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Leveraging Financial Inclusion to Drive Public-Private Partnership Investments in Energy: Role of Financial Institutions in ASEAN Nations

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Amid rising concerns over energy security and the growing demand for sustainable infrastructure, mobilizing public-private partnership (PPP) investments in the energy sector has become a critical policy objective for ASEAN nations. This study contributes to the literature by uncovering the pivotal role of financial inclusion (FIC) in enhancing such investments. By improving access to financial services, FIC fosters a more conducive environment for energy-related PPPs, particularly in emerging economies where capital mobilization is constrained. Using panel data from 1999 to 2023 for ASEAN countries, the analysis confirms that FIC exerts a positive and statistically significant impact on PPP investments in energy (PPI), even after controlling for government spending, FDI, economic growth, and aid. These findings position financial inclusion not only as a tool for economic empowerment but also as a strategic lever for infrastructure development. The study further strengthens its conclusions through robust empirical techniques. Overall, this research offers novel insights into how inclusive financial systems can unlock private investment in critical energy infrastructure, supporting broader sustainable development goals in the region.

Keywords: *ASEAN; CS-ARDL; Financial Inclusion; Public-Private Partnership (PPP); PPPs Investment in Energy*.

Introduction

Energy security (ES) is a vital concern for both developed and developing economies, given the rising global energy demand, resource constraints, and the transition towards low-carbon systems. As a core element of SDG 7, ensuring reliable, affordable, and sustainable energy access remains a critical development priority. Recent literature emphasizes that energy security risks are increasingly influenced by structural and institutional factors such as financial development, resource management, and economic planning (Hassan *et al.*, 2025; Ullah *et al.*, 2024). For example, Hassan et al. (2025) demonstrated that enhanced financial development significantly reduces energy security risks across E7 countries, while Ullah et al. (2024) uncover that even in resource-rich BRICS economies, inefficient energy governance and lack of diversification heighten security vulnerabilities. Furthermore, Haq et al. (2024a) established that economic fitness and sustainability-oriented policies can mitigate environmental and energy-related risks. Complementing this, Ul-Haq et al. (2024b) showed that in the Chinese context, high-quality economic development plays a pivotal role in reducing regional disparities in energy insecurity. These findings collectively underscore the need for inclusive and financially resilient energy frameworks. In this light, financial inclusion emerges as a promising lever to mobilize public-private investments, enhance infrastructure resilience, and ultimately, strengthen national and regional energy security.

The global energy situation is undergoing a significant transformation driven by the dual challenges of ensuring access to affordable, reliable, sustainable energy while simultaneously addressing the need for reducing carbon emissions to mitigate climate change (Bonfert, 2024). Energy security and sustainability have become paramount concerns for governments, businesses, and citizens alike. To achieve the goals set by international frameworks such as the United Nations' Sustainable Development Goals (SDGs), particularly SDG 7 (affordable and clean energy), innovative financing mechanisms and collaborative models are required. In this context, leveraging financial inclusion to drive public-private partnerships (PPP hereafter) in the energy sector can offer a viable solution for addressing the energy needs of underserved populations while fostering sustainable development. While PPPs have been successfully implemented in developed economies for decades (Guo *et al.*, 2024), their application in the energy sectors of developing countries has often faced challenges including limited financial resources, regulatory bottlenecks, and inadequate institutional frameworks. This is where financial inclusion can play a transformative role. By expanding access to financial services such as credit, savings, insurance, and digital payments, financial inclusion can empower individuals and small businesses to invest in clean energy technologies such as solar home systems or energy-efficient appliances (Kar & Swain, 2024).

Financial inclusion (FIC hereafter) defined as the availability and equality of opportunities to access financial services (Khan *et al.,* 2024), plays a critical role in enabling low-income individuals and businesses to participate in the formal economy. As more people gain access to financial services particularly through digital platforms, their capacity to engage in energy markets increases. In parallel, PPPs have emerged as a powerful vehicle for financing and managing large-scale infrastructure projects particularly in sectors like energy, where capital requirements are high and long-term sustainability is essential (Casady, et al., 2024). The convergence of FIC and PPPs in the energy sector has the potential to address critical barriers including financing gaps, infrastructure bottlenecks, and energy poverty which remain major hurdles in many developing and emerging economies. In this essence, the current study aims to explore the role of financial inclusion in deriving the PPPs investment in energy.

Financial inclusion which aims to provide individuals and businesses with access to financial services has emerged as a key enabler of economic empowerment and poverty reduction (Boulanouar *et al.,* 2024). By extending access to credit, savings, and insurance products, financial inclusion can empower marginalized communities to invest in clean energy technologies, participate in decentralized energy markets, and build resilience against energy price volatility and climate-related risks. In tandem, PPPs offer a collaborative model to leverage private sector investment, expertise, and efficiency in large-scale infrastructure projects, including those in the energy sector. However, while financial inclusion and PPPs have been studied separately in the context of energy (Guo *et al.,* 2024; Kar & Swain, 2024), limited research exists on how these two concepts can be combined to drive investments in sustainable energy infrastructure. This gap in the literature provides the foundation for this study. By examining the synergies between financial inclusion and PPP models, the research aims to provide insights into how these mechanisms can be leveraged to address the energy access challenge, particularly in underserved regions.

This study investigates the relationship between financial inclusion (FIC) and PPP investments in the energy (PPI hereafter) across ASEAN nations from 1999 to 2023. The analysis employs the CS-ARDL model, providing a comprehensive framework to examine the long-term dynamics between financial inclusion and energy-related PPP investments. To ensure the robustness of the findings, two alternative estimation techniques named FMOLS and GMM were applied, further validating the core results. The findings posit that financial inclusion functions as a catalyst in PPP investments by mobilizing private capital, improving access to credit and financial services, and reducing transaction costs, thereby enabling broader participation from individuals and firms in energy infrastructure projects. In addition to FIC, the study analyzed the effects of several control variables including government subsidies, economic growth, FDI inflows, foreign aid, corruption control, and political stability on PPP investments in energy. The results disclosed that with the exception of foreign aid, all control variables positively influence PPI.

