Actions speak louder than words: Determinants of energy transition in PPP projects[1]

Vedanshi Nevatia[2]

Abstract: This paper investigates the determinants of renewable energy transition in public-private partnerships (PPPs) across emerging and developing economies (EMDEs). In the last decade, EMDEs have experienced a systemic compositional shift in PPP investments from fossil fuel to renewable energy projects. By combining the World Bank's PPI database with institutional, macroeconomic, and policy indicators, I analyze the drivers of this shift to inform blended finance policy initiatives in clean energy projects in EMDEs. Using a mixed-method approach, I first conduct a probit analysis to identify project-level characteristics that distinguish renewable from conventional PPPs. I then estimate Tobit and dynamic GMM model specifications to assess how energy access, regulatory quality, investment incentives, and market-based instruments influence the dynamic share of renewable PPPs by volume and investment. The results show that renewable energy PPPs are shaped by multi-dimensional policy environments rather than isolated interventions. Quantifiable actions like public investment, international financial support, and project-based policy tool adoption are consistently associated with greater renewable participation. Investment policies are favored in low-income economies while market and regulatory instruments are more responsive in upper-middle-income contexts. This study highlights the importance of bundled policy approaches and public finance continuity in mobilizing private investment for clean energy, offering actionable insights for sustainable infrastructure planning in emerging markets.

JEL Codes: O13, Q28, Q56, H54, L32, G23, C23

Keywords: Renewable energy, public-private partnerships, infrastructure finance, energy transition, green finance, institutional quality, policy instruments, developing countries, dynamic GMM, climate policy.

[1] This research did not receive any financial support from external sources. The author certifies that they have no material financial relationships (including employment, consulting, or ownership) with firms or institutions that might be substantially affected by this research, as defined by the NBER disclosure policy.

[2] Visiting Assistant Professor, The College of Wooster, 1189 Beall Ave, Wooster, OH 44691. Email: vnevatia@wooster.edu

1. Introduction

An International Energy Agency (IEA) 2021 report on climate financing in Emerging and Developing Economies (EMDEs) states that while EMDEs represent two-thirds of the global population, they receive only one-fifth of clean energy investment and hold just one-tenth of global financial assets[3]. Since 2016, energy investments in these regions have declined by 20%, reflecting persistent barriers to clean energy finance (IEA, 2021). Over 70% of clean energy investments are publicly financed, particularly in the renewable power sector. While clean technologies like the solar PV cells often require high upfront costs, they offer long-term savings through lower operating expenditures. Blended finance mitigates the initial barrier by combining concessional public resources with private capital, reducing initial financial risks and improving the investment attractiveness of these technologies. Consequently, it can be an efficient route to mobilizing private capital through private participation in infrastructure (PPI), especially in high-risk or early-stage markets.

Sovacool, (2013) argues that pro-poor Public-Private Partnerships (PPP) are one of the best mechanisms to supplement and overcome government budgetary constraints for widening access to energy services. Renewable energy PPIs (REPPI) in particular can introduce private sector capital, technological innovation as well as managerial efficiency into public service provisions (Cedrick & Long, 2017). Evidence also suggests that this private sector mobilizing mechanism also offers a transition pathway to mitigate the environmental impact typically associated with foreign direct investment (Caetano et al., 2023). There is a bourgeoning literature that studies the determinants of REPPI in developing economies (Abba et al., 2022; Azhgaliyeva et al., 2023; Baldwin et al., 2017; Fleta-Asín & Muñoz, 2021a; Kim, 2020; Meckling et al., 2022; Othman et al., 2024; Polzin et al., 2019; Ragosa & Warren, 2019; Vagliasindi, 2012). Studies suggest the importance of targeted local and international support (Fleta-Asín & Muñoz, 2021a), holistic enabling clean energy policy mechanisms (Abba et al., 2022), institutional capacity and regulatory certainty (Azhgaliyeva et al., 2023) as pertinent to increasing PPI in renewable infrastructure.

However, almost no research focuses on factors driving energy transition in PPI projects, that is, the systemic compositional shift in PPP investments from fossil fuel to renewable energy technology. Only one study by Vagliasindi, (2012) shows that government schemes and institutional quality affect the entry of PPI in the renewable market, but do not drive the overall switching to renewable energy. In this study, therefore, I address the question of determinants of this *compositional shift* in PPI projects in EMDEs.

[3] Report by IEA, 2021, "Financing Clean Energy Transition in Emerging and Developing Economies." Accessed using: https://www.iea.org/reports/financing-clean-energy-transitions-in-emerging-and-developing-economies.

There is strong evidence that suggests persistent energy transition in PPP investments. Figure 1 illustrates a clear upward trend in the share of renewable energy project volumes and monetary investments within the EMDE PPP portfolio since the early 2000s, with particularly sharp growth after 2010. Vagliasindi, (2012) explains this jump through external factors such as the establishing of the Kyoto Protocol amidst rising oil prices and energy security concerns. However, despite volatility in absolute renewable investment, there has been a consistent rise in both share indicators of infrastructure financing towards clean energy. This motivates the need to understand the policy and institutional drivers of this transition in PPI.

Private sector involvement generally needs guarantees to face policy and the financing uncertainties in EMDEs (Alloisio & Carraro, 2015a). The effectiveness of climate policies in directing PPPs towards renewable energy is dependent on their ability to facilitate smoother investment environments for the private investor. Consequently, current literature emphasizes on risk-management policies and their role in reducing transaction costs in EMDEs (Aziz & Jahan, 2023; Cedrick & Long, 2017; Fleta-Asín & Muñoz, 2021b; H. Wang et al., 2018). This includes project-based infrastructural support, demand creation as well as domestic and international public finance guarantees. More recent literature also explores the synergistic relationships between internal enabling environments of host countries instead of a particular factor in facilitating blended finance (Abba et al., 2022; Ameli et al., 2021; Kerr & Hu, 2025a). Consequently, the effectiveness of policy is shown to vary substantially across income groups and regions (Baldwin et al., 2017). Ciplet et al., (2022) argues that "*climate finance in many ways reproduces relationships of dependency*," that is it favors higher income countries which are less vulnerable to climate change, infrastructural bottlenecks as well as financial volatility.

Following from extant literature, renewable energy engagement through PPPs may not be driven by a single instrument but by the interplay of many factors including energy access expansion, R&D support, market mechanisms, trade relationships and enabling regulatory environments. Hence, in this study, I adopt a mixed-method approach to examine the determinants of renewable energy transitions in PPPs across emerging and developing economies (EMDEs). I integrate quantitative econometric models with text-based analysis of project documentation and policy sources. I draw on a panel dataset of PPI projects undertaken in 72 low- and middle-income countries from 1996 to 2023, constructed by merging the World Bank's PPI database with institutional indicators from the Worldwide Governance Indicators (WGI), macroeconomic variables, and project-level characteristics. I use a keyword-based policy extraction technique to systematically classify local support given to specific renewable energy projects. To perform the empirical analysis, I first apply a probit model to identify distinguishing characteristics of renewable PPPs at the project level. Subsequently, I estimate the Tobit models and the dynamic

difference Generalized Method of Moments (GMM) specifications for country-level data to assess how public finance, cumulative policy actions, income group interactions, and regional heterogeneity influence the intertemporal share of renewable PPPs in both volume and investment value.

