index provides a broader representation of the financial capacity available for sustainable transition. Similarly, much of the environmental-finance literature uses carbon emissions as the dependent variable.

Emissions are important but provide an indirect measure of transition. Renewable energy consumption more directly represents the transformation of the energy system. Third, governance is frequently represented by one institutional indicator.

Since government effectiveness, regulatory quality, rule of law and corruption control influence investment through related mechanisms, a composite governance measure may provide a more comprehensive assessment. Individual dimensions can subsequently be used for robustness analysis.

The present research addresses these gaps by examining the relationship between financial development and sustainable transition in Asian economies and by explicitly modelling governance as a moderator. It therefore allows the study to determine not only whether financial development promotes sustainable transition, but also under what governance conditions it does so.

3.Development of Hypotheses

Financial development mobilises savings, reduces information asymmetry, improves risk allocation and lowers financing constraints. These functions should increase the ability of firms and governments to invest in renewable-energy technologies.

H1: Financial development has a positive effect on sustainable transition.

Strong governance improves policy implementation, regulatory credibility, contract enforcement and control of corruption. These conditions reduce the risks associated with renewable-energy investment.

H2: Governance quality has a positive effect on sustainable transition.

Financial resources are more likely to be channelled towards sustainable investment where environmental policies are credible and institutions are effective. Governance should therefore strengthen the contribution of financial development.

H3: Governance positively moderates the relationship between financial development and sustainable transition, such that the effect of financial development becomes stronger at higher levels of governance quality.

4. Data, Variables and Econometric Methodology

4.1 Data and Sample

This study investigates the relationship between financial development and sustainable transition and examines whether governance conditions this relationship across 18 Asian economies over the period 2004–2024. The sample includes economies at different stages of financial, institutional, and economic development,

thereby providing substantial variation for examining whether the sustainability implications of financial development differ according to institutional conditions. The analysis deliberately retains heterogeneity across the selected Asian economies, including advanced and emerging financial systems, energy-importing and energy-exporting economies, and countries characterized by substantially different institutional and regulatory environments.

This heterogeneity is particularly relevant to the central proposition of the study that the sustainability consequences of financial development may depend upon the institutional environment within which financial resources are mobilized and allocated. The dependent variables contain sufficient observations for the principal empirical analysis. No interpolation or mean substitution is applied to the sustainable-transition measures, thereby avoiding the artificial smoothing of renewable-energy series.

4.2 Measurement of Sustainable Transition

The principal dependent variable is renewable energy consumption (REC), measured as a percentage of total final energy consumption. This indicator captures the extent to which an economy's final energy requirements are supplied through renewable rather than conventional energy sources. Unlike measures based exclusively on investment commitments or installed capacity, REC reflects the actual penetration of renewable sources into the energy mix and therefore provides an outcome-oriented measure of sustainable transition.

As an alternative measure, the study employs renewable electricity output (REO), measured as a percentage of total electricity output. REC captures renewable penetration across final energy consumption more broadly, whereas REO focuses specifically on electricity generation. Re-estimation using REO therefore provides an important robustness assessment of the dependent-variable choice.

4.3 Construction of the Financial Development Index

Financial development represents the principal explanatory variable. Since financial development is inherently multidimensional, relying on a single indicator may provide an incomplete representation of the depth and functioning of a country's financial system. Accordingly, this study constructs a composite Financial Development Index (FD) using Principal Component Analysis (PCA).

The index combines five financial indicators for which sufficiently consistent observations are available across the sample including ATMs per 100,000 adults, domestic credit to the private sector by banks (% of GDP), broad money (% of GDP), market capitalization of listed domestic companies (% of GDP), and stocks traded, total value (% of GDP).

4.3.1 Standardization of the Financial Indicators

Because the constituent indicators are measured on different scales, each variable is standardized before applying PCA. The standardized value of each financial indicator is calculated as:

$$Z_{k,t} = (X_{k,t} - \bar{X}_k) \div S_k$$

where:
$Z_{k,t}$ = standardized value of financial indicator k for country i in year t;
$X_{k,t}$ = original value of financial indicator k for country i in year t;
$\bar{X}_k$ = sample mean of financial indicator k; and
S_k = standard deviation of financial indicator k.