This study makes significant theoretical contributions by advancing the understanding of how FIC can be a critical driver of PPP investments in the energy sector. Traditionally, much of the literature on PPPs has focused on the role of government policies, economic factors, and institutional quality in facilitating infrastructure development (Devkar *et al.,* 2020; Almarri & Boussabaine, 2023; Sharma, 2023; Mofokeng *et al.,* 2024), while the impact of FIC has been less explored. By integrating FIC into the theoretical framework of PPP investments, this research introduces a novel perspective highlighting how access to financial services can mobilize private sector resources, reduce transaction costs, and expand investment opportunities. This study extends existing PPP theories by suggesting that financial inclusion empowers individual investors and fosters a broader financial ecosystem conducive to large-scale infrastructure projects, particularly in the energy sector. Empirically, this study contributes to the growing body of literature by providing comprehensive evidence from ASEAN nations over a period spanning 1999 to 2023. The research employs the CS-ARDL model to analyze long-term relationships. Moreover, the robustness of the analysis is tested through alternative models namely FMOLS and GMM which help ensure the reliability of the results. The study's empirical findings which reveal a significant positive effect of FIC on PPI add depth to our understanding of the factors that influence PPPs in emerging markets.

In terms of policy implications, the study offers practical insights for policymakers and stakeholders seeking to enhance

PPP investments in the energy sector. By demonstrating the critical role of financial inclusion (FIC), this research suggests that governments in ASEAN countries should prioritize policies that expand access to financial services for both individuals and enterprises. Financial inclusion initiatives such as digital banking, microfinance, and financial literacy programs can help lower the barriers to investment and increase the flow of private capital into energy projects. Furthermore, the study highlights the importance of institutional factors like political stability and corruption control which are essential for attracting and retaining private investment in long-term energy projects. The finding that foreign aid has a limited impact on PPP investments underscores the need for domestic financial mechanisms and policies that promote self-sustaining investment models. Therefore, the study's contributions are not only academic but also actionable, offering a roadmap for enhancing the effectiveness of PPPs in energy infrastructure development through inclusive finance strategies.

The settings of the paper proceed as follows: Section 2 is of the theoretical framework, empirical literature, Section 3 is of review of literature and hypothesis, Section 4 is of data and methodological settings, Section 5 is of presentation of results, and Section 6 is a discussion of findings. In Section 7, we conclude the study and enlist the policy implications.

Theoretical Framework

This study draws upon the financial intermediation theory, resource mobilization theory, and the public-private partnership (PPP) investment framework to understand how financial inclusion influences PPP investments in the energy sector, particularly within ASEAN economies. According to financial intermediation theory (Gurley & Shaw, 1960; Goldsmith, 1969), financial institutions act as intermediaries that facilitate the efficient allocation of capital by channeling savings into productive investments. Financial inclusion, as an extension of this theory, broadens participation in financial markets by integrating underserved and unbanked populations into the formal economy. Enhanced access to credit, savings, and insurance mechanisms empowers individuals and businesses to invest, innovate, and participate in infrastructure-related projects. This is particularly relevant in energy infrastructure where large capital inflows, risk-sharing mechanisms, and long-term financing are essential.

Similarly, resource mobilization theory (Tilly, 1978) complements this by emphasizing that financial systems must be inclusive and robust to mobilize domestic and international financial resources efficiently. In ASEAN countries, where disparities in access to financial services still exist, financial inclusion ensures that both consumers and smaller investors can contribute to and benefit from infrastructure development. In this essence, inclusive financial systems can enhance trust, improve creditworthiness, and reduce the perceived risks for private sector entities considering investment in public utilities like energy. Meanwhile, the PPP investment framework highlights the role of collaborative arrangements between public institutions and private investors in addressing infrastructure gaps. Effective PPPs require stable macroeconomic environments, transparent financial systems, and accessible capital. Financial inclusion helps create a favorable ecosystem for PPPs by increasing liquidity, enabling diversified financing sources, and building institutional trust.

In synthesis, the theoretical framework underpinning this study posits that financial inclusion facilitates the flow of funds, reduces credit constraints, mitigates information asymmetries, and encourages private sector confidence, all of which are prerequisites for successful PPP investments in energy infrastructure. Given ASEAN's energy transition goals and infrastructure needs, financial inclusion emerges not only as a developmental goal but also as a strategic enabler of public-private investment cooperation.

Literature Review

In recent years, the intersection of financial inclusion and energy development has garnered significant attention from researchers and policymakers alike. For instance, Koomson and Danquah (2021) investigated the liason between FIC (financial inclusion) and energy poverty in Ghana, utilizing data from two rounds of living standards surveys. The research employed an instrumental variable approach and observed that an increased FIC correlates with a significant decrease in household energy poverty. Results indicate a slight decline in energy poverty from 81 % to 80 % over four years. Li, et al., (2022) aimed to examine how FIC influences renewable energy demand in China, utilizing the S-GMM model with provincial data during the green finance era. The findings revealed that enhanced FIC significantly fosters renewable energy development, particularly in northern regions with established renewable industries, while also demonstrating that wind and photovoltaic power generation effectively mediate this relationship. Ali et al., (2023) explored how digital FIC, energy transition, and diversification contribute to achieving the UN SDGs and COP26 targets in the E-7. The findings based on various econometric techniques advocated that energy transition, diversification, and technological innovation help reduce CO_2 emissions, while digital finance and economic growth exacerbate environmental issues.

Chang et al., (2023) investigated the connection between FIC (financial inclusion) and the sustainable energy performance index in E7 countries particularly in the context of the COVID-19 pandemic. The research found that China leads in energy performance, followed by Russia, while Mexico and Brazil lag significantly. Khan, et al., (2023) aimed to investigate how FIC influences energy poverty across six emerging economies over 2004 to 2019. Utilizing advanced methodologies like CS-ARDL model, the research constructed multidimensional indices for energy poverty and FIC. The findings revealed that FIC significantly mitigates energy poverty. Yu and Tang (2023) investigated the impact of FIC on energy efficiency across 251 prefecture-level cities in China from 2011 to 2015. The findings revealed that an increase in FIC correlates with a significant rise in energy efficiency, estimated at about 6.5 % per unit increase.

