



Public Investment and Renewable Energy in Developing Nations: A Path to Sustainable Growth

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Abstract. This study examines the impact of public finance mechanisms, including public-private partnership (PPP) investments, government subsidies, central government debt, and foreign direct investment (FDI), on renewable energy consumption across five developing countries—Indonesia, Turkey, Ukraine, Malaysia, and South Africa—during the period from 2017 to 2021. Using a panel data regression model, the study reveals that PPP investments have a significant positive effect on renewable energy consumption, highlighting their crucial role in fostering the energy transition in resource-constrained nations. However, the results for government subsidies and central government debt were not statistically significant, suggesting that these public finance tools may not be effectively allocated to promote renewable energy adoption. The findings also demonstrate notable country-specific differences in renewable energy consumption, pointing to the need for tailored policy approaches. This research contributes to the literature by providing empirical evidence on the role of public finance in renewable energy development in emerging economies. Limitations of the study include data constraints and the focus on a small set of countries, which limits the generalisability of the findings. Future research should expand the sample size and explore the long-term effects of public finance mechanisms, as well as the role of institutional quality and governance in shaping renewable energy policies.

Keywords: Public Finance, Renewable Energy, Public-Private Partnership, Developing Countries, Panel Data Analysis

1 Introduction

The transition towards renewable energy has become one of the primary global efforts in addressing climate change and reducing dependency on fossil fuels. Developing countries, such as Indonesia, Turkey, Ukraine, Malaysia, and South Africa, play a critical role in this transition, as they face unique challenges in mobilizing financial resources for renewable energy projects [1]. Despite progress in the adoption of renewable energy, these nations are often constrained by limited public budgets, high levels of government debt, and a dependency on energy subsidies for fossil fuels [2]. At the same time, many of these countries have begun to adopt public-private partnerships (PPPs) to enhance investment in the renewable energy sector, allowing for shared risk between the public and private sectors in energy infrastructure projects.

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Public finance plays a crucial role in overcoming financial barriers to renewable energy investment. Government subsidies, central government debt, and foreign direct investment (FDI) inflows are key instruments that can help accelerate the transition to renewable energy in developing nations. However, rising public debt often creates fiscal burdens that hinder these countries' ability to further invest in the energy sector [3].

Research on the relationship between public finance and renewable energy investment in developing countries remains relatively limited, particularly those that employ multi-country panel data over an extended period. Most previous studies have focused on developed nations or regional analyses, where financial resources are more abundant, and the challenges of energy transition are easier to manage. Therefore, a significant gap exists in the literature regarding how public finance—including public investment, government debt, FDI, and energy subsidies—affects renewable energy consumption in developing countries, particularly during the period from 2017 to 2021.

Developing nations often face a policy dilemma: they must encourage investment in renewable energy to meet long-term climate goals, yet they also confront fiscal pressures that prevent significant investment in green energy infrastructure [4]. In this context, the role of public-private partnerships (PPPs) in alleviating such fiscal pressures becomes increasingly important, though the long-term impact of these partnerships on renewable energy consumption remains underexplored.

This research aims to fill this gap by examining the influence of public finance—through public-private partnership investments, energy subsidies, central government debt, and FDI inflows—on renewable energy consumption in five developing countries (Indonesia, Turkey, Ukraine, Malaysia, and South Africa) over the period from 2017 to 2021. By employing a panel data model, this study is expected to provide new insights into how public financial policies can play a pivotal role in accelerating the energy transition in developing economies.

2 Literature Review

The relationship between public finance and renewable energy consumption can be understood through a combination of public finance theory, neoclassical growth theory, and institutional theory. These theoretical frameworks provide the foundation for understanding how government policies, investments, and institutional arrangements influence the development of the renewable energy sector in developing countries.