Thus, each financial indicator is converted to a common scale with a mean of approximately zero and a standard deviation of one. This prevents variables measured on larger numerical scales from disproportionately influencing the PCA results.

4.3.2 Principal Component Extraction

PCA transforms the standardized financial indicators into a smaller number of mutually uncorrelated components. The first principal component is retained as the Financial Development Index because it captures the largest possible proportion of common variation among the five financial indicators. Accordingly:

$$FD_{it} = PC1_{it}$$

The preferred five-indicator specification produced a Kaiser–Meyer–Olkin statistic of 0.769, supporting the suitability of the variables for dimension reduction. The first principal component explains approximately 60.21% of the total common variation among the selected financial indicators. All five indicators exhibit positive loadings on the first component: broad money (0.898), domestic credit to the private sector (0.860), ATMs (0.748), stocks traded (0.739), and market capitalization (0.606). Consequently, higher values of FD represent greater financial development.

The PCA-based index provides two methodological advantages. First, the weights are determined by the underlying covariance structure of the data rather than being imposed arbitrarily. Second, combining correlated financial indicators into a single index mitigates the multicollinearity that could arise if the five indicators were entered simultaneously into the regression models.

4.4 Governance and the Moderating Mechanism

The central proposition of this study is that the effect of financial development on sustainable transition is conditional upon institutional quality. Governance is therefore incorporated both directly and as a moderator of the financial

development–sustainable transition relationship. The analysis considers six dimensions: Government Effectiveness, Control of Corruption, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, and Voice and Accountability.

Government Effectiveness (GE) serves as the principal governance moderator. It is particularly relevant because the existence of financial resources alone does not determine their allocation. Effective governments may facilitate sustainable capital allocation through credible environmental policies, efficient public administration, appropriate regulation, institutional coordination, and effective implementation of renewable-energy strategies. Financial development and government effectiveness are standardized before constructing the interaction term. The principal interaction variable is therefore:

$$Interaction_{it} = FD_{it} \times GE_{it}$$

A positive coefficient on this interaction would indicate that stronger government effectiveness makes the relationship between financial development and sustainable transition more favourable. The other five governance dimensions are subsequently employed as alternative moderators to examine whether the institutional conditioning effect extends beyond government effectiveness.

The empirical models incorporate a parsimonious set of macroeconomic controls selected on theoretical grounds and subject to data availability. GDP per capita (GDPPC) captures the level of economic development and is entered in natural logarithmic form.

Trade openness (TRADE) captures international economic integration. Urbanization (URBAN) controls for structural changes in population concentration, infrastructure, and energy demand. Inflation (INF) captures macroeconomic instability that may affect financing costs and long-term renewable-energy investment.

Foreign direct investment (FDI) captures international capital flows that may facilitate investment, technological transfer, and access to cleaner production technologies. Finally, industry value added (IND) controls for differences in economic structure and the potentially higher energy requirements associated with industrial activity.

4.5 Econometric Model Specification

The empirical analysis proceeds sequentially. The models first examine the relationship between financial development and sustainable transition before introducing governance and the central moderating mechanism.

4.5.1 Baseline Financial Development Model

The baseline specification examines whether financial development is associated with renewable energy consumption after controlling for relevant macroeconomic characteristics:

$$REC_{it} = \alpha + \beta_1 FD_{it} + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Here, β_1 captures the relationship between financial development and renewable energy consumption after controlling for the selected macroeconomic factors.

4.5.2 Financial Development and Governance Model

Government effectiveness is subsequently introduced to distinguish its direct relationship with sustainable transition from that of financial development:

$$REC_{it} = \alpha + \beta_1 FD_{it} + \beta_2 GE_{it} + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

The coefficient β_2 captures the conditional association between government effectiveness and renewable energy consumption.