Hao et al., (2024) studied how digital FIC (financial inclusion) affects energy consumption in the context of China's digital transformation. The findings indicated that an increased digital FIC leads to reduced energy use, particularly in less developed regions, where its depth of use plays a significant role. Additionally, the research highlighted that industrial agglomeration acts as a mechanism for this relationship. Kar and Swain (2024) investigated the association between FIC and energy poverty in 27 SSA countries from 2004 to 2021. Utilizing advanced regression techniques like system GMM, the analysis revealed that an increased FIC significantly alleviates energy poverty. Additionally, the findings indicate a positive link between energy access and GDP per capita, while higher oil prices and energy intensity negatively affect energy access. Khan, et al., (2024) investigated the role of FIC in enhancing energy efficiency. In doin so, they developed a comprehensive index that assesses availability, accessibility, and usage of financial services. Their findings indicated a consistently positive relationship between FIC and energy efficiency across various quantiles. Additionally, the study highlighted that while green innovation and human capital contribute positively to energy efficiency, improvements in political risk initially have a negative impact before becoming beneficial (Ali *et al.*, 2025).

Lang et al., (2024) aimed to explore the relationship between FIC, energy efficiency, and environmental sustainability in developed countries. Utilizing various econometric methods, their analysis revealed a nonlinear relationship and structural breaks among the variables. The findings highlighted that while FIC is vital for promoting a sustainable environment, implementing energy efficiency policies is essential for reducing emissions effectively. Ramzan, et al., (2024) investigated the influence of inclusive digitalization, financial inclusion, and inclusive growth on energy demand across 103 countries from 2004 to 2022 with a focus on income disparities. The findings revealed that inclusive digitalization and FIC positively impact renewable energy demand in all income categories, although inclusive growth does not affect middle-income countries. The results also highlight bi-causal relationships among the variables. Sun, et al., (2024) inspected the impact of digital FIC, ICT, education, and energy security risks among major energy-consuming nations from 2011 to 2022. The results indicated that digital FIC, along with factors such as ATM availability and electronic payments played a significant role in reducing energy security risks. Additionally, while ICT, education, GDP, and renewable energy production contribute positively to energy security, increased carbon emissions were found to heighten these risks.

Despite numerous studies highlighting the role of financial inclusion (FIC) in energy development, energy efficiency, and mitigating energy poverty, there remains a notable gap in the literature regarding the impact of FIC on PPP investment in the energy sector. This oversight suggests an unexplored avenue for research that could illuminate how FIC influences PPP dynamics and investment decisions in energy projects. Addressing this gap could be achieved by investigating the following hypothesis.

H_1: *Finacial inclusion has a significant positive relationship with public-private partnership (PPP) investment in energy*.

Data and Methods

Data and Sample

The data utilized in this study encompasses a comprehensive panel dataset from ASEAN nations over the period from 1999 to 2023. The selection of this timeframe allows for the analysis of both short-term and long-term dynamics as it covers significant economic developments in the region, including the expansion of PPPs in the energy sector, the advancement of financial inclusion, and various macroeconomic and political changes that affect investment climates. The focus on ASEAN countries is particularly relevant given the region's rapid economic growth, increasing energy demands, and active engagement in PPP models for infrastructure development. Notably, two countries named Brunei Darussalam and Singapore were excluded from the sample due to the unavailability of comprehensive data on PPI. Both nations while important members of the ASEAN bloc lack sufficient data on their energy-related PPP investments. Brunei Darussalam's economy is heavily reliant on oil and gas exports, limiting the scope for energy PPPs in the renewable or alternative energy sectors, whereas Singapore's small land area and advanced energy infrastructure reduce the need for significant PPP projects in energy compared to its regional counterparts.

The final sample comprises eight ASEAN countries (details provided in Table 5), selected based on their active participation in PPP investments in the energy sector and the availability of consistent and comparable data. ASEAN nations represent a diverse yet increasingly integrated economic bloc where energy security, sustainable development, and financial inclusion are high on the policy agenda. These countries face a dual challenge: rapidly growing energy demand driven by urbanization and industrialization, and the imperative to transition toward cleaner, more sustainable energy systems. Recognizing these challenges, ASEAN member states have pursued strategic initiatives to attract private investment in energy infrastructure, supported by regional cooperation mechanisms such as the ASEAN Plan of Action for Energy Cooperation (APAEC). Furthermore, significant progress in expanding financial services particularly digital financial inclusion offers a timely context to examine how inclusive financial systems can catalyze infrastructure investment. Thus, studying ASEAN countries provides valuable insights into the interplay between financial inclusion and PPP energy investments in emerging markets undergoing structural transformation. Data for PPI, financial inclusion and control variables were sourced from World Development Indicators (WDI), The World bank.

Research Models and Variables

In this study, we primarily employ the CS-ARDL model, which can be written as follows:

Core model of study

$$PPI_{it} = \beta_\circ + \sum_{i=1}^{p} \alpha_1 \Delta PPI_{it-1} + \sum_{i=1}^{p} \beta_1 \Delta FIC_{it-1} + \varphi_1 PPI_{it-1} + \varphi_2 FIC_{it-1} + \varepsilon_{it} \qquad Eq.(1)$$

After adding the control variables

$$PPI_{it} = \beta_\circ + \sum_{i=1}^{p} \alpha_1 \Delta PPI_{it-1} + \sum_{i=1}^{p} \beta_1 \Delta FIC_{it-1} + \sum_{i=1}^{p} \gamma_1 \Delta GOS_{it-1} + \sum_{i=1}^{p} \gamma_2 \Delta ECO_{it-1} + \sum_{i=1}^{p} \gamma_3 \Delta FDI_{it-1} + + \sum_{i=1}^{p} \gamma_4 \Delta AID_{it-1} + \sum_{i=1}^{p} \gamma_5 \Delta COC_{it-1} + \sum_{i=1}^{p} \gamma_6 \Delta POS_{it-1} + \varphi_1 PPI_{it-1} + \varphi_2 FIC_{it-1} + \varphi_3 GOS_{it-1} + \varphi_4 ECO_{it-1} + \varphi_5 FDI_{it-1} + \varphi_6 AID_{it-1} + \varphi_7 COC_{it-1} + \varphi_8 POS_{it-1} + \varepsilon_{it} \qquad Eq.(2)$$

For FMOLS model, Equation (1) can be modified as

$$PPI_{it} = \beta_\circ + \alpha_1 FIC_{it} + \beta_1 GOS_{it} + \beta_2 ECO_{it} + \beta_3 FDI_{it} + \beta_4 AID_{it} + \beta_5 COC_{it} + \beta_6 POS_{it} + \varepsilon_{it} \qquad Eq.(3)$$