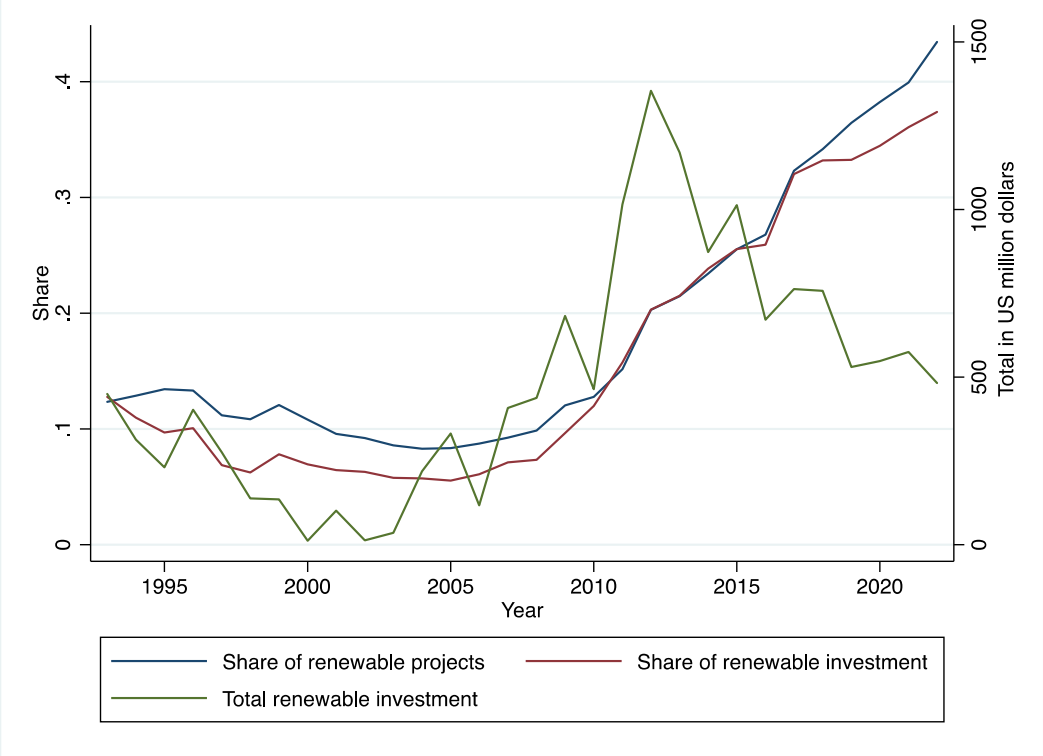


Figure 1. Trends in renewable energy project volumes and monetary investments in Public-Private Partnerships (PPP) in emerging and developing economies between 1994–2022. The blue and red lines (corresponding to the left-axis) indicate the annual share of renewable projects and renewable investment, respectively, as a proportion of total energy PPP activity. The green line (corresponding to the right axis) shows the total volume of renewable investment in millions of U.S. dollars. Sourced from World Bank PPI dataset and author's calculations.

The findings underscore that realized, quantifiable and directed public action- like local and multilateral development bank support given to projects, higher public investment in RE and electricity production through renewable sources- has more consistent associations with compositional change in PPI investments than planned policies and contributions. Moreover, market and trade policies are more responsive in upper-middle income economies. While government institutions matter in initial investment decisions, they do not drive the transition of PPI to renewable energy. These results support the view that energy transition in infrastructure through PPPs needs quantifiable, directed, and regionally tailored policy frameworks to be effective, especially in low-income economies.

This research makes several contributions to the literature on private sector mobilization for infrastructure decarbonization. It is the first study to examine energy transition within the context of PPI projects. By combining static Tobit models with a dynamic GMM framework, the study offers new insights into how policy complementarities, and public finance shape long-term transition trajectories. It further contributes to the data by extracting and quantifying renewable energy-related policy instruments from project-level documentation. The findings offer both diagnostic and prescriptive value for policymakers seeking to design integrated and adaptive policy regimes that crowd in private investment for clean energy infrastructure.

The rest of the chapter is divided as follows: Section 2 presents a review of extant literature, Section 3 luminates the data and the local support extraction process, Section 4 describes the project level analysis model and the corresponding results, Section 5 elucidates on the country-level analysis, results and policy insights and Section 6 concludes.

2. Review of Literature

2.1. Risk-Management in PPI

Risk-management policies, specifically feed-in tariffs (FiTs) and their role in reducing transaction costs for private investors have been a prevalent topic in the extant literature on PPI (Aziz & Jahan, 2023; Cedrick & Long, 2017; Fleta-Asín & Muñoz, 2021a; H. Wang et al., 2018). Lower costs of participation, determined by risk sharing and profit guarantees leads to higher private participation with the public sector (Fleta-Asín & Muñoz, 2021). Aziz & Jahan, (2023) show that renewable energy regulations, FiTs, tendering and public investments have a positive role in attracting renewable investment. Azhgaliyeva et al., (2023) uses panel fixed-effects on 13 countries to illustrate the high impact of smoother investment environments, enhanced FiT mechanisms and government R&D in facilitating private investment from asset finance in developing countries. Kim, (2020) focuses on the variability in PPP policy strength based on technology diffusion stages and finds that government regulatory schemes are more potent that FiT mechanisms. However, multilateral support, prior knowledge, and economy-wide market stability in the host country are all major factors for private finance mobilization. Romano et al., (2017) corroborates these findings, citing green policies as essential in the initial phase of renewable transition.

Alloisio & Carraro, (2015) emphasize on the public-private cooperation for mutual risk sharing in PPP projects. Othman & Khallaf, (2022) use questionnaire survey design to collects opinions of 60 PPP experts and identify political and regulatory barriers as the main global risk factors in renewable energy PPI investment. An interesting result from a panel-data study by Vagliasindi, (2012) is that the likelihood of switching to renewable PPI is driven more by long-run factors like oil prices and the introduction of

Kyoto Protocol rather than the short-run policies. The study also finds that FiT schemes have no impact on reducing the amount of fossil fuel generation through PPP projects.

2.2. Regional Variations in Policy Effectiveness

Several renewable energy PPP case studies on specific regions concentrate on more granular policy approaches. For example, study of PPP in thermal and electric power production through biomass in Greece and Italy (Manos et al., 2014) suggest tailored incentives for local needs and stakeholders. Arbulú et al., (2017) illustrate the efficacy of waste-to-energy in small tourism-dependent islands in Spain. Insights from South Africa's Renewable Energy Independent Power Producer Procurement Program show that private finance in renewable energy can be mobilized through well-designed procurement process, reasonable profitability guarantee and risk mitigation by the government (Eberhard et al., 2014). Baldwin et al., (2017) finds that RE generation is driven by feed-in-tariffs and renewable portfolio standards in high-income countries, feed-in tariffs alone in middle-income countries, and by subsidies in low-income countries. Alloisio & Carraro, (2015) concentrates on the MENA region and shows that the private sector needs guarantee to deal with policy and financing risks associated with the time gap between the project's planning phase and its actual implementation.

2.3. A Holistic Approach

More recent literature on mobilizing private finance for clean energy transition in emerging and developing economies (EMDEs) stresses on the importance of enabling environments of host countries, rather than a particular factor. (Abba et al., 2022; Ameli et al., 2021; Azhgaliyeva et al., 2023; Kerr & Hu, 2025b). The systematic literature review of renewable energy (RE) risks and methods used for risk assessment by Abba et al., (2022) with focus on the Sub-Saharan African countries recognizes that RE risks are complex, dynamic and require multidisciplinary perspectives for effective mitigation. Kerr & Hu, (2025) shows that closing the green finance gap in EMDEs requires leveraging private finance which must involve cohesive packages of public, private, and market support to establish socioeconomic and political frameworks conducive to effective policy execution.

Othman & Khallaf, (2022) reviews PPP projects across 6 regions to report that a combination of government support, strategic planning and policy framework, as well as minimized operating costs drive private investment in EMDEs. Fleta-Asín & Muñoz, (2021) use Tobit estimation technique to demonstrate the importance of better institutional and economic environments, combined with support of multilateral development banks (MDBs) in attracting private renewable investment. Ragosa & Warren, (2019) uses linear and logistic fixed effects model to test the determinants of foreign private capital flows into renewable projects and finds that international public finance is a strong factor, as well as regulatory

support and feed-in-tariffs. L. Wang et al., (2024) studies PPP projects across 36 Belt and Road Initiative countries and cites the role of synergetic institutions rather than a single factor resulting high participation of private investors.

2.4. Energy Transition

Comparative studies of circumstantial and contractual characteristics of renewable and conventional energy PPPs or those analyzing degree of energy transition in PPPs remain scarce. Casady et al., (2024) shows that low-carbon and clean infrastructure are associated with more creative risk-sharing tools and larger stakeholders. Vagliasindi, (2012) also looks at fossil-to-clean energy switching factors, but being an early study, only considers China, Brazil, Peru and Mexico. Čaušević, (2022) discusses risk mitigation for renewable energy investments in developing countries, emphasizing the need for more research on how PPP structures influence the pace and quality of energy transition, especially in Sub-Saharan Africa.