4.5.3 Governance Moderation Model

The principal empirical specification introduces an interaction between financial development and government effectiveness:

$$REC_{it} = \alpha + \beta_1 FD_{it} + \beta_2 GE_{it} + \beta_3 (FD_{it} \times GE_{it}) + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Equation (3) constitutes the central empirical model of the study. The coefficient β_3 is the principal parameter of interest and captures whether government effectiveness moderates the relationship between financial development and sustainable transition. A positive and statistically significant β_3 indicates that stronger government effectiveness makes the financial development–sustainable transition relationship more favourable. Importantly, once an interaction is included, β_1 cannot be interpreted as the unconditional effect of financial development. Instead, the marginal effect of financial development depends upon government effectiveness:

$$\text{Marginal effect of FD} = \beta_1 + \beta_3 GE_{it} \quad (4)$$

Equation (4) is used to evaluate the effect of financial development at different levels of government effectiveness and to identify the governance level at which the estimated relationship changes direction.

4.5.4 Alternative Governance Dimensions

To determine whether the moderating relationship represents a broader institutional mechanism, the principal model is re-estimated using alternative WGI dimensions:

$$REC_{it} = \alpha + \beta_1 FD_{it} + \beta_2 GOV_{it} + \beta_3 (FD_{it} \times GOV_{it}) + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (5)$$

Here, GOV is replaced sequentially by Control of Corruption, Political Stability, Regulatory Quality, Rule of Law, and Voice and Accountability. Government Effectiveness remains the principal moderator, while these alternative measures provide robustness evidence concerning the broader role of institutional quality.

4.6 Estimation Strategy and Model Selection

Country-specific characteristics such as geography, resource endowments, historically persistent institutions, and structural features of national energy systems may simultaneously influence financial development and renewable-energy use. The empirical models therefore incorporate country fixed effects (μ_i). Similarly, year fixed effects (λ_t) are included to absorb common annual shocks such as global energy-price movements, technological developments, international climate initiatives, and global financial disturbances.

Formal specification testing supports this choice. The joint significance test for country effects strongly rejects pooled OLS, while year effects are also jointly significant. Furthermore, the correlated-random-effects/Mundlak test rejects the assumption that the explanatory variables are uncorrelated with country-specific effects. Thus the preferred estimator can therefore be described as a two-way fixed-effects model with country and year fixed effects and Driscoll–Kraay standard errors.

4.7 Robustness and Sensitivity Analysis

Several additional specifications are estimated to examine the robustness of the principal findings.

4.7.1 One-Year Lagged Specification

Because changes in financial development and institutional quality may require time to influence capital allocation and the energy structure, financial development and government effectiveness are lagged by one year. This specification provides a temporal-ordering robustness test.

$$REC_{it} = \alpha + \beta_1 FD_{i,t-1} + \beta_2 GE_{i,t-1} + \beta_3 (FD_{i,t-1} \times GE_{i,t-1}) + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

4.7.2 Alternative Measure of Sustainable Transition

The principal model is re-estimated using renewable electricity output as the dependent variable:

$$REO_{it} = \alpha + \beta_1 FD_{it} + \beta_2 GE_{it} + \beta_3 (FD_{it} \times GE_{it}) + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (7)$$

This specification establishes whether the results remain robust when sustainable transition is measured specifically through renewable electricity generation.

4.7.3 Log-Transformed Dependent Variable

To reduce sensitivity to the distribution and scale of renewable energy consumption, the principal dependent variable is alternatively transformed as:

$$\ln(1 + REC_{it}) = \alpha + \beta_1 FD_{it} + \beta_2 GE_{it} + \beta_3 (FD_{it} \times GE_{it}) + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (8)$$

The ln(1 + REC) transformation reduces the influence of unusually large observations while permitting observations with zero values to remain in the sample.

4.7.4 Nonlinear Financial Development Specification

The relationship between financial development and sustainable transition may not necessarily be linear. At relatively low stages of financial development, additional financing may primarily facilitate conventional industrial expansion and energy-intensive economic activity. More sophisticated financial systems, however, may eventually develop the depth, instruments, expertise, and risk-allocation capacity required to finance renewable-energy projects and green technologies.