Public finance theory posits that government spending and fiscal policies, such as subsidies, debt management, and public investment, are crucial in correcting market failures and promoting public goods. In the context of renewable energy, market failures such as the underpricing of fossil fuels and the public good nature of clean energy necessitate government intervention. Public finance theory suggests that government investments in energy infrastructure, the provision of subsidies, and fiscal tools like debt financing can stimulate renewable energy projects that would otherwise be underfunded due to high initial capital costs or risk aversion among private investors. This theory is particularly relevant for developing countries, where

the state often plays a significant role in driving infrastructural investments that support sustainable development [5].

Neoclassical growth theory, which highlights the importance of capital accumulation and technological advancement as drivers of long-term economic growth, provides a complementary perspective. According to this theory, investments in renewable energy, supported by both public and private sectors, can contribute to economic growth by fostering innovation, improving energy efficiency, and reducing dependence on imported fossil fuels. Public-private partnerships (PPPs) in renewable energy projects facilitate the mobilization of capital and expertise from both the state and the private sector, enhancing the speed and scale of renewable energy adoption in developing countries. Public finance, in this context, acts as a catalyst that reduces investment risk, incentivizes private sector involvement, and accelerates the deployment of clean energy technologies [6].

Institutional theory emphasizes the role of formal and informal institutions in shaping economic behavior and development outcomes. In the case of renewable energy, institutional frameworks—such as regulatory policies, government incentives, and international agreements—are crucial for creating an environment conducive to investment in renewable energy projects. Institutional theory suggests that government debt and fiscal management practices can either enable or hinder the implementation of large-scale renewable energy projects. For example, high levels of public debt may limit a government's ability to finance new energy projects, while well-managed fiscal policies can provide the financial space needed for energy subsidies and other incentives [7]. Furthermore, the stability and effectiveness of institutional frameworks influence the extent to which foreign direct investment (FDI) flows into the renewable energy sector in developing countries [8].

Several empirical studies have explored the relationship between public finance and renewable energy development. A study by Zeng et al. found that government subsidies and investments in renewable energy infrastructure significantly contributed to the growth of renewable energy capacity in China and other developing nations [9]. Similarly, research by Sadorsky demonstrated that FDI inflows have a positive impact on renewable energy consumption, particularly in countries with stable institutional frameworks and supportive government policies [10].

The role of public-private partnerships in facilitating renewable energy investment has also been extensively studied. For instance, Polzin et al. highlighted that PPPs play a crucial role in mitigating the high capital costs and risks associated with renewable energy projects, especially in developing countries where public sector resources are constrained. However, the effectiveness of PPPs is often contingent on the regulatory environment and the presence of adequate government support in the form of subsidies or debt management strategies [11]. Additionally, research by Apergis and Payne established a strong link between public investment in energy infrastructure and long-term economic growth, particularly in developing countries transitioning towards renewable energy. Their findings suggest that well-structured public finance policies can serve as a major driver for both economic development and environmental sustainability [12].

Despite these findings, gaps remain in the literature, particularly regarding the specific roles of government debt, subsidies, and PPP investments in influencing renewable energy consumption across a range of developing countries. The majority

of studies focus on developed nations or single-country case studies, leaving significant room for exploration in the context of multiple developing nations over a comparable period.

Based on the theoretical frameworks and empirical findings discussed, this study proposes the following hypotheses:

H_1 : Public-private partnership investments in renewable energy have a positive effect on renewable energy consumption in developing countries.

H_2 : Government subsidies for energy positively influence renewable energy consumption in developing countries.

H_3 : Central government debt has a negative effect on renewable energy consumption, as high debt levels may restrict a government's ability to invest in renewable energy projects.

H_4 : Foreign direct investment (FDI) inflows positively impact renewable energy consumption in developing countries by providing additional capital and technological know-how.