For GMM model, Equation (2) can be modified as

$$PPI_{it} = \beta_\circ + \gamma_1 PPI_{it-1} + \alpha_1 FIC_{it} + \beta_1 GOS_{it} + \beta_2 ECO_{it} + \beta_3 FDI_{it} + \beta_4 AID_{it} + \beta_5 COC_{it} + \beta_6 POS_{it} + \mu_i + \omega_t + \varepsilon_{it} \qquad Eq.(4)$$

Equation (1) is the core model of the study where FIC solely impacts PPI. Equation (2) shows the effect of FIC (financial inclusion) on PPI (PPPs investment in energy). This includes the control variables named GOS (government subsidies), ECO (economic growth), FDI (FDI inflow), AID (foreign aid), COC (corruption control), and POS (political stability). This equation shows both long-run and short-run effect of explanatory variables on PPI. Equation (3) is for FMOLS model and Equation (4) shows the underlying mechanism for GMM model.

Explaining the variables, PPP investment in energy (PPI) is a key dependent variable. In this study, PPI is measured as the natural logarithm of the total investment in energy-related PPPs, expressed in current US dollars. By applying the logarithmic transformation, the scale of the data is adjusted to mitigate the effects of outliers and to ensure a smoother distribution, which is particularly useful for econometric analysis. This measure captures the financial commitment from both sectors towards sustainable energy projects, reflecting the extent to which these collaborations contribute to addressing energy needs, promoting innovation, and achieving long-term economic growth. Such a measurement is also reflected in recent literature.

Financial Inclusion (FIC) in this study is measured as an aggregate score encompassing several key indicators of financial accessibility and efficiency. These include the number of Automated Teller Machines (ATMs) and commercial bank branches per 100,000 adults, which represent the physical availability of financial services, and the bank capital to assets ratio and bank liquid reserves to assets ratio, which reflect the stability and liquidity of the banking sector. Additionally, the nonperforming loans to total gross loans ratio indicates credit risk, while the number of borrowers from commercial banks measures access to formal credit. Broad money growth, broad money as a percentage of GDP, and the broad money to total reserves ratio provide insights into the money supply and liquidity within the economy. Together, these indices offer a comprehensive picture of the financial system's inclusiveness (Khan *et al.*, 2024), and its capacity to support PPPs particularly in the energy sector.

The study incorporates several key control variables to provide a comprehensive analysis of the factors influencing PPI. Government subsidies (GOS) measured as the percentage of subsidies and other transfers relative to total government expenses capture the extent of state support in reducing costs for energy investments, thereby encouraging PPPs. Economic growth (ECO) represented by GDP per capita growth (annual %), reflects the overall economic environment of a country, with higher growth rates indicating more resources and a more favorable climate for private sector investments in energy infrastructure. FDI inflows measured as a percentage of GDP, represent the net inflows of international capital, which can provide crucial funding for energy projects and foster collaboration between public and private sectors. Foreign aid (AID), expressed as a percentage of GNI, reflects the level of financial assistance received from external sources, typically through official development assistance (ODA). While foreign aid can support energy projects, its effect on PPPs may vary, potentially substituting or complementing private sector involvement. Additionally, COC measured as an estimate of governance effectiveness is crucial for fostering a transparent and secure investment environment. Better corruption control enhances investor confidence and reduces risks, which is critical for long-term energy investments. Finally, political stability (POS), measured by the absence of violence or terrorism, is vital for creating a secure and predictable environment for PPPs, as political stability reduces the risks of disruption and makes countries more attractive for sustained energy investments. These control variables collectively provide a nuanced understanding of the broader economic, political, and institutional factors that shape PPP investments in energy. A brief measurement of variables is detailed in Table 1.

Table 1

Detail of Variables

Variable	Acronym	Measurement	Data source
Public-Private investment in energy	**PPI**	Log (Public private partnerships investment in energy (current US$))	WDI
Financial inclusion	**FIC**	Aggregate score on various indices representing the status of financial efficiency e.g., ATMs, Bank Branches, Deposits, and offering of Life insurance policies etc.	WDI
Government subsidies	**GOS**	Subsidies and other transfers (% of expense)	WDI
Economic growth	**ECO**	GDP per capita growth (annual %)	WDI
Foreign direct investment inflow	**FDI**	Foreign direct investment, net inflows (% of GDP)	WDI
Foreign aid	**AID**	Net ODA received (% of GNI)	WDI
Control of corruption	**COC**	Control of Corruption: Estimate	WDI
Political stability	**POS**	Political Stability and Absence of Violence/Terrorism: Estimate	

Source: *The measurement of variables is extracted from existing literature.* ***Notes:*** *This table is showing the measurement of variables, data source, and acronym detail of all variables used in existing study.*

Methodology

To ensure the robustness and reliability of the results, the methodology of this study involves a comprehensive approach, employing a range of pre-estimation techniques before applying the CS-ARDL model and confirming the results using FMOLS and GMM models. These pre-estimation techniques include Cross-Sectional Dependence (CD) analysis (Breusch & Pagan, 1980; Pesaran, 2004), second-generation unit root testing (Pesaran, 2007), and cointegration analysis (Kao, 1999) which are crucial for validating the econometric models used in panel data analysis. The first step of the pre-estimation analysis is to test for CD among the variables. In panel data settings, ignoring CD can lead to biased and inconsistent results, especially in cases where countries are economically integrated or share common shocks. As reported in Table 2, the results indicate the presence of CD in almost all variables. This confirms that the variables are not independent across the countries, which justifies the use of methodologies that account for CD such as the CS-ARDL model.

Given the CD identified, the next step is to assess the stationarity of the variables using second-generation unit root tests. These tests including the CIPS and CADF tests allow for CD while examining the integration properties of the data. Table 3 presents the results of the unit root analysis. For most variables, stationarity is achieved after taking the first difference, indicating that the series are integrated of order one, I(1). Once the stationarity of the variables is confirmed, the next step is to determine whether a long-run equilibrium relationship exists among the variables using cointegration analysis. The study uses the Kao Residual Cointegration Test, a robust method to test for cointegration in panel data with CD. The results as reported in Table 4 show a statistically significant values, indicating the presence of cointegration. This suggests that a long-run relationship exists between the variables. The presence of cointegration is critical as it allows the study to move forward with long-term dynamic modeling, validating the application of models like CS-ARDL, FMOLS, and GMM.