This possibility is examined by introducing the squared Financial Development Index:

$$REC_{it} = \alpha + \beta_1 FD_{it} + \beta_2 FD^2_{it} + \beta_3 GE_{it} + \beta_4 (FD_{it} \times GE_{it}) + \gamma_1 \ln(GDPPC_{it}) + \gamma_2 TRADE_{it} + \gamma_3 URBAN_{it} + \gamma_4 INF_{it} + \gamma_5 FDI_{it} + \gamma_6 IND_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (9)$$

A negative coefficient on the linear FD term combined with a positive and statistically significant coefficient on FD^2 is consistent with a U-shaped relationship. Where such nonlinearity is identified, the turning point is calculated as:

$$FD = -\beta_1 \div (2\beta_2)^* \quad (10)$$

The turning point represents the estimated level of financial development at which the direction of its relationship with renewable energy consumption changes, conditional on the model specification.

4.7.5 Additional Sensitivity Tests

The robustness analysis is supplemented by a leave-one-country-out procedure, under which the preferred model is sequentially re-estimated after excluding each economy. This determines whether the principal findings are disproportionately influenced by any individual country.

Statistical inference is additionally compared across conventional, country-clustered, two-way country-and-year clustered, and Driscoll–Kraay standard errors. This provides further evidence on whether the statistical significance of the central interaction effect is sensitive to alternative assumptions regarding the covariance structure.

5. Empirical Results and Discussion

5.1 Descriptive Statistics

Table 1 presents the descriptive statistics for the variables used in the empirical analysis. Renewable energy consumption (REC), the principal measure of sustainable transition, has a sample mean of 18.39% of total final energy consumption, with values ranging from zero to 63.50%.

Renewable electricity output (REO), employed subsequently as an alternative dependent variable, averages 15.57% and ranges from zero to 59.78%. These relatively large standard deviations indicate substantial heterogeneity in the extent of renewable-energy penetration across the sampled Asian economies.

Table 1. *Descriptive Statistics*

Variable	Mean	Std. Dev.	Minimum	Maximum
Renewable energy consumption (%)	18.390	17.715	0.000	63.500
Renewable electricity output (%)	15.575	14.338	0.000	59.780
Financial Development Index	0.000	1.737	−2.308	5.041
Government Effectiveness	0.303	0.730	−0.944	2.293
Log GDP per capita	8.866	1.352	6.122	11.594
Trade openness (% GDP)	99.074	79.040	23.432	437.327
Urban population (%)	63.162	26.725	14.913	100.000
Inflation (%)	5.020	7.097	−4.863	72.309
FDI net inflows (% GDP)	3.572	5.416	−2.760	32.262
Industry value added (% GDP)	36.771	12.324	18.099	74.497

Note: *The Financial Development Index is constructed using PCA. REC = renewable energy consumption; FDI = foreign direct investment.*
Source: *Own study.*

The dispersion in financial development is also substantial, with the PCA-based index ranging from −2.31 to 5.04. Government effectiveness varies from −0.944 to 2.293, providing considerable institutional variation with which to examine the study's central moderation hypothesis. Particularly wide variation is also observed in trade openness, urbanization, inflation and FDI. Such dispersion is expected given

the structural diversity of the sample and reinforces the importance of controlling for country-specific heterogeneity.

5.2 Financial Development, Governance and Sustainable Transition

Table 2 reports the principal estimates. The dependent variable is renewable energy consumption as a percentage of total final energy consumption. Both country and year fixed effects are included, and inference is based on Driscoll–Kraay standard errors.

Table 2. *Financial Development, Governance and Renewable Energy Consumption*

Variable	Coefficient	DK Std. Error	t-statistic	p-value
Financial Development	−2.845***	0.809	−3.518	0.003
Government Effectiveness	−1.003	0.803	−1.250	0.228
FD × Government Effectiveness	**2.967***	0.481	6.171	<0.001
Log GDP per capita	7.686***	0.782	9.824	<0.001
Trade openness	−0.044***	0.013	−3.318	0.004
Urbanization	0.384***	0.063	6.086	<0.001
Inflation	−0.083***	0.020	−4.177	0.001
FDI	−0.088	0.082	−1.065	0.302
Industry value added	−0.208**	0.073	−2.861	0.011
Observations	378			
Countries	18			
Country fixed effects	Yes			
Year fixed effects	Yes			
Overall R^2	0.779			
Adjusted R^2	0.776			
Within R^2	0.450			

***Notes:** Dependent variable = renewable energy consumption (% of total final energy consumption). Driscoll–Kraay standard errors with two lags. **p < 0.05; **p < 0.01.*
***Source:** Own study.*

The central result is the positive and highly significant interaction between financial development and government effectiveness ($\beta = 2.967$, $p < 0.001$). In contrast, the coefficient on financial development is negative and significant ($\beta = -2.845$, $p = 0.003$), while the standalone coefficient on government effectiveness is statistically insignificant.