3 Methodology

This study adopts a quantitative research approach to investigate the impact of public finance variables on renewable energy consumption across five developing countries: Indonesia, Turkey, Ukraine, Malaysia, and South Africa. The analysis focuses on the period between 2017 and 2021. The research employs panel data regression to account for both cross-country and time-series variations. The data used in this study are secondary and sourced from internationally recognized databases such as the World Bank, International Energy Agency (IEA), International Monetary Fund (IMF), and the United Nations Conference on Trade and Development (UNCTAD). Specifically, renewable energy consumption is measured as the percentage of total final energy consumption derived from renewable sources, including solar, wind, biomass, and hydropower. Public-private partnership investments in energy, measured in current US dollars, reflect the total value of infrastructure projects in the energy sector implemented under PPP agreements. The data for government subsidies and other transfers, expressed as a percentage of total government expenditure, represent the financial assistance provided by governments to the energy sector, particularly to encourage renewable energy development. Central government debt, expressed as a percentage of GDP, reflects the financial burden carried by the state, which can potentially restrict the government's ability to invest in energy infrastructure. Foreign direct investment (FDI), measured as net inflows as a percentage of GDP, represents external capital that can significantly contribute to renewable energy projects.

The study uses a panel data regression model, which is particularly advantageous as it controls for unobserved heterogeneity across countries and over time. The two main models employed are the fixed effects (FE) model and the random effects (RE) model. The fixed effects model controls for country-specific characteristics that do not change over time, such as geography or institutional quality. In contrast, the random effects model assumes that differences across entities are uncorrelated with the independent variables. The Hausman test is applied to determine whether the fixed

effects or random effects model is more appropriate. If the test indicates that individual effects are correlated with the independent variables, the fixed effects model is preferred; otherwise, the random effects model is adopted.

The panel data regression model is specified as follows:

$$REC_i = \alpha + \beta_1 PPP_i + \beta_2 SOT_i + \beta_3 CGD_i + \beta_4 FDI_i + \varepsilon_i \quad (S4)$$

In this equation, REC_i refers to renewable energy consumption in country i at time t , which is the dependent variable, measured as the percentage of total final energy consumption derived from renewable sources such as solar, wind, biomass, and hydropower. The independent variables include PPP_i , representing public-private partnership investments in energy, measured in current US dollars, in country i at time t . This variable reflects the total value of infrastructure projects in the energy sector undertaken under public-private partnership agreements, where higher investments are expected to positively influence renewable energy consumption.

The variable SOT_i denotes subsidies and other transfers, measured as a percentage of total government expenditure in country i at time t . These subsidies are financial incentives provided by governments to support renewable energy initiatives and are hypothesized to have a positive impact on the adoption and consumption of renewable energy.

CGD_i represents central government debt, expressed as a percentage of gross domestic product (GDP) in country i at time t . Higher levels of government debt may constrain a government's ability to invest in renewable energy projects due to fiscal limitations, and thus this variable is expected to have a negative relationship with renewable energy consumption. Finally, FDI_i refers to foreign direct investment inflows, measured as a percentage of GDP in country i at time t . FDI inflows bring external capital and technological advancements, which are anticipated to boost renewable energy consumption by enabling large-scale projects and technology transfers. The error term, ε_i , captures other factors not included in the model.

To ensure the robustness of the results, several diagnostic tests are performed. First, stationarity is tested using the Levin-Lin-Chu (LLC) test and the Im-Pesaran-Shin (IPS) test, as stationarity is crucial to avoid spurious regressions. Multicollinearity is checked using the variance inflation factor (VIF); a VIF greater than 10 suggests significant multicollinearity that may distort the results. Heteroskedasticity is assessed using the Breusch-Pagan test, and if heteroskedasticity is present, robust standard errors are employed to correct for this issue. Autocorrelation is examined using the Durbin-Watson statistic, as the presence of autocorrelation in the residuals could lead to inefficient estimates, necessitating model adjustments.

This study adopts a rigorous econometric approach to ensure the accuracy and reliability of the findings. The dataset has been carefully constructed using reputable international sources, and interpolation methods were employed to address missing data, ensuring consistency and comparability across countries and time periods.

4 Result and Discussion

4.1 Regression Analysis

The results from the Fixed Effects panel data regression model provide valuable insights into the impact of public-private partnership investments, government subsidies, and central government debt on renewable energy consumption across five developing countries over the period 2017–2021. The dependent variable in this analysis is renewable energy consumption (REC), while the independent variables include public-private partnership investments (PPP), subsidies and other transfers (SOT), and central government debt (CGD).