The CS-ARDL (Cross-Sectional Autoregressive Distributed Lag) model is the primary model employed in this study. This model is particularly suited for panels with CD and provides both short-term and long-term coefficient estimates. The CS-ARDL model incorporates cross-sectional averages to address potential biases arising from CD and is useful for analyzing the long-run and short-run dynamics between variables. The motivation for using the CS-ARDL model lies in its ability to address the complications of non-stationarity, CD, and heterogeneity across countries which are common in panel datasets like the one used in this study, spanning multiple nations over several decades (1999 to 2023). To check the robustness of the findings, the FMOLS model is employed. The FMOLS method is particularly effective for dealing with endogeneity and serial correlation issues in cointegrated panel data models. It modifies the least squares estimation to account for potential biases introduced by the presence of endogenous regressors, which could arise from feedback effects between the dependent and independent variables. The significance of FMOLS lies in its ability to provide consistent and unbiased long-run estimates in the presence of endogeneity, making it an essential tool for confirming the reliability of the results obtained from the CS-ARDL model.

Additionally, the GMM model is applied to further confirm the robustness of the results. The GMM model is advantageous in handling potential endogeneity, especially in dynamic panels where lagged values of the dependent variable can be used as an instruments. In this study, GMM is particularly useful for addressing potential simultaneity and reverse causality between financial inclusion and PPP investments in energy. The GMM model is motivated by its flexibility in dealing with dynamic panel models and its ability to produce consistent estimates even when there is a risk of endogeneity. By using lagged variables as instruments, the GMM approach mitigates concerns about the endogenous relationship between financial inclusion and energy investment.

Table 2

Cross-Sectional Dependence (CD) Analysis

	Breusch Test		Pesaran Test	
Variables	***Statistic***	***Probability***	***Statistic***	***Probability***
PPI	48.008	0.010	1.604	0.108
FIC	131.917	0.000	12.817	0.000
GOS	176.807	0.000	22.971	0.000
ECO	238.616	0.000	27.102	0.000
FDI	69.902	0.000	4.530	0.000
AID	145.912	0.000	14.688	0.000
COC	176.032	0.000	18.712	0.000
POS	228.345	0.000	25.703	0.000

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1. Moreover, this table reports the estimation for CD analysis. Most values are significant, showing that existence of CD issue.*

Table 3

Analysis of Stationarity through Unit Root Testing

	CIPS		**CADF**	
Variables	**At Level (0)**	**At first difference (1)**	**(0)**	**(1)**
PPI	(-2.098)	-	(35.270)	-
	0.001		0.000	
FIC	(-2.068)	(-7.647)	(19.267)	(85.597)
	0.393	0.000	0.255	0.000
GOS	(0.294)	(-5.298)	(18.421)	(65.255)
	0.615	0.000	0.188	0.000
ECO	(-4.498)	-	(53.018)	-
	0.000		0.000	
FDI	(-3.390)	-	(43.299)	-
	0.001		0.000	
AID	(2.844)	-	(36.150)	-
	0.000		0.000	
COC	(-0.690)	(-5.377)	(20.097)	(59.044)
	0.244	0.000	0.216	0.000
POS	(0.296)	(-7.593)	(11.467)	(85.946)
	0.616	0.000	0.176	0.000

Source: *self-analysis.* ***Note:*** *the acronyms can be seen in the Table 1. In this table ( ) are the coefficient values while without ( ) are the probability values. This Table is about the stationarity analysis of variables.*

Table 4

Cointegration Analysis

Cointegration Test of Kao Residual		
Test Name	**t-statistics**	**Probability**
ADF	-2.498	0.006
Residual Variance	0.557	-
HAC Variance	0.254	-

Source: *self-estimation* ***Note:*** *the significant probability value indicates that the cointegration exist.*

Results of Study

Descriptive Analysis

In Table 5, the mean values of the variables provide a crucial understanding of the central tendencies within the dataset used in the study. Each mean value represents the average performance or state of the corresponding variable over the sample period across countries or regions being analyzed. The mean value of 8.624 for PPI suggests that, on average, there has been a significant level of investment in energy through PPPs across the sample countries. This indicates that countries have been actively involving the private sector in energy-related projects, which could be a result of efforts to improve infrastructure and meet growing energy demands. The mean value of 31.599 for financial inclusion reflects the average level of financial access and services provided to the population across the countries in the sample. Financial inclusion is typically measured through metrics such as access to bank accounts, availability of ATMs, or the percentage of adults using financial services. This relatively high mean value indicates that, on average, financial inclusion has been moderately high in these countries, signaling progress in making financial services more accessible to the population. For control variables, government subsidies (GOS) average 28.954 %, highlighting their role in economic policies. Economic growth (ECO) shows a healthy average of 4.153 %, and FDI averages 3.724 % of GDP, signaling steady investment inflows. Foreign aid (AID) accounts for 2.262 % of GDP on average. However, COC and POS show negative mean values of -0.696 and -0.593, respectively, indicating challenges in governance and political conditions that may affect energy projects and investment climates.

Table 5

Panel Descriptive Trends

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
PPI	8.624	8.628	10.575	6.612	0.733	-0.580	3.120
FIC	31.599	23.990	84.336	6.678	18.204	1.022	2.883
GOS	28.954	24.101	91.084	0.080	18.643	1.253	4.316
ECO	4.153	4.325	12.766	-12.629	3.713	-1.154	3.642
FDI	3.724	2.829	14.1457	-2.757	3.339	1.534	3.030
AID	2.262	0.565	17.519	-0.642	3.380	1.889	4.513
COC	-0.696	-0.682	0.396	-1.672	0.498	0.281	2.483
POS	-0.593	-0.578	1.157	-2.408	0.739	-0.058	2.422

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1. The reported values provide an overview of data structure and help in understanding the overall pattern of financial statistics.*