These coefficients require careful interpretation because the presence of an interaction changes the meaning of the constituent terms. The negative coefficient on financial development does not imply that financial development universally inhibits sustainable transition. Since government effectiveness is standardized, −2.845

represents the estimated association between financial development and REC when government effectiveness is at approximately its sample mean. The positive interaction indicates that this relationship becomes progressively less negative—and eventually positive—as government effectiveness improves.

This finding provides direct empirical support for the study's central theoretical proposition: the sustainability consequences of financial development are institutionally conditional. Financial systems mobilize savings, allocate credit, facilitate risk sharing and broaden access to capital, but these functions are environmentally neutral in themselves.

Financial deepening can finance renewable energy and clean technologies, but it can equally facilitate conventional infrastructure, industrial expansion and fossil-fuel-intensive activity. What matters, therefore, is not merely the amount of finance available but the institutional environment that influences its allocation. Government effectiveness appears to operate as an enabling condition.

Where public institutions possess greater implementation capacity and policy credibility, financial development is more likely to operate within a framework that rewards sustainable investment, lowers policy uncertainty surrounding renewable projects and improves the effectiveness of environmental and energy policies. Conversely, where implementation capacity is weak, expansion of financial intermediation may predominantly reinforce the existing structure of economic activity.

This interpretation also helps explain why the standalone coefficient on government effectiveness is insignificant. Governance may matter less as an isolated determinant of renewable-energy penetration than as an institutional mechanism affecting how financial resources are translated into economic outcomes. In other words, the principal contribution of governance in this model is conditional rather than additive.

Several control variables are statistically significant. Log GDP per capita has a large positive coefficient ($\beta = 7.686$, $p < 0.001$). Trade openness exhibits a negative association with REC ($\beta = -0.044$, $p = 0.004$). For the sampled Asian economies, greater trade integration may coincide with export-oriented manufacturing, transportation activity and energy-intensive production structures.

The result suggests that the environmental benefits associated with technology transfer through trade may not automatically outweigh the energy-demand effects of greater economic integration. Urbanization, by contrast, is positively and strongly associated with renewable-energy consumption ($\beta = 0.384$, $p < 0.001$). Urban concentration may improve the economic viability of modern energy infrastructure, facilitate grid development and increase the scalability of renewable-energy systems. Inflation has a negative and statistically significant coefficient ($\beta = -0.083$, $p = 0.001$).

Renewable-energy infrastructure typically involves high initial capital requirements and long investment horizons. Macroeconomic instability can increase financing costs, create uncertainty over future cash flows and weaken incentives for long-duration capital investment.

The negative coefficient is therefore economically plausible. Industry value added is similarly negative and significant ($\beta = -0.208$, $p = 0.011$), consistent with the possibility that industrial expansion in many sampled Asian economies remains relatively dependent on conventional energy sources. FDI, however, is statistically insignificant, indicating that foreign capital inflows do not systematically increase renewable-energy penetration unless their sectoral destination and technological content are taken into account.

5.3 Marginal Effects of Financial Development

Because the interaction coefficient is central to the analysis, interpreting β_1 and β_3 separately is insufficient. Table 3 therefore reports the marginal effect of financial development at different levels of government effectiveness.

Table 3. *Marginal Effect of Financial Development at Alternative Governance Levels*

Government Effectiveness	Marginal Effect of FD	Std. Error	p-value
Low governance (−1 SD)	−5.813***	1.033	<0.001
Mean governance (0 SD)	−2.845***	0.809	<0.001
High governance (+1 SD)	0.122	0.839	0.885

Source: *Own study.*

At one standard deviation below mean government effectiveness, the marginal effect of financial development is strongly negative (−5.813, $p < 0.001$). At the mean level of governance, the effect remains negative (−2.845, $p < 0.001$). At one standard deviation above the mean, however, the estimated marginal effect rises to 0.122 and becomes statistically indistinguishable from zero. The estimated point at which the marginal effect crosses zero occurs at approximately 0.96 standard deviations above mean government effectiveness.