3. Data

3.1. Private Participation in Infrastructure

In order to test for the determinants of energy transition in PPPs, I collect the sample of PPP projects from The World Bank Private Participation in Infrastructure Database (WBPPI), which records "*projects that are owned or managed by private companies in low- and middle-income countries*" with at least 20% stake[4]. To define the sample, I select all projects from the electricity sub-sector, each pertaining to either conventional or renewable technologies[5]. The final sample contains 2075 renewable and 3211 conventional PPPs deployed in 106 countries during the period between 1996-2023. Figure 2 plots the relative percentages of projects across technologies. While diesel and natural gas dominate in electricity production, solar photovoltaic and onshore wind production also account for considerable shares, higher than hydroelectricity.

WBPPI also provides details of other characteristics for each project, including total private investment commitments (in USD million), period of project in years, percentage of private participation, direct and indirect local government support, bilateral and multilateral support, type of project (greenfield, brownfield, management and lease and divestiture), power capacity produced (in kwh), competitive bidding criteria, the status of project (active, completed, distressed or canceled), as well as the region of PPP and its corresponding income group. Additionally, the database keeps a record of project descriptions which provides comprehensive information about the corporation involved, risk-mitigating tools used,

[4] Retrieved from the World Bank Private Participation in Infrastructure Database. https://ppi.worldbank.org/en/ppi.
[5] Projects from other sub-sectors in the database, like Information & Communication Technologies and Transport do not use renewable energy and are therefore not included in the study, in line with previous literature (Fleta-Asín & Muñoz, 2021a).

circumstances surrounding updated statuses of projects if applicable, and other granular details. Table 1 presents summary statistics of all continuous and categorical project-level variables. The statistics illustrated show that renewable projects are on average smaller in capacity, planned for shorter periods and with lesser investment commitments, but with higher percentage` of private risk-sharing.

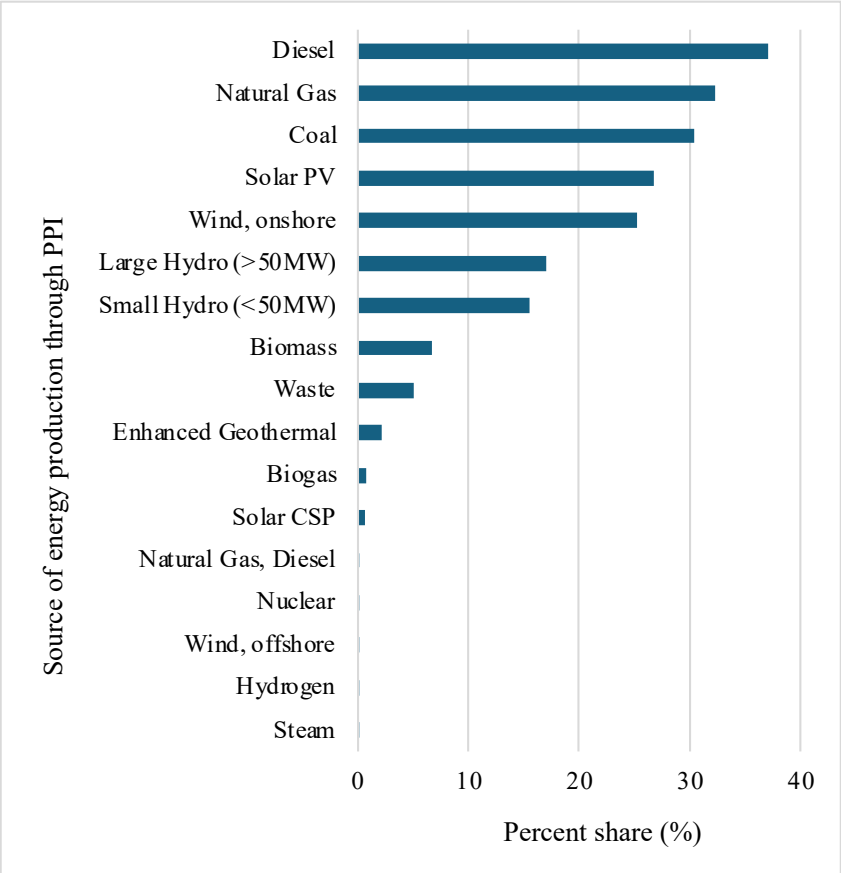


Figure 2: Distribution of private participation in infrastructure (PPI) energy projects across the sources of production.

Table 1. Summary statistics for project-level data

Continuous variables	**Obs.**	**Mean**	**SD**	**Min.**	**Max.**
Power Generation Capacity (in kilowatt hours)					
Conventional:	2,531	1562.563	9063.172	1	350000
Renewable:	2,037	686.6504	19472.52	0.25	850000
Private participation (in %)					
Conventional:	3,027	84.7371	22.69977	1	100
Renewable:	2,065	97.54973	12.79128	8.5	400
Period of project (in years)					
Conventional:	1,698	30.09482	15.7215	1	95
Renewable:	1,025	24.27317	8.13362	3	70
Private investment amount (in USD million)					

Conventional:	2,662	259.3261	549.4361	0.0521	8637
Renewable:	1,982	121.2021	167.6661	1.03	2270

Categorical Variables	**Conventional**	**Renewable**
Status of project		
Active	2848 (88.7%)	2062 (99.37%)
Cancelled	111 (3.46%)	6 (0.29%)
Concluded	49 (1.53%)	7 (0.34%)
Distressed	203 (6.32%)	
Type of project		
Brownfield	821 (25.57%)	36 (1.73%)
Divestiture	881 (27.44%)	21 (1.01%)
Greenfield project	1460 45.47%)	2015 (97.11%)
Management and lease contract	48 (1.49%)	1 (0.05%)
Income Group		
Low income	66 (2.06%)	57 (2.75%)
Lower middle income	828 (25.79%)	633 (31%)
Upper middle income	2317 (72.16%)	1385 (66.75%)
Region		
AFR	153 (4.76%)	196 (9.45%)
EAP	616 (19.18%)	613 (29.54%)
ECA	495 (15.42%)	250 (12.05%)
LAC	1494 (46.53%)	612 (29.49%)
MENA	50 (1.56%)	83 (4%)
SAR	403 (12.55%)	321 (15.47%)
Bilateral Support	83 (2.58%)	236 (11.37%)
Multilateral Support	702 (21.86%)	412 (19.86%)

Note: AFR stands for Sub-Saharan Africa, EAP for East Asia and Pacific, ECA for Europe and Central Asia, LAC for Latin America and the Caribbean, MENA for Middle East and North Africa, and SAR for South Asia Region.

3.2. Extraction of Local Support Tools

Indicator for the type of local support, however, does not contain any information for 87.47% of the projects. WBPPI classifies various support instruments into sub-categories: Direct government support entails government liabilities that cover project costs, either through cash payments or in-kind contributions. It is further categorized into capital subsidies, which fund physical assets during construction; revenue subsidies, which assist with operational revenue recovery (e.g., availability payments); and in-kind contribution, such as land provision. Indirect government support, by contrast, includes contingent liabilities and policy-based incentives that facilitate investment. These include payment guarantees and purchase agreements, debt guarantees, revenue guarantees (ensuring minimum revenue thresholds), exchange rate guarantees, construction cost guarantees, interest rate guarantees, and tariff rate guarantees. Additionally, tax deductions or government credits are considered support if tied

specifically to a project or project type (e.g., renewable energy), though broad-based incentives are excluded.

Many such instruments, while not explicitly stated as sovereign support, appear in contracts of private partnerships with government entities in project descriptions. For example, the Gunung Salak Geothermal Power Plant, a 165 MW facility in West Java, Indonesia was developed as a PPP between PT Dayabumi Salak Pratama (Unocal affiliate) and PT Nusamba Geothermal. It was not provided any direct local support. However, the description notes that "*the project involved expansion of an existing plant operated by the national utility, PLN, under a 30-year power purchase agreement signed in 1995*." Alternatively, PLN promised to purchase electricity produced by the Gunung Salak Geothermal Power Plant on pre-agreed price terms for the next 30 years, hence guaranteeing revenue. The Ergon Peru rural electrification project, another major Peruvian solar PV PPP with planned 173,000 kwh capacity, benefited from a publicly tendered investment contract awarded by the Supervisory Agency for Investment in Energy and Mining. It was supported by a blended finance package from the Peruvian development bank COFIDE and SMBC.