The average values across countries in Table 6 highlight significant variations in FIC and PPI. For instance, Thailand has the highest FIC score of 55.554, followed by Malaysia at 46.592 and Indonesia at 40.686, suggesting these countries have more developed financial sectors which could facilitate higher PPI. In contrast, Lao PDR and Cambodia exhibit lower FIC scores of 17.548 and 21.656, respectively. Despite its low FIC, Lao PDR has the highest PPI at 9.146, indicating other factors such as government subsidies (GOS) or economic growth (ECO) may play a critical role. Indonesia and Thailand also show high PPI of 8.816 and 8.994 respectively. Regarding GOS, Indonesia leads with 64.349 %, reflecting substantial government support while Cambodia and Thailand have relatively lower subsidies. Economic growth (ECO) is highest in Myanmar (6.718%) and Cambodia (5.532 %), whereas countries like Malaysia and Thailand show slower growth at 2.825 % and 2.732 %, respectively. FDI is remarkably high in Cambodia (9.322 %) and Viet Nam (4.841 %), signaling stronger international investment. In terms of governance indicators, Malaysia shows positive scores for both COC (0.180) and POS (0.204), whereas countries like Myanmar and Indonesia struggle with negative governance indicators, with Myanmar showing the lowest POS at -1.338. This comparison reveals a complex relationship between financial inclusion, government policies, and governance, impacting each country’s ability to attract PPI in energy projects.

Table 6

Average Values Across Countries

Countries	FIC	PPI	GOS	ECO	FDI	AID	COC	POS
Cambodia	21.656	7.994	22.231	5.532	9.322	6.329	-1.166	-0.288
Indonesia	40.686	8.816	64.349	3.515	1.246	0.292	-0.683	-1.004
Lao PDR	17.548	9.146	10.257	4.754	4.809	6.913	-1.021	0.045
Malaysia	46.592	8.435	41.611	2.825	3.249	0.044	0.180	0.204
Myanmar	19.179	8.507	15.023	6.718	3.122	1.896	-1.194	-1.338
Philippines	19.979	8.477	24.129	2.996	1.739	0.320	-0.593	-1.156
Thailand	55.554	8.994	25.076	2.732	2.583	0.042	-0.394	-0.617
Viet Nam	25.648	8.773	10.987	5.173	4.841	2.014	-0.541	0.197

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1. The reported values provide an important trend across the nation. Each country shows a specific value for a specific variables, aiding in understanding the trend across the sampled nations.*

Correlation Analysis

The correlation values reported in Table 7 provide insight into the relationships between PPI and various explanatory variables. The correlation between FIC and PPI is 0.127, indicating a weak but positive relationship. This suggests that an increase in financial inclusion is associated with a slight increase in investment in energy projects through PPP. Similarly, FDI shows a positive correlation of 0.119 with PPI, suggesting that higher FDI inflows tend to be associated with more energy-related PPP investments, though the relationship is not strong. On the other hand, GOS have a very weak positive correlation of 0.077 with PPI, suggesting that subsidies slightly influence PPP investments, but the effect is minimal. Economic growth (ECO) with a correlation of 0.029 also has a very minor positive relationship with PPI, indicating that GDP growth has a negligible effect on public-private energy investments. Interestingly, foreign aid (AID) has a negative correlation of -0.058, implying that an increase in foreign aid is slightly associated with a reduction in PPP investments in the energy sector. This could be due to the potential crowding-out effect, where foreign aid displaces private sector investments. COC and POS show very weak positive correlations of 0.054 and 0.004, respectively, with PPI. While both governance indicators suggest that better governance and stability might improve PPP investments, their impact appears to be very limited based on the correlation values. Overall, these results indicate generally weak relationships between PPI and the studied variables, with none showing strong correlations.

The variance inflation factor (VIF) values reported (in Table 7) for all explanatory variables range between 2.989 and 4.213, which are well below the commonly accepted threshold of 10. This indicates that multicollinearity is not a serious concern in the model, and the estimated coefficients are unlikely to be distorted due to high intercorrelations among the independent variables.

Table 7

Correlation Analysis

Variables	PPI	FIC	GOS	ECO	FDI	AID	COC	POS
PPI	1.000							
FIC	0.127	1.000						
GOS	0.077	0.373	1.000					
ECO	0.029	-0.274	-0.261	1.000				
FDI	0.119	-0.215	-0.291	0.136	1.000			
AID	-0.058	-0.440	-0.439	0.191	0.338	1.000		
COC	0.054	0.586	0.373	-0.371	-0.312	-0.455	1.000	
POS	0.004	0.182	-0.165	-0.027	0.442	0.128	0.297	1.000
Multicollinearity test								
VIF	3.098	3.998	4.081	4.213	2.989	3.022	3.512	3.668

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1. The reported coefficient values of variables help in understanding the degree of correlation among the study variables.*

Regression Analysis

Table 8 presents the core findings from the CS-ARDL model estimating the impact of financial inclusion (FIC) on PPP investments in the energy sector. In the long run, FIC shows a positive and statistically significant effect on PPI with a coefficient of 0.025 and a p-value of 0.013, indicating that greater financial inclusion promotes private sector investment in energy infrastructure over time.

After adding the control variables, the regression results in Tables 9 and 10 show the relationship between financial inclusion (FIC) and PPP investment in energy. In the CS-ARDL model (Table 9), the long-run coefficients indicate that FIC has a significant positive effect on PPP investment, with a coefficient of 0.050, meaning that a 1 % increase in FIC is associated with a 0.05 % increase in PPP investment. Other variables, such as government subsidies (GOS, 0.155), economic growth (ECO, 0.073), foreign direct investment (FDI, 1.237) and control of corruption (COC, 2.390) also have positive and significant long-run effects while foreign aid (AID) has a negative impact (-0.673), implying it may crowd out PPP investments in energy. The short-run results show weaker relationships, with the error correction term (COINTEQ01) being significant at the 5 % level, indicating adjustment towards long-run equilibrium. In the robustness analysis (Table 10) using FMOLS and System GMM models, FIC continues to have a positive and significant effect across both models, reinforcing its importance in fostering PPP investments. The coefficients for FDI, COC, and POS also remain significant and positive in both models while AID has a negative impact, consistent with the long-run results from the CS-ARDL model. The adjusted R-squared values show that the models explain between 31.9 % and 42.2 % of the variation in PPP investments.