From the regression output, the model explains 97.9% of the variation in renewable energy consumption (R-squared = 0.979), indicating a strong fit. The F-statistic of 114.9 (p-value = 4.67e-13) also confirms that the overall model is statistically significant.

Table 1. Descriptive Statistic

Variable	Coefficient	Std. Error	t-Statistic	P-value
Intercept	23.164	3.519	6.582	0.000
Public-private partnership (PPP)	4,92E-07	1.34e-10	3.672	0.002
Subsidies and other transfers (SOT)	-0.0864	0.076	-1.133	0,1895833 33
Central government debt (CGD)	0,2895833 33	0.037	1.114	0,1951388 89
Malaysia (Country effect)	-16.391	1.185	-13.833	0.000
South Africa (Country effect)	-14.296	1.145	-12.488	0.000
Turkey (Country effect)	-10.932	1.212	-9.020	0.000
Ukraine (Country effect)	-14.029	0,6354166 67	-15.327	0.000

Source: Author owns estimation (2024)

The results from the panel data regression analysis reveal several important insights. Public-private partnership investments (PPP) show a positive and statistically significant impact on renewable energy consumption, highlighting the critical role that PPPs play in fostering energy transitions in the countries studied. The coefficient indicates that higher levels of investment in PPP energy projects are associated with increased renewable energy consumption. This finding underscores the importance of mobilizing both public and private resources to finance large-scale renewable energy projects.

However, the results for subsidies and other transfers (SOT), which were expected to positively influence renewable energy consumption, are not statistically significant. The negative coefficient suggests a weak inverse relationship, potentially indicating that subsidies may not be effectively targeted or that other factors, such as policy inefficiencies or allocation towards non-renewable energy sectors, are at play. This finding suggests that the current structure and distribution of energy subsidies in the

countries studied might require further refinement to better support the growth of renewable energy.

The impact of central government debt (CGD) on renewable energy consumption is also found to be statistically insignificant. Although the coefficient is positive, suggesting that higher debt does not necessarily constrain renewable energy investments, the result implies that debt levels alone may not be a major determinant of renewable energy consumption in the short term. This could indicate that despite fiscal constraints, developing countries continue to pursue renewable energy projects, potentially through external financing or targeted investments that are insulated from broader debt concerns.

Additionally, the significant country-specific effects show that renewable energy consumption patterns differ markedly between countries. Malaysia, South Africa, Turkey, and Ukraine all display significantly lower renewable energy consumption levels compared to Indonesia, the baseline country in the analysis. These country-level differences highlight the varied national contexts and institutional factors that influence energy transitions, further reinforcing the importance of tailored energy policies for each country.

4.2 Discussion

The findings of this study highlight the critical importance of public-private partnerships (PPPs) in driving renewable energy consumption in developing countries. As indicated by the significant positive relationship between PPP investments and renewable energy consumption, the mobilization of both public and private resources plays a key role in overcoming the financial barriers that often inhibit large-scale renewable energy projects. This aligns with existing literature, where PPPs are identified as effective mechanisms for pooling resources, sharing risks, and leveraging private sector expertise in infrastructure development. The substantial contribution of PPPs to renewable energy consumption observed in this study suggests that further expansion of such partnerships could accelerate the transition towards clean energy in countries where public sector resources are constrained. However, the lack of significance for subsidies and government debt calls for a more nuanced understanding of how public finance instruments influence energy consumption. Subsidies, while intended to lower the cost barriers for renewable energy adoption, may not be effectively reaching the renewable energy sector, particularly in countries where fossil fuel subsidies dominate the energy policy landscape. This highlights a potential inefficiency in subsidy allocation, where financial resources may be misdirected or insufficient to stimulate significant increases in renewable energy usage.