While such projects lack an explicit government guarantee, the involvement of state-owned banks and national utilities suggests strong institutional backing that enhances creditworthiness without constituting a direct sovereign liability. They also, therefore, act as risk-mitigating instruments (Kerr & Hu, 2025b). To identify such public support tools, I employed a systematic keyword-matching approach based on the WBPPI classification. I first scanned the project descriptions for the presence of predefined keywords grouped under three overarching categories: (i) direct support, (ii) indirect support, as well as (iii) clean energy-specific financial instruments. For the first two categories, I utilized the keyword groups mirroring those defined by WBPPI, with an addition of political tools criteria which collects instruments like political risk insurance. The more specific clean energy tools comprised of: (i) *Green finance instruments* (e.g., "green bond", "climate finance"), (ii) *Climate funds* (e.g., "Green Climate Fund", "Climate Investment Fund"), (iii) *Clean energy subsidies* (e.g., "feed-in tariff", "renewable auction"), and (iv) *Market mechanisms* (e.g., "carbon credit", "renewable energy certificate", "clean development mechanism"). I then computed *Tool Count* which aggregates the number of distinct support instruments associated with each project, drawing both from support tool tags in the original database and those identified through keyword extraction. After the extraction, percentage of projects without any form of support dropped to 65.34% (71.35% for conventional and 56.05% for renewable projects). Figure 3 presents a heatmap for category-wise tool count distribution across RE technologies, and Figure 4 shows their corresponding clean-energy tool count concentrations (see Appendix C for conventional tool count distribution).

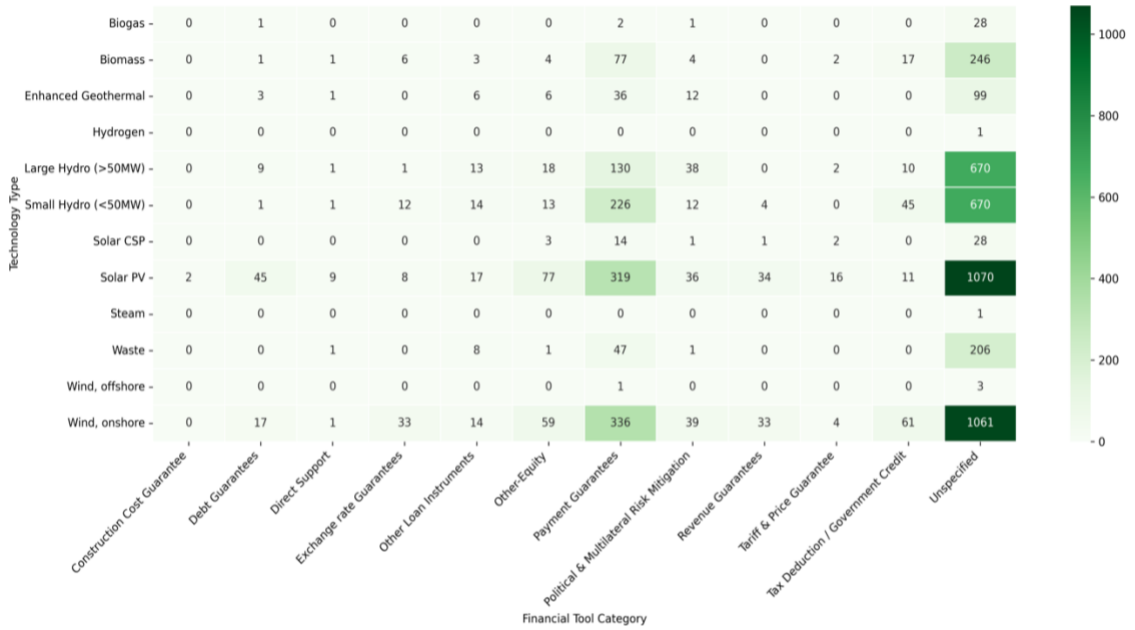


Figure 2: Heat map of renewable energy project-specific local support tool count categorized according to instrument (x-axis) and technology (y-axis). Tool count is calculated from the World Bank private participation in infrastructure database by summing up the local support data and tools extracted from the project description using a keyword extraction process.

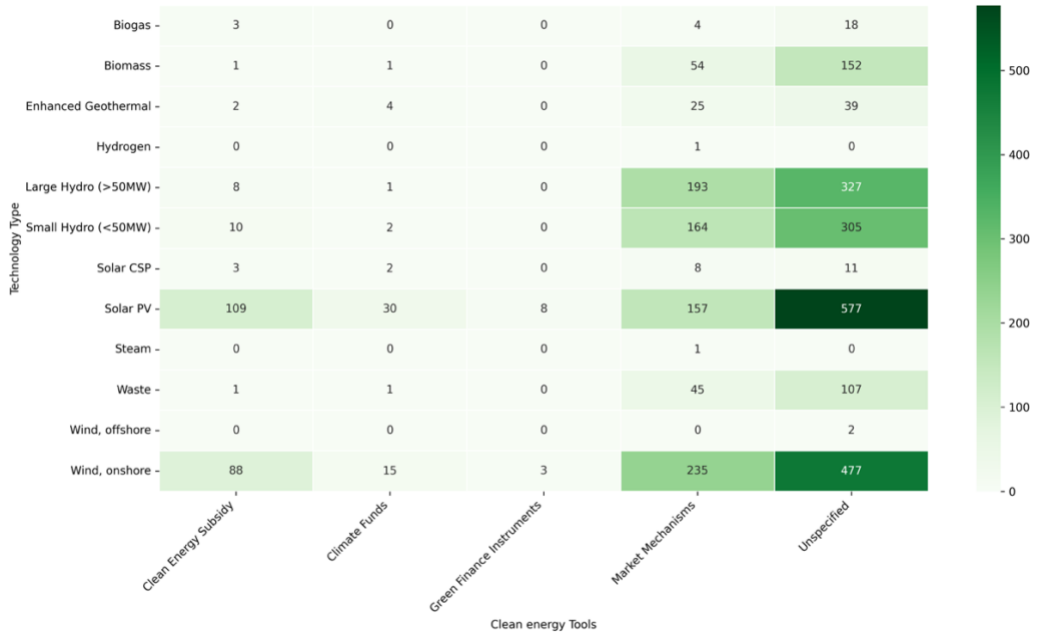


Figure 3: Heat map of renewable energy project-specific clean energy tool count categorized according to instrument (x-axis) and technology (y-axis). Clean energy tool count is extracted from the World Bank private participation in infrastructure database from the project description using a keyword extraction process.

Solar PV and onshore wind projects are most frequently supported, with 1,070 and 1,061 occurrences respectively, followed by small hydro and large hydro projects. Among financial tools, payment guarantees appear prominently across multiple technologies, followed by tax deductions and debt guarantees. Biogas and biomass technologies remain largely unsupported, reflecting different risk profiles across technology types. Solar PV and onshore wind projects are also associated with substantial clean market mechanisms, subsidy tools as well as climate funds (in many cases, green bonds), which can possibly be explained by high upfront costs and a more mature technology diffusion stage (Fleta-Asín & Muñoz, 2021a; Kim, 2020).

3.3. Country-Level Patterns

To examine the dynamics of energy transition within public-private partnerships (PPPs), I construct share variables by dividing the total volumes and investments in renewable energy PPPs by those in all energy-related PPPs at the country-year level. This generates a panel dataset that captures the relative prevalence of renewable energy investments over time and across countries. Figure 5 plots the number of projects pertaining to countries with at least 10 active renewable PPPs while rest are combined under 'Others' category. 22 countries do not have any active renewable energy PPP as of 2023[6]. While many of these are island countries, Ghana is a surprising entry. According to (Kerr & Hu, 2025b), Ghana aims to meet 55% of its conditional emissions cuts via Article 6 under the Paris Agreement, supported by a USD 4.9 billion investment plan, a 2023 carbon market framework, and MOUs with partner countries—positioning it well for future large-scale cooperation. However, it has not exploited the PPP pathway for emission reduction yet.