Table 8

Core Results-Effect of Financial Inclusion on PPP Investment in Energy

	CS-ARDL			
	PPI as a dependent			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
	Long Run Equation			
FIC	0.025 [a]	0.010	2.497	0.013
	Short Run Equation			
COINTEQ01	-0.738 [a]	0.114	-6.469	0.000
D(FIC)	-0.003	0.005	-0.676	0.499
C	6.359 [a]	0.991	6.415	0.000

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1.* ***Note:*** *the superscripts a, b show the significance level at 1% and 5% relatively. the estimated coefficient values reveal the degree of impact of a specific independent variable on dependent variable.*

Table 9

Effect of Financial Inclusion on PPP Investment in Energy

	CS-ARDL			
	PPI as a dependent			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
	Long Run Equation			
FIC	0.050 [a]	0.007	6.784	0.000
GOS	0.155 [a]	0.017	8.818	0.000
ECO	0.073 [a]	0.020	3.633	0.000
FDI	1.237 [a]	0.146	8.449	0.000
AID	-0.673 [a]	0.116	-5.797	0.000
COC	2.390 [a]	0.360	6.628	0.000

Variable	CS-ARDL			
	PPI as a dependent			
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
POS	0.128 [a]	0.031	4.072	0.000
	Short Run Equation			
COINTEQ01	-0.286 [b]	0.149	-1.915	0.061
D(PPI(-1))	-0.375 [b]	0.190	-1.966	0.054
D(FIC)	-0.024	0.017	-1.373	0.176
D(FIC(-1))	-0.047	0.033	-1.438	0.156
D(GOS)	0.006	0.053	0.114	0.909
D(GOS(-1))	-0.011	0.037	-0.310	0.757
D(ECO)	0.041	0.026	1.574	0.121
D(ECO(-1))	-0.023	0.045	-0.526	0.600
D(FDI)	0.194	0.218	0.888	0.378
D(FDI(-1))	0.028	0.139	0.202	0.840
D(AID)	-0.339	0.816	-0.415	0.679
D(AID(-1))	-0.732	0.665	-1.101	0.276
D(COC)	1.447	1.559	0.928	0.357
D(COC(-1))	2.040868	1.064278	1.917608	0.0610
D(POS)	-0.612902	0.666998	-0.918897	0.3627
D(POS(-1))	-1.153786	1.098855	-1.049989	0.2989
C	2.366806	1.099191	2.153224	0.0362

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1.* ***Note:*** *the superscripts a, b show the significance level at 1% and 5% relatively. the estimated coefficient values reveal the degree of impact of a specific independent variable on dependent variable.*

Table 10

Robustness Analysis-Effect of Financial Inclusion on PPP Investment in Energy

Variables	PPI as a dependent variable			
	FMOLS Model		System GMM Model	
	Coefficients	**Probability**	**Coefficients**	**Probability**
Constant	-	-	0.313 [a]	0.030
PPI (-1)	-	-	0.176 [b]	0.056
FIC	0.017 [a]	0.022	0.730 [a]	0.000
GOS	0.023	0.162	0.713 [a]	0.003
ECO	0.007	0.674	0.540 [a]	0.011
FDI	0.034 [a]	0.036	0.866 [a]	0.011
AID	-0.171 [a]	0.009	-0.688 [a]	0.033
COC	0.914 [a]	0.011	0.881 [a]	0.011
POS	0.098	0.526	0.945 [a]	0.040
Adjusted R-squared		0.319	0.422	
S.E. of regression		0.602	0.638	
Long-run variance		0.363	-	
Hansen Test		-	0.222	
AR (2)		-	0.031	

Source: *self-estimation.* ***Note:*** *the acronyms can be seen in Table 1.* ***Note:*** *the superscripts a, b show the significance level at 1% and 5% relatively. Notably, the estimated results that are reported in this table show the robustness of previous estimation in the case of CS-ARDL.*

Discussion on Findings

For regression analysis, the study mainly considers the CS-ARDL model as a baseline model and checks the robustness through FMOLS and GMM models. The findings show that financial inclusion (FIC) plays a crucial role in enhancing public-private partnership (PPP) investment in the energy sector, as demonstrated by the positive coefficient observed in both the long-run and robustness models. This relationship implies that when more individuals, households, and businesses have access to financial services such as savings, credit, and insurance, the overall environment becomes more conducive for investment activities particularly in infrastructure sectors like energy. A well-functioning financial system that reaches all segments of society enables greater resource mobilization which is essential for financing large-scale projects that are typically required in the energy sector. By improving financial access, financial inclusion lowers the barriers for individuals and firms to participate in or benefit from PPP initiatives, encouraging greater private sector involvement (Sun *et al.*, 2024). Moreover, financial inclusion helps reduce transaction costs and improves the efficiency of capital allocation. This facilitates the flow of funds into long-term investments like energy infrastructure where capital-intensive projects require large upfront financing. It also mitigates investment risks by providing access to diversified financial products and services such as insurance and credit which are critical for managing the inherent risks in large-scale energy investments. Enhanced financial inclusion fosters entrepreneurial activities and strengthens the ability of smaller firms to engage in energy-related projects, boosting overall economic participation and support for PPP models.

In addition, a financially inclusive system contributes to social stability and economic resilience, which are both important for sustaining long-term investments. When individuals and businesses have access to financial services, they can manage shocks more effectively and are better equipped to engage in productive activities, including energy-related initiatives. This increases the capacity for PPP investment in energy, where both public and private sectors work together to meet growing energy needs and address infrastructure gaps. The positive impact of FIC on PPP investment also reflects the growing recognition that financial inclusion is not only a tool for economic development but also a catalyst for sustainable infrastructure investment. By ensuring that financial services are accessible to all, FIC enables broader participation in the economy, creating a more favorable environment for PPP investments in essential sectors such as energy, which is critical for both economic growth and development (Hao *et al.*, 2024).

In addition to FIC, the study examines the impact of various control variables on PPP investment in energy (PPI). As per analyses, government spending (GOS) has a significantly positive effect on PPP investment in energy. This indicates that an increased public expenditure enhances infrastructure development, encouraging private sector participation in energy projects. Governments often act as key stakeholders in large energy projects, providing necessary funding, regulatory frameworks, or subsidies that reduce risks and incentivize private investment. Therefore, a higher level of government spending signals a conducive environment for PPPs by showing public commitment to energy development, which attracts private partners (Wang *et al.*, 2019). Economic growth (ECO) also positively influences PPI, suggesting that a growing economy provides better opportunities for both public and private sectors to collaborate on large infrastructure projects. When economic conditions are favorable, the returns on energy investments tend to be higher, leading to more robust participation from private investors. A growing economy also increases energy demand, further incentivizing investment in energy infrastructure to meet future needs (Ari & Koc, 2020).