This threshold result sharpens the interpretation considerably. Governance does not simply amplify an already positive finance–sustainability relationship. Rather, it appears to transform the character of that relationship.

Under weak institutional conditions, greater financial development is associated with lower renewable-energy shares; as government effectiveness improves, this adverse association progressively contracts. Only at comparatively high levels of government effectiveness does the estimated marginal relationship turn positive.

5.4 Robustness Across Governance Dimensions

The main specification is next re-estimated using alternative dimensions of governance.

Table 4. *Alternative Governance Dimensions as Moderators*

Governance Dimension	FD Coef.	Governance Coef.	FD × Governance	Interaction p-value	Adj. R^2
Control of Corruption	−2.491**	0.782	**2.415***	0.003	0.774
Government Effectiveness	−2.845***	−1.003	**2.967***	<0.001	0.776
Political Stability	−1.901**	0.051	**1.537**	0.019	0.772
Rule of Law	−1.577**	−0.708	0.757	0.305	0.771
Regulatory Quality	−1.644**	−0.297	**1.823**	0.046	0.772
Voice and Accountability	−2.556***	−1.266*	**−2.269***	<0.001	0.773

Notes: *Each row represents a separate two-way fixed-effects model with Driscoll–Kraay standard errors. The same macroeconomic controls are included in all specifications.*
Source: *Own study.*

The positive moderation result extends to Control of Corruption, Political Stability and Regulatory Quality. Government Effectiveness nevertheless generates the largest positive interaction coefficient among these specifications. Rule of Law produces a positive but statistically insignificant interaction. Most notably, Voice and Accountability produces a negative and highly significant interaction coefficient.

This heterogeneity is theoretically informative. It indicates that "good governance" should not be treated as a single undifferentiated institutional construct. Government effectiveness, regulatory quality and control of corruption are closely connected with administrative implementation, regulatory credibility and the allocation environment facing investors. These dimensions may therefore directly affect whether financial resources are channelled toward renewable projects.

The negative interaction for Voice and Accountability deserves a more cautious interpretation. Political participation and accountability are valuable institutional characteristics, but their implications for the finance–energy nexus need not operate through the same mechanism as administrative effectiveness. Greater political contestation can reflect diverse societal preferences, distributional conflicts surrounding energy reforms, policy turnover, or resistance from groups bearing transition costs.

The result does not imply that voice and accountability are undesirable; rather, it suggests that their role in conditioning the relationship between finance and

renewable-energy penetration differs from that of implementation-oriented governance dimensions.

This distinction strengthens the decision to use Government Effectiveness as the primary moderator, rather than mechanically aggregating the six WGI dimensions into a single governance index.

5.5 Alternative Outcome, Timing and Functional-Form Tests

Table 5 summarizes the principal robustness exercises.

Table 5. *Robustness and Sensitivity Analysis*

Specification	FD Coefficient	Governance Coefficient	Interaction Coefficient	Interaction p-value	Adj. R^2
Baseline REC model	−2.845***	−1.003	**2.967***	<0.001	0.776
One-year lag model	−2.766***	−1.073	**3.403***	<0.001	0.778
ln(1 + REC)	−0.275***	−0.107**	**0.175***	<0.001	0.787
Renewable electricity output	−0.474	−2.545***	**2.544***	<0.001	0.715

Source: *Own study.*

The one-year lagged specification yields an interaction coefficient of 3.403 ($p < 0.001$), while lagged financial development remains negative and significant. Thus, the central moderation result survives the introduction of temporal separation between the explanatory variables and sustainable-transition outcome. The result is also preserved when the dependent variable is transformed as ln(1 + REC). The interaction remains positive and highly significant ($\beta = 0.175$, $p < 0.001$), suggesting that the baseline result is not an artefact of the scale or skewness of renewable-energy consumption.