The insignificance of central government debt in relation to renewable energy consumption suggests that higher debt levels do not necessarily limit a government's capacity to invest in renewable energy. This finding may reflect the broader trend in developing countries of relying on external financing and international aid to support renewable energy projects, rather than solely depending on domestic financial resources. While government debt can impose fiscal constraints, it appears that renewable energy investments are often prioritised, perhaps due to their strategic importance for long-term sustainability goals. Furthermore, the significant country-

specific effects reveal the substantial differences in renewable energy consumption between the countries studied. Factors such as institutional capacity, policy frameworks, and national priorities likely contribute to these differences, suggesting that a one-size-fits-all approach to renewable energy policy may not be effective. Instead, each country requires tailored strategies that account for its unique socio-economic and institutional contexts to ensure the success of renewable energy initiatives. The variation in country-level effects also highlights the importance of robust national policies and institutional frameworks that can effectively guide the implementation of renewable energy projects and ensure the sustainable development of the energy sector.

5 Conclusion

This study has demonstrated the pivotal role of public-private partnerships (PPPs) in promoting renewable energy consumption in developing countries. The significant relationship between PPP investments and renewable energy consumption suggests that mobilizing resources through collaborative public and private sector efforts is a key strategy in overcoming financial barriers to large-scale renewable energy projects. The results also highlight the need to re-evaluate the effectiveness of existing subsidy mechanisms, as the insignificance of subsidies in this study implies that they may not be reaching or effectively stimulating renewable energy adoption. The findings further show that central government debt does not significantly hinder renewable energy consumption, indicating that, even in the context of fiscal constraints, many governments are prioritizing clean energy projects, potentially through external financing and international support.

However, this research has several limitations that should be acknowledged. First, the study is constrained by the availability and consistency of data across the selected countries, which necessitated interpolation for some missing values. This may introduce bias into the analysis. Additionally, the focus on only five developing countries limits the generalizability of the findings to other regions, particularly those with different institutional and policy environments. Future research could expand the sample to include a wider range of countries and explore the long-term effects of public finance mechanisms on renewable energy consumption. Furthermore, investigating the role of institutional quality and governance in mediating the effectiveness of public finance instruments, such as subsidies and debt management, would provide deeper insights into how these factors influence renewable energy transitions.

References

1. International Energy Agency (IEA), *World Energy Outlook 2021*. Paris: IEA, 2021.
2. World Bank, *Financing the Future of Energy*. Washington, DC: World Bank, 2020.
3. International Monetary Fund (IMF), *Fiscal Monitor: Policies for the Recovery*. Washington, DC: IMF, 2020.

4. United Nations Conference on Trade and Development (UNCTAD), *World Investment Report 2021: Investing in Sustainable Recovery*. Geneva: UNCTAD, 2021.
5. R. A. Musgrave and P. B. Musgrave, *Public Finance in Theory and Practice*. New York: McGraw-Hill, 1989.
6. R. M. Solow, "A contribution to the theory of economic growth," *Quarterly Journal of Economics*, vol. 70, no. 1, pp. 65–94, 1956, doi: 10.2307/1884513.
7. D. C. North, *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press, 1990, doi: 10.1017/CBO9780511808678.
8. Z. Tang, Y. Jiang, and L. Liu, "The relationship between institutional quality and renewable energy consumption: The role of foreign direct investment," *Environmental Science and Pollution Research International*, vol. 27, no. 8, pp. 9090–9103, 2020, doi: 10.1007/s11356-020-07621-1.
9. S. Zeng, W. Yuan, L. Zhang, and Y. Wang, "Renewable energy capacity and public finance: A case study in China," *Journal of Cleaner Production*, vol. 256, p. 120550, 2020, doi: 10.1016/j.jclepro.2020.120550.
10. P. Sadorsky, "The impact of financial development on energy consumption in emerging economies," *Energy Policy*, vol. 38, no. 5, pp. 2528–2535, 2012.
11. F. Polzin, M. Migendt, F. A. Täube, and P. von Flotow, "Public policy influence on renewable energy investments: A panel data study across OECD countries," *Energy Policy*, vol. 80, pp. 98–111, 2015.
12. N. Apergis and J. E. Payne, "Renewable energy consumption and growth in Eurasia," *Energy Economics*, vol. 32, no. 6, pp. 1392–1397, 2010.

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