The inflow FDI plays a critical role in bolstering PPP investment in energy (PPI). The significant positive coefficient for FDI highlights its importance as a source of capital and expertise for energy projects. FDI brings in not only financial resources but also technological knowledge and management skills, which are crucial for the successful implementation of large-scale energy projects. In this context, FDI serves as a bridge between global capital markets and local energy infrastructure needs, facilitating sustainable investments that might otherwise be out of reach for domestic investors alone (Raghutla *et al.,* 2024). Conversely, aid (AID) has a negative effect on PPI, which might seem counterintuitive at first glance. However, this could indicate that reliance on foreign aid potentially crowds out private investment as energy projects funded through aid may reduce the perceived need for private sector involvement. Aid might also come with conditions that limit the flexibility of PPP arrangements or focus more on social projects rather than commercially viable energy investments, hence its negative impact on private sector participation in energy (Wang & Castejon, 2024).

For governance variables, COC has a significantly positive influence on PPI. Effective control of corruption creates a transparent and predictable business environment, which is crucial for attracting private investment. When corruption is minimized, transaction costs are reduced, contract enforcement improves, and the risks associated with long-term energy projects diminish. This enhances investor confidence and encourages more private sector participation in energy-related PPPs. Lastly, POS has a positive effect on PPI, although its coefficient is relatively smaller compared to other variables. Political stability is essential for creating a reliable and predictable environment in which long-term energy investments can thrive. Political instability or uncertainty often leads to investment hesitancy, as private investors fear sudden changes in government policies or regulations that could negatively impact their investments. Thus, a stable political climate fosters an environment where both public and private sectors feel secure in entering long-term energy infrastructure partnerships (Peng *et al.*, 2024).

Overall, the analysis reveals the promising role of FIC in PPI, leading to acceptance of underlying notion developed in current study. In addition, the effect of control variables on PPI highlights that a supportive macroeconomic and governance environment coupled with sound fiscal policies significantly enhances the potential for PPI.

Conclusion and Policies

The conclusion of this study highlighted the significant role that financial inclusion (FIC) plays in promoting PPP investments in the energy sector (PPI). The findings show that higher levels of FIC positively impact PPI, indicating that an improved access to financial services allows both businesses and individuals to engage in energy projects more effectively. This underscores the importance of expanding financial access to promote sustainable energy infrastructure development. Furthermore, the study revealed that various control variables, such as government spending (GOS), economic growth (ECO), foreign direct investment (FDI), corruption control (COC), and political stability (POS), also play critical roles in shaping the environment for PPI. Government expenditure and foreign direct investment are especially important, as they provide the necessary resources and expertise for large-scale energy projects. Meanwhile, corruption control and political stability foster investor confidence, ensuring that energy projects are executed efficiently and transparently.

Interestingly, foreign aid (AID) shows a negative relationship with PPI, suggesting that while aid is beneficial for certain sectors, it may inadvertently discourage private sector participation in energy infrastructure by reducing the need for private investment. Overall, this study emphasizes the need for policies that promote financial inclusion, government commitment, and a stable economic and political environment to attract and sustain private sector investment in energy through PPPs. By addressing these key factors, countries can strengthen their energy infrastructure, improve energy access, and support sustainable economic growth.

Policy Implications

The policy implications of this study are profound, particularly for governments aiming to foster sustainable development through enhanced energy infrastructure. Firstly, the positive impact of financial inclusion (FIC) on PPP investments in the energy sector emphasizes the need for policies that promote broader access to financial services. Governments should prioritize expanding banking services, digital payment systems, and credit facilities to underserved populations and regions. Doing so will enable greater participation from individuals and businesses in energy-related projects, ultimately leading to increased investment in renewable energy infrastructure and more efficient energy systems. In addition, the findings highlight the importance of creating an enabling environment through sound fiscal policies and investment incentives. Policymakers must ensure that government spending (GOS) is effectively channeled into energy projects that leverage private sector resources and expertise. At the same time, providing attractive conditions for inflow FDI such as tax breaks, streamlined approval processes, and strong legal frameworks will further enhance private sector participation in energy infrastructure development.

Corruption control (COC) and political stability (POS) are also shown to have a significant positive effect on energy investments. Thus, policymakers should focus on improving governance and reducing corruption to build investor confidence. Strong institutions, transparent regulatory processes, and mechanisms to combat fraud and mismanagement are essential to sustaining long-term investments in energy infrastructure. Similarly, maintaining a stable political climate will ensure that both domestic and foreign investors view energy projects as viable and low-risk, encouraging greater capital inflow. Lastly, the negative effect of foreign aid (AID) on PPP investment suggests that over-reliance on aid may inadvertently crowd out private sector investment. Governments should strategically utilize foreign aid in a way that complements, rather than replaces, private investment. This may involve using aid to build capacity, improve regulatory frameworks, or fund early-stage projects that later attract private investors.

In sum, the study calls for a holistic approach to policy-making that integrates financial inclusion, sound fiscal management, good governance, and political stability to create a conducive environment for sustainable energy investments through PPPs. These strategies can significantly enhance energy access, contribute to the energy transition, and support economic growth in developing countries.

Limitations and Future Research

The limitations of this study primarily stem from data constraints and model-specific assumptions. Firstly, the study focuses on a limited set of variables to analyze the relationship between FIC and PPI, potentially overlooking other critical factors such as technological innovations, energy market volatility, or regulatory frameworks. Additionally, the dataset may not fully capture the complexities of all regions or countries, especially considering the diversity in economic, political, and energy infrastructure development across countries. The time period covered might also limit the generalizability of the results, as it does not account for more recent economic disruptions, such as the global pandemic or geopolitical events, which could have altered financial inclusion policies and their impact on PPI. Future research could expand on this study by incorporating a broader range of variables such as the role of energy market structures, technological advancements in energy production, or the influence of environmental policies on PPPs in the energy sector. Moreover, future studies could explore the long-term impact of digital financial services and green finance initiatives on energy infrastructure investments.

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