Perhaps more importantly, replacing REC with renewable electricity output produces a positive interaction of 2.544 ($p < 0.001$). The direct financial-development coefficient becomes statistically insignificant, whereas government effectiveness becomes negative and significant. Nevertheless, the variable central to the theoretical hypothesis—the interaction between financial development and government effectiveness—remains strongly positive. Collectively, these tests indicate that the governance-conditioning result is not dependent on one particular measurement scale, contemporaneous timing, or definition of sustainable transition.

5.6 Nonlinear Financial Development

The possibility that the relationship between financial development and sustainable transition changes across stages of financial-system development is examined by introducing a squared financial-development term.

Table 6. *Nonlinear Financial Development Specification*

Variable	Coefficient	DK Std. Error	t-statistic	p-value
Financial Development	−5.040***	0.804	−6.271	<0.001
Financial Development²	**2.018***	0.369	5.464	<0.001
Government Effectiveness	−0.940	0.721	−1.303	0.210
FD × Government Effectiveness	0.747	0.583	1.280	0.218

Source: *Own study.*

The linear financial-development term is negative, while its squared term is positive and highly significant. This combination is consistent with a U-shaped relationship. The estimated turning point is approximately 1.25 standard deviations above the mean level of financial development.

An economically plausible interpretation is that early financial deepening primarily expands the financing capacity of the existing production structure. Where that structure remains carbon- and energy-intensive, financial development may initially reinforce conventional energy demand. At more advanced stages, however, financial systems may acquire deeper capital markets, specialized financial instruments, superior risk-management capacity and greater ability to fund long-duration innovative projects. These characteristics can lower the financing barriers confronting renewable-energy technologies.

An important qualification arises, however. Once FD^2 is introduced, the FD × Government Effectiveness interaction becomes statistically insignificant ($\beta = 0.747$, $p = 0.218$). The nonlinear and governance-moderation results should therefore not be presented as simultaneously established mechanisms.

Rather, the quadratic specification reveals a credible alternative explanation: the relationship may depend both on institutional conditions and on the stage of financial development. For this reason, the governance moderation model remains the principal specification because it directly tests the study's theoretical hypothesis, while the nonlinear model is more appropriately interpreted as a sensitivity analysis and an avenue for further research.

5.7 Influence and Inference Robustness

Given the relatively small number of countries and the substantial structural differences among them, it is important to establish that the central finding is not driven by one influential economy. The leave-one-country-out analysis confirms this. After each of the 18 countries is excluded sequentially, the FD × Government Effectiveness coefficient remains positive and statistically significant in every specification.

For example, excluding China reduces the interaction coefficient to 1.891, while excluding Japan increases it to 3.582; in both cases it remains significant. This stability substantially reduces concern that the baseline result is generated by a particular large economy, financial center, or hydrocarbon exporter. The moderation result is similarly robust to alternative covariance estimators.

Table 7. *Sensitivity to Alternative Standard-Error Estimators*

Variable	Conventional p	Country-clustered p	Two-way clustered p	Driscoll–Kraay p
Financial Development	<0.001	0.088	0.076	0.003
Government Effectiveness	0.196	0.682	0.668	0.228
FD × Government Effectiveness	**<0.001**	**0.009**	**0.004**	**<0.001**

Source: *Own study.*

The statistical significance of the direct financial-development coefficient is somewhat sensitive to the covariance estimator, falling to the 10% level under country and two-way clustering. In contrast, the interaction remains significant under every covariance structure examined. This distinction is important. The strongest and most stable empirical result of the study is therefore not the negative standalone coefficient on financial development, but the finding that its relationship with sustainable transition varies systematically with government effectiveness.

5.8 Overall Discussion

Taken together, the empirical evidence reveals a more nuanced finance–sustainability relationship than a simple proposition that "financial development promotes renewable energy." Financial development appears capable of supporting sustainable transition, but its environmental consequences depend substantially on the institutional context within which financial resources are allocated.

These findings have an important theoretical implication. Financial development should not be conceptualized as an inherently green force. It is better understood as an enabling infrastructure whose sustainability consequences are shaped by the institutional and structural environment in which it operates.