As per (Kerr & Hu, 2025b), participation in Clean Development Mechanisms (CDMs) has been historically concentrated in a few countries- China, Brazil and India. Similar pattern is reflected in renewable PPP participation, wherein the three countries together account for 58.89% of all RE projects. However, within-country transition of PPP concentration from conventional to renewable technologies in many countries has also been remarkable. Figure 6 shows trends of shares of RE PPP volume and investments across top 10 countries. In many cases, including Mexico, Pakistan, South Africa, Turkey and Ukraine, there is a discontinuous jump between the period 2009-2012. Studies cite growing energy security concerns; rising oil and gas prices; as well as establishment of the Kyoto Protocol in early 2005 as reasons for this momentous shift (Vagliasindi, 2012). Another point to note is the divergence of volume and investment in the case of India, Turkey, Thailand and others, possibly due to higher risks

[6] Countries with only conventional energy PPP: Bolivia, Cameroon, Comoros, Cuba, Dominica, Fiji, The Gambia, Ghana, Grenada, Guinea-Bissau, Guyana, Haiti, Iraq, Kyrgyz Republic, Lebanon, Moldova, Papua New Guinea, Timor-Leste, Uruguay, Venezuela (RB), West Bank and Gaza, and Yemen (Rep.).

associated with larger investments. Such trends however necessitate a relative (over absolute) study of energy sources for nuanced policy perspectives.

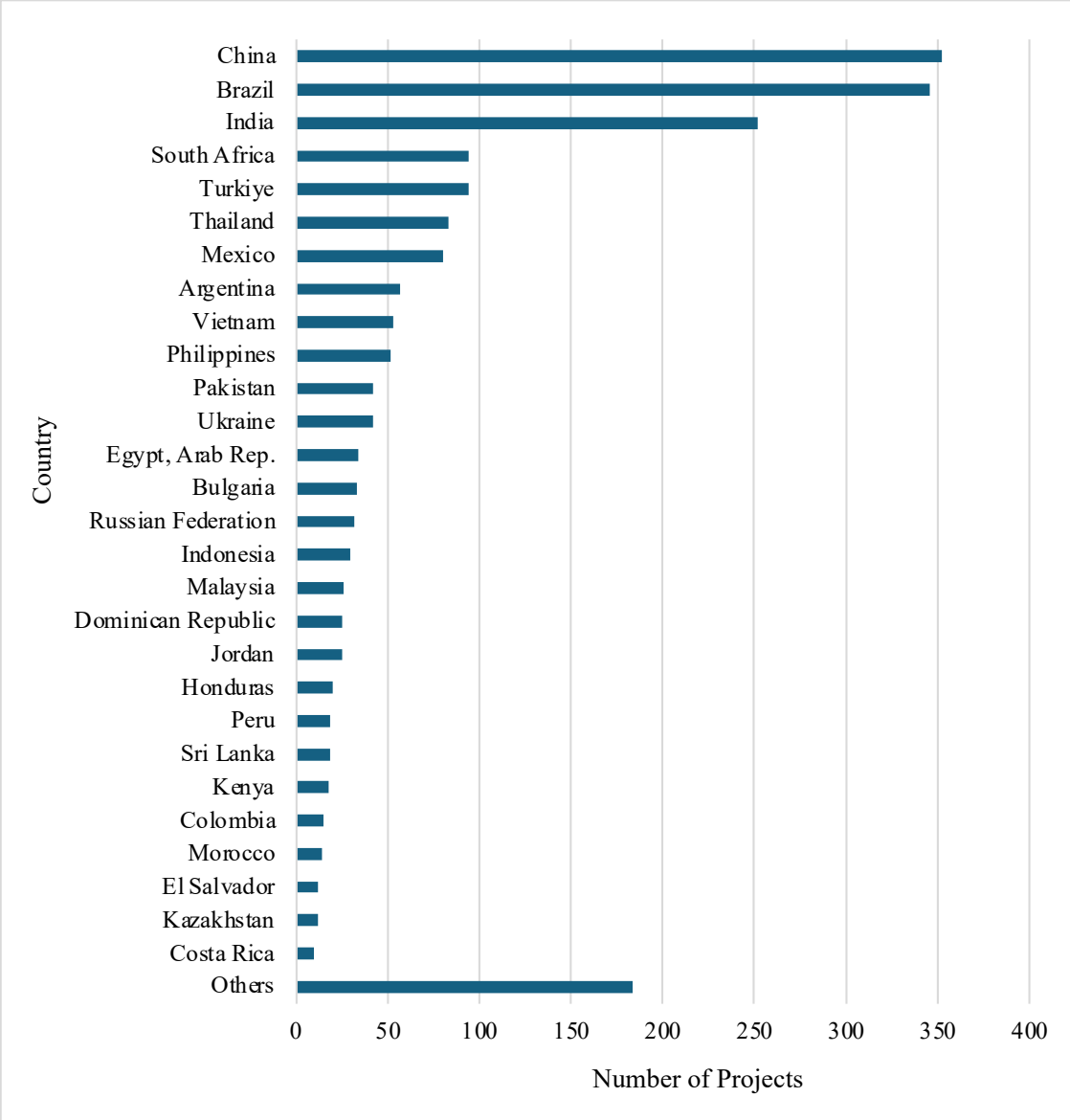


Figure 4: Distribution of private participation in infrastructure (PPI) renewable energy projects across countries.

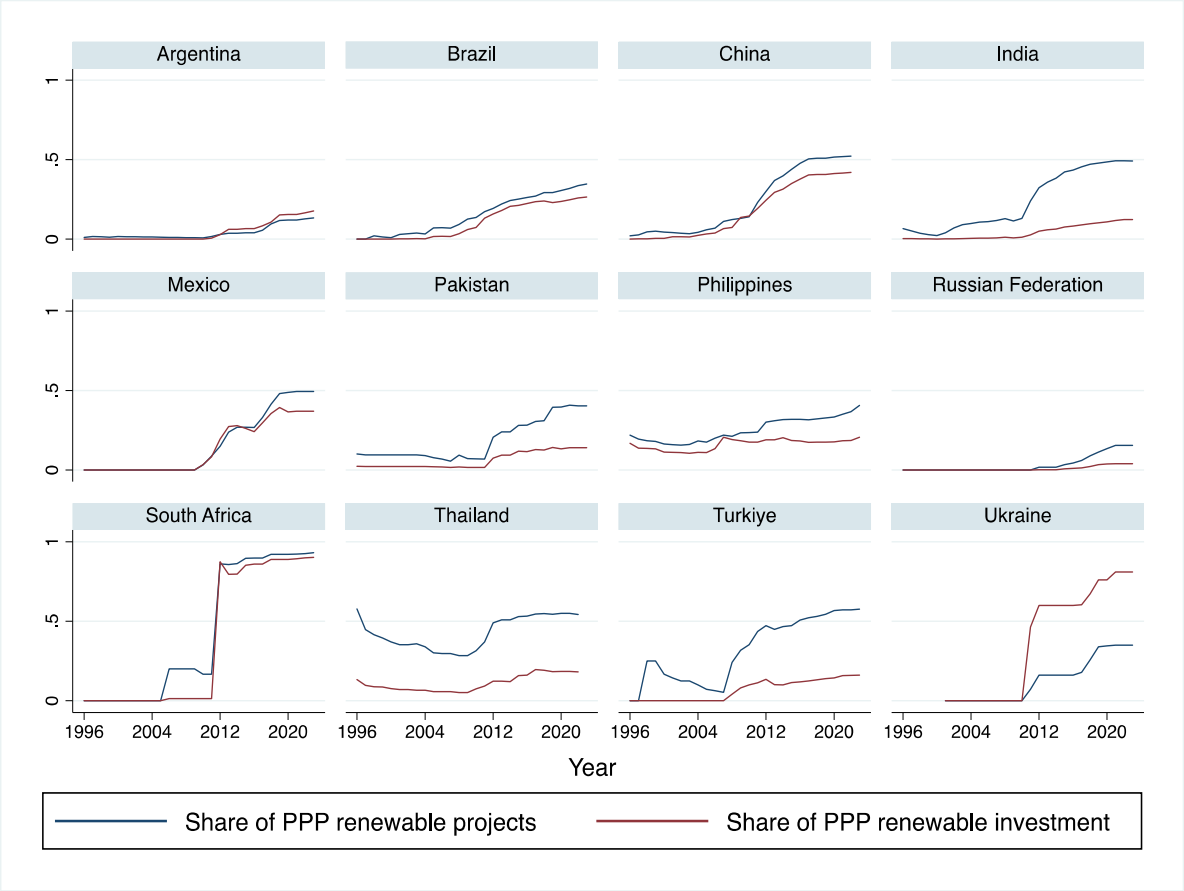


Figure 5: Trends in renewable energy project volumes and monetary investments in Public-Private Partnerships (PPP) in top 10 emerging and developing economies between 1994–2022. The blue and red lines indicate the annual share of renewable projects and renewable investment, respectively, as a proportion of total energy PPP activity.

3.4. Climate Policy

I construct policy instruments using the IEA/IRENA Renewable Energy Policies and Measures Database[7,8]. I divide the policies into six categories based on instrument type: regulatory instruments, market-based instruments, public finance and R&D, planning and framework, free-trade agreements and energy access. *Regulatory instruments* represent obligations schemes that have legally binding targets like

[7] The database is the most comprehensive cross-country compilation of renewable energy policy measures available from internationally recognized agencies. It has been widely used by studies for developing country analysis (Baldwin et al., 2017; Carley et al., 2017; Fleta-Asín & Muñoz, 2021a). Data retrieved from the IEA's renewables policies and measures website (https://www.iea.org/policies/about) in April 2025.

[8] Note that policy indicators designed in this section differ from project-based local support in Section 3.2. The former are overarching country-wide measures which can be assumed to have lagged effects on PPP adoption (Fleta-Asín & Muñoz, 2021a), while the latter can differ across projects and serves to assess risk-mitigation by the government.

utilities and generators required to meet the quantity goals on purchase, ban or limitations on fossil fuel generation, antidumping measures on solar PV cells, steel coils and other industrial waste related to energy production, and greenhouse gas emissions allowance. While obligation schemes have been found to have positive impact on RE PPP adoption (Fleta-Asín & Muñoz, 2021a), other policies have not been adequately tested in literature.

Market-based instruments include FiT, carbon pricing schemes, and tax relief. FiTs offer revenue certainty by ensuring that producers receive a fixed payment to cover production costs. Prior research has explored the risks associated with FiTs (Carley et al., 2017). Structurally, FiTs are designed to deliver a predictable income stream over time; however, this future revenue is contingent on the continued existence of the policy. As a result, in developing countries, investors often prefer immediate financial support over deferred returns. Tax incentives offer time-bound reductions in tax obligations to encourage investment. Carbon tax is a powerful instrument that can increase relative competitiveness of RE technologies in host countries (Bistline et al., 2023). It has only been enacted by five countries in the sample: Argentina, Colombia, Mexico, Chile, Ukraine and South Africa.

Public finance refers to government spending in various transition measures, such as carbon capture and storage, investment in clean technologies, infrastructure, transport and power. It also includes grants to provide financial support to project developers by lowering upfront costs of RE projects in various scales. Public finance has also not received proper attention in literature (Polzin et al., 2019). *R&D* entails training programs for innovation and green jobs, incentives for innovations, and knowledge management. Not many countries have adopted these measures. Nationally Determined Contributions (NDCs) and strategic plans for RE capacity targets to achieve fall under *Planning and framework instruments.* While not obligatory*,* such schemes demonstrate government's willingness for RE transition.

Clean energy provisions under *Free Trade Agreements (FTAs)* relate exclusively to cross-border PPPs. While studies find that international cooperation can accelerate energy transition (Raghutla & Kolati, 2023), degree of quantifiability of FTA provisions matter (Dent, 2021). However, the relationship between PPP and FTAs has been understudied. Another underexplored policy area is the spillover effects of increasing *access to energy* on PPP. While the literature finds positive impact of PPP on renewable energy consumption (Yin & Qamruzzaman, 2024a), policies tagged as promoting socioeconomic inclusion may attract PPP through indirect provisions. For example, the Peruvian government created the Social Inclusion Energy Fund (FISE) in 2012 to bring clean energy to the most vulnerable segments of the population. The programs financed by this fund consisted of granting subsidies on LPG prices and electricity tariffs to low-income households, promoting car conversions to LPG or natural gas, and installing solar PVs in isolated homes that are not physically connected to the grid. This led to 177 609

solar panels being installed by 2019. Peru also had solar PV PPPs during the period. Empirical tests of this association may reveal interesting insights.

All policy indicators are coded as binary: they take the value 1 if a policy is in force, and 0 if it has ended or not introduced. They are then aggregated for each country for each year. The country-level summary statistics for each policy instrument is given in Table 2.

Table 2: Summary statistics for country-level data

	Obs.	Mean	SD	Min.	Max.
Project variables					
Share of renewable PPP investments	1,705	0.1838	0.2973	0	1
Share of renewable PPP projects	1,705	0.2161	0.2774	0	1
Cumulative local support	1,705	1.7916	3.5680	0	25.5957
Cumulative international support	1,705	0.9419	1.7586	0	10.8833
Macroeconomic Indicators					
GDP	1,692	4.0339	4.5355	-28.7586	34.5000
Inflow of FDI (% GDP)	1,689	4.0085	6.3164	-37.1727	103.3374
Inflation (CPI)	1,692	9.8406	31.7097	-27.0487	921.5357
Public investment in renewables	1,693	219.8092	673.2811	0.0000	6821.4700
Infrastructure Score	568	53.1778	20.5326	10.0000	100.0000
Renewable Electricity Production (in million kwh)	1,355	6820	50800	0	1110000
Fossil fuel consumption (%total)	1,490	63.3837	27.4996	0	100
Climate Policy Action					
Regulatory policy score	1,693	1.9421	4.2367	0.0000	41.0000
Market mechanism score	1,693	0.4282	1.1190	0.0000	12.0000
Planning and framework score	1,693	0.4595	1.2064	0.0000	10.0000
Investment policy score	1,693	1.0248	3.4314	0.0000	47.0000
Trade policy score	1,693	4.6078	5.9488	0.0000	42.0000
Access to energy policy score	1,693	4.2717	10.8179	0.0000	147.0000
World Governance Indicators					
Voice & Accountability	1,693	-0.3383	0.7112	-2.2333	1.2221
Control of corruption	1,685	-0.5085	0.5243	-1.6728	1.3309
Government Effectiveness	1,685	-0.3675	0.5226	-1.9870	1.2377
Political Stability	1,690	-0.4446	0.7604	-2.8100	1.2752
Rule of Law	1,693	-0.4822	0.5306	-1.9225	0.9122
Regulatory quality	1,685	-0.3243	0.5791	-2.3486	1.2602

3.5. Governance Indicators and Other Variables

Apart from policy architectural tools, a possibly important yet understudied driver of RE PPP is direct public expenditure in renewable energy (Kim, 2020). Distinct from domestic planned investment and R&D schemes as described in Section 3.4, RE public investment as measured by the International

Renewable Energy Agency (IRENA) includes all domestic, international and MDB contributions to the host country's renewable infrastructure through various instruments including debt, equity, and grants. It therefore represents all realized public financial flows towards renewable projects and can spur transition through targeted funding and early-stage risk-management. I include country-wise public investment (in USD million) for each year to test this association.

Developing countries pose higher political, management and administrative risks for investors (Ameli et al., 2021). To account for institutional factors, I therefore use the World Bank's Worldwide Governance Indicators database (WGI). WGI has been used widely in literature examining the governance impact on PPP (Fleta-Asín & Muñoz, 2021a; Percoco, 2014; Spohr et al., 2024) due to its comprehensive, multi-dimensional framework. It covers six measures: voice and accountability (VA), political stability and absence of violence (PS), government effectiveness (GE), regulatory quality (RQ), rule of law (RL), and control of corruption (CC). Kaufmann et al., (2010) defines governance indicators as follows: control of corruption measures the misuse of public power for private gain; government effectiveness captures the quality and independence of public services and policymaking; political stability reflects the risk of government destabilization through violence; regulatory quality assesses the ability to design policies supporting private sector growth; rule of law measures confidence in legal institutions and protection of rights; and voice and accountability capture citizen participation and freedoms of expression, association, and media. However, to avoid collinearity, combinations of uncorrelated indicators are used together in the empirical model (see Appendix C for the correlation matrix).

Additionally, I use renewable electricity production (in kilowatt hours) as a proxy for adoption and scaling of renewable energy technology. While not a perfect measure, it serves to account for degree of technology diffusion in the host country (Kim, 2020). I also use percentage of energy consumption from fossil fuel sources to measure the change in structural composition of energy demand. Infrastructure score is used to account for infrastructural quality in the host country, including grid connectivity and renewable energy integration. Finally, I use GDP (% growth), inflation (% CPI) and inflow of FDI (% of GDP) to control for economy size, macroeconomic stability and degree of openness of the economy. All abovementioned variables are extracted from the World Development Indicators (WDI) by World Bank. Summary statistics for all variables are given in Table 2.

4. Project-Level Analysis

4.1. Probit Model

In this section, I examine the project-level characteristics distinguishing renewable PPPs from conventional ones. Given the binary nature of the dependent variable, probit regression is an appropriate methodology to estimate the probability of a PPP being renewable (or conventional) based on relevant characteristics. This initial step will help identify significant predictors and provide preliminary evidence, guiding variable selection and structuring subsequent aggregated country level analysis.

In line with previous literature (Kim, 2020), projects are restricted to non-hydro renewable energy (NHRE) due to the prevalent skepticism regarding large hydropower's classification as a sustainable source (Chala et al., 2019). The probit model is specified as:

$$Pr(ren_i = 1/X_i) = \Phi\big(\alpha + \beta_1 Income_i + \beta_2 Type_i + \beta_3 Status_i + \beta_4 Int_Support_i + \beta_5 Tool_Count_i + \beta_6 Inv_i + \beta_7 Period_i + \beta_8 Region_i + \beta_9 Private_i + \beta_{10} Capacity_i\big) \quad (1)$$

where Φ is the cumulative distribution function of the standard normal distribution. ren_i is the binary dependent variable that takes the value 1 if the project is renewable and 0 if conventional. The independent categorical variables include host-country's category according to income-level ($Income_i$), project type ($Type_i$), project status ($Status_i$), degree of international support ($Int_Support_i$), and region of PPP deployment ($Region_i$). The continuous explanatory variables are number of policy tools ($Tool_Count_i$), project investment size (Inv_i), project period ($Period_i$), private sector participation share ($Private_i$), and project capacity ($Capacity_i$). To construct the degree of international support, I assign 0 to projects with no support, 1 to projects with either bilateral or multilateral support, and 2 to projects with both supports. All other variable descriptions follow from section 3.

4.2. Probit Results

Results from the probit model confirms that Renewable energy PPPs are significantly different in circumstantial and contractual characteristics from conventional energy PPPs. The marginal effects for project characteristics with statistically significant explanatory power are illustrated in Figure 7 (see Appendix C for detailed results). In line with (Kerr & Hu, 2025b), results indicate PPP concentration in comparatively well-equipped countries. Figure 7(i) shows that projects in lower-middle (p-value=0.012) and upper-middle-income (p-value=0.000) countries are significantly more likely to be renewable compared to low-income countries. Regional differences are also statistically significant, with lower renewable PPP probabilities observed in Latin America and the Caribbean (LAC) and South Asia Region

(SAR) (Figure 7(v)). This is interesting, as although Brazil and India are countries with highest number of renewable projects, fossil fuels have historically dominated most of these regions' PPP portfolio. After controlling for project and country characteristics, the relative likelihood of a PPP being renewable remains lower in LAC and SAR regions due to the continued prevalence of conventional energy projects.

Project type, status, capacity, amount of investment, private participation, tool count and international support, together account for the project's degree of risk-loading. Categories within project type range from management and lease contract (in which the private contractor only assumes the risk of managing a public asset) to full divestiture (wherein the private investor bears ownership of building, operating and running the project). Greenfield projects that are usually build-operate-transfer projects also hand over substantial risk to private firms and they significantly predict renewable investment (p-value = 0.000) (Figure 7(ii)). Fleta-Asín & Muñoz, (2020) uses this project type as a proxy for degree of risk-transfer to the private investor. They show that higher risk-transfer relates to higher probability of PPP success. This association seems to explain RE deployment as well. Figure 7(vi) shows that greater private sector involvement is associated with higher probabilities of a PPP being renewable, and Figure 7(iii) illustrates that cancelled and concluded projects negatively predict renewable status.

However, other factors suggest that the additional ownership borne by private firms is also backed by more risk-management tools in case of RE projects. In line with literature, more international support and numbers of policy tools significantly increases renewable PPP likelihood (p = 0.000) (Fleta-Asín & Muñoz, 2021a). These results highlight the importance of supportive policy environments in facilitating renewable PPPs. Subsequent country-level analysis incorporates the relative share of project type, status and tool count to systematically assess the policy, macroeconomic and institutional drivers of renewable energy transitions in PPP markets. Model specifications also distinguish across regions and income-levels.

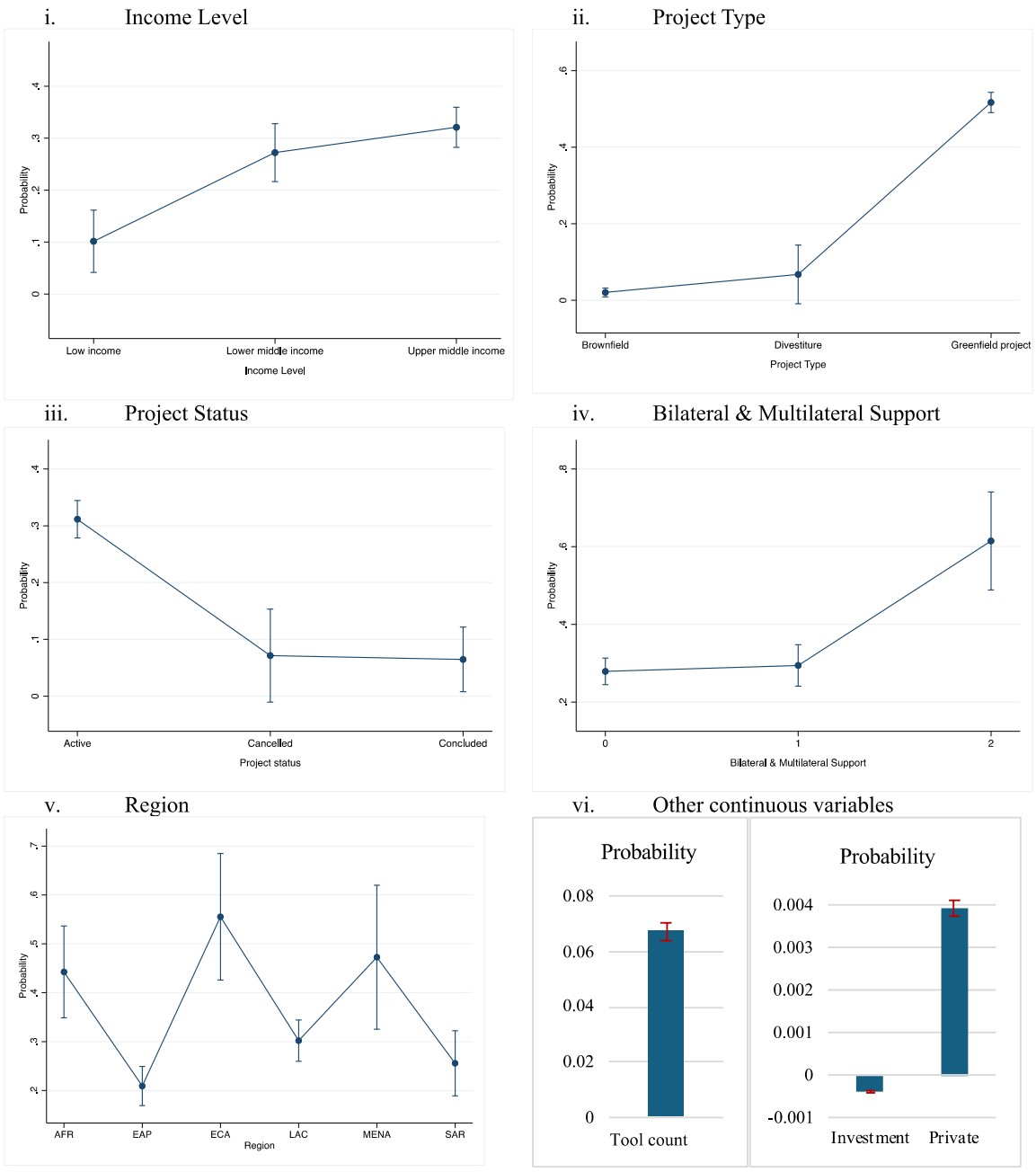


Figure 6: Marginal effects from the probit model estimating the probability of a PPP project being renewable. The plots display average marginal effects with 95% confidence intervals for (i) income level, (ii) project type, (iii) project status, (iv) bilateral/multilateral support, (v) regional groupings, (vi) Other continuous variables including local support tool count, total private investment, and private participation.

5. Country-Level Analysis

5.1. Method

I use two methods to test for hypotheses H2-H4 (Section 2). H2: '*Share of renewable energy in PPPs is influenced by a multidimensional set of systemic factors rather than being predominantly driven by a singular policy instrument'* and H3: '*Impact of factors driving share of renewable energy vary across regions and income groups'* address structural but static questions. Accordingly, I use the panel-data Tobit model censored at lower limit 0 and upper limit 1, to examine the drivers of share of renewable energy projects and investment in PPP. Given that data for explanatory variables is not available for many developing countries, the final panel contains observations for 72 countries across 23 years (1996-2023).

The Tobit model has been commonly used in the PPP literature (Fleta-Asín & Muñoz, 2021a; H. Wang et al., 2018; L. Wang et al., 2024), but it is not without its limitations (Kim, 2020). In this research, since the data distribution is such that a large proportion of values of the dependent variables are clustered at 0 and 1 (see Appendix C) which reflects actual private investor choices rather than data deficiencies, the Tobit model is the most appropriate modeling choice (Amore & Murtinu, 2021). Given the high degree of correlation among several policy and institutional indicators (see Appendix C), I employ four distinct model specifications, each incorporating different combinations of variables, to examine systematic associations. Model specification 1 (Equation 2) assesses the role of energy access and policy support instruments. Model specification 2 (Equation 3) isolate the impact of regulatory and institutional frameworks. Model specification 3 (Equation 4) analyzes investment-related drivers. And Model specification 4 (Equation 5), examine the influence of market-oriented policy factors. The model specifications are respectively:

$$Ren_share_{it} = \beta_0 + \beta_1 Macro_{it} + \beta_2 GE_{it} + \beta_3 Plan_{it} + \beta_4 (Access_{it} \times Inc_i) + \beta_5 Tools_{it} + \beta_6 Int_sup_{it} + \gamma_t + \mu_i + \epsilon_{it} \quad (2)$$

$$Ren_share_{it} = \beta_0 + \beta_1 Macro_{it} + \beta_2 GE_{it} + \beta_3 VA_{it} + \beta_4 RL_{it} + \beta_5 (Reg_{it} \times Inc_i) + \beta_6 Tools_{it} + \beta_7 Int_sup_{it} + \gamma_t + \mu_i + \epsilon_{it} \quad (3)$$

$$Ren_share_{it} = \beta_0 + \beta_1 Macro_{it} + \beta_2 GE_{it} + \beta_5 (Inv_{it} \times Inc_i) + \beta_6 Tools_{it} + \beta_7 Int_sup_{it} + \gamma_t + \mu_i + \epsilon_{it} \quad (4)$$

$$Ren_share_{it} = \beta_0 + \beta_1 Macro_{it} + \beta_2 GE_{it} + \beta_3 (Market_{it} \times Region_i) + \beta_4 Trade_{it} + \beta_6 Tools_{it} + \beta_7 Int_sup_{it} + \gamma_t + \mu_i + \epsilon_{it} \quad (5)$$

where Ren_share_{it} represents the share of monetary amount of private investment commitment in RE projects in developing county i in the year t, *Macro* is the vector of macroeconomic variables, *GE* is institutional indicator for government effectiveness. It is used as a proxy for governance quality control in all models except Model 2 that tests for institutional framework (L. Wang et al., 2024). *Int_sup* is the aggregated multilateral and bilateral support and *Tools* is the aggregated domestic support provided for each project in a country in a year and they act as proxy for degree of targeted risk-mitigation. γ_t indicates country fixed-effects and μ_i time fixed-effects. ϵ_{it} represents robust standard errors. I incorporate the abovementioned variables in all models, while the rest I employ as per model specifications.

A combination of energy access policy factor, *Access*, and planning and framework policy factor, *Plan* is used in Model 1. *VA* is the governance indicator for voice and accountability and *RL* for rule of law. These are incorporated in Model 2 with *GE*[9] and the regulatory policy indicator, *Reg*. *Inv* is the public finance and R&D policy factor used in Model 3. And Model 4 comprises of *Market* representing market mechanism policy factor and *Trade* representing FTA policy factor. I interact the policy factors with categorical variables for income, *Inc*, and for region, *Region,* to test for spatial heterogeneity in policy adoption. I also run all models with share of number of renewable projects, *Ren_count* as the dependent variable.

Hypothesis H4: '*Energy transition in PPP is a trend dependent phenomenon influenced by endogenous policies and institutions'* states a dynamic phenomenon. Consequently, to account for the growth trajectory of renewable energy participation over time, I employ a Generalized Method of Moments (GMM) estimation strategy. The GMM framework is particularly suited to modeling dynamic processes, as it allows for the inclusion of lagged dependent variables as regressors while addressing potential endogeneity issues. For instance, if more climate policy actions lead to higher RE PPP concentration, higher concentration can also prompt supporting policy actions, leading to simultaneity problem in the Tobit model (Pindyck, 1998). I employ a two-step Arellano-Bond dynamic panel GMM estimator (Arellano & Bond, 1991; Arellano & Bover, 1995), which is widely used for instrumental variable (IV) estimation. GMM offers efficiency gains over conventional 2SLS, particularly under heteroskedasticity, by exploiting orthogonality or first-difference conditions between instruments and error terms. The problem of autocorrelation caused by lagged dependent variable is also resolved by instrumenting it with past levels.

[9] Since the correlation factor for GE, VA and RL is less than 0.5, they can be used together in the model. However, other WGI indicators are highly correlated with either GE, VA or RL, and are excluded from the model.

Likewise, I use lagged values of dependent and independent variables in level form as instruments in a first difference equation. This method controls for weak forms of endogeneity since it assumes these variables are weakly exogenous, which is theoretically relevant for this study. While the systems GMM (Blundell & Bond, 1998) is suited for strong cases of endogeneity, it requires the additional assumption that the differences used as instruments are uncorrelated with the error term (mean stationarity). I augment difference GMM with Ahn-Schmidt nonlinear moment conditions (Ahn & Schmidt, 1995) which not only overcomes the weak instrument problem of Arellano & Bond, (1991) but is also robust to deviations from mean stationarity. I also run the model with the Arellano & Bond, (1991) estimator, and find that the results are robust (see Appendix C).

To address the prevalence of zeros, I exclude countries with no renewable PPP projects before 2015, which reduces the panel by 17 countries. The 4 model specifications follow from the Tobit model, with the addition of lagged first-difference variables. A general form is presented below:

$$Ren_share_{it} - Ren_share_{it-1} = \beta_1(Macro_{it} - Macro_{it-1}) + \beta_2(WGI_{it} - WGI_{it-1}) + \beta_3(Project_{it} - Project_{it-1}) + \beta_4(Policy_{it} - Policy_{it-1}) + \epsilon_{it} \quad (6)$$

where the subscript $t-1$ represents l lag for the corresponding variable, *WGI* are the vector of selected WGI indicators, *Project* represent project-level controls and *Policy* is the vector for selected policy factors as per model specifications given above.

5.2. Results and Discussion

Table 3 -6 present the results from the Tobit (marginal effects) and GMM regression models for the dependent variables: share of renewable PPP investment (*ren_share*) and share of renewable PPP volumes (*ren_count*). Results are divided according to model specifications: Table 3 primarily shows the association with energy access and framework policies, Table 4 that with regulatory policies, Table 5 that with public finance and R&D policies and Table 6 with market mechanisms and trade policies.

Direct public investment

The strong positive association between public investment in renewables and the share of renewable PPP is observed across all specifications (Table 3-Table 6) in both static (Tobit) and dynamic (GMM) models. The data reveals statistically significant positive coefficients for public investment across both Tobit