Finance determines the capacity to mobilize and allocate capital; governance influences the rules, incentives, credibility and implementation environment surrounding that allocation. Sustainable transition emerges when these capacities become sufficiently aligned.

For Asian economies, this distinction is particularly consequential. Many economies in the region face simultaneously rising energy demand, continuing industrialization, expanding financial systems and increasingly ambitious climate commitments. Policies focused exclusively on financial deepening may therefore generate limited

environmental gains unless accompanied by improvements in public-sector effectiveness, regulatory implementation and credible sustainable-finance frameworks.

The results consequently shift the policy question from "Does financial development promote sustainable transition?" toward a more useful question: "Under what institutional conditions does financial development become supportive of sustainable transition?"

6. Conclusion and Policy Implications

6.1 Conclusion

The transition toward more sustainable energy systems requires substantial and sustained financial resources, yet greater financial development does not necessarily ensure that these resources are directed toward environmentally desirable activities. Against this background, this study examined the relationship between financial development and sustainable transition across 18 Asian economies, with particular attention to whether government effectiveness conditions this relationship.

By combining a multidimensional PCA-based measure of financial development with institutional quality and renewable-energy indicators, the study moves beyond the conventional assumption that financial deepening is inherently supportive of environmental progress. The empirical findings reveal a distinctly conditional relationship between finance and sustainable transition.

Financial development, when considered independently at the reference level of governance, is negatively associated with renewable energy consumption. More importantly, however, its interaction with government effectiveness is positive and highly significant.

The marginal-effect analysis further demonstrates that the negative association between financial development and renewable energy consumption progressively weakens as government effectiveness improves and eventually disappears at sufficiently high levels of institutional effectiveness.

This finding represents the central contribution of the study. Financial development appears to provide the capacity to mobilize and allocate capital, but governance influences whether that capacity becomes supportive of sustainable transition. A more developed financial system can finance renewable-energy infrastructure, technological innovation and environmentally sustainable investment; equally, however, it can expand credit and investment in conventional industries and carbon-intensive activities.

Financial deepening should therefore be viewed as an enabling mechanism rather than an intrinsically green process. The relevant question is not simply whether financial development promotes sustainable transition, but rather under what institutional conditions financial development becomes supportive of that transition. The evidence from Asian economies indicates that government effectiveness constitutes an important part of this institutional foundation.

6.2 Policy Implications

The findings have several implications for policymakers, particularly in Asian economies where rapid financial development, industrialization, rising energy demand and climate commitments increasingly intersect.

First, policies designed to deepen financial systems should be accompanied by improvements in institutional capacity. Expanding banking activity, private-sector credit, capital markets and financial access can increase the resources available for investment, but financial expansion alone does not determine where those resources ultimately flow. Strengthening the effectiveness of public institutions, regulatory implementation and policy coordination can improve the environment within which financial resources are allocated toward sustainable activities.

Second, governments should seek greater alignment between financial-sector development and national energy-transition objectives. Sustainable-finance frameworks, green taxonomies, disclosure requirements, renewable-energy financing mechanisms and credible regulatory standards can help financial institutions distinguish genuinely sustainable investments from conventional activities. The objective should not merely be to expand the quantity of finance but to improve its direction and environmental quality.

Third, the results emphasize the importance of policy credibility and implementation capacity. Renewable-energy projects typically involve large initial investments, long planning horizons and exposure to regulatory uncertainty. Even where domestic financial resources are abundant, inconsistent policies or weak implementation can increase project risk and discourage long-term sustainable investment. Stable regulatory frameworks and credible government commitments can therefore enhance the ability of financial development to contribute to energy transition.

Fourth, the findings suggest that a uniform policy prescription may be inappropriate across Asia. Countries differ considerably in financial maturity, institutional capacity, energy structure and development priorities. Economies with relatively advanced financial systems but weaker institutional implementation may benefit more from improving governance and regulatory effectiveness than from pursuing financial expansion alone.

Conversely, countries with stronger institutions but less-developed financial systems may need to broaden access to long-term financing and deepen capital markets capable of supporting renewable infrastructure.

The broader policy implication is therefore one of institutional–financial complementarity. Sustainable transition requires not simply more finance or better governance in isolation, but greater alignment between the two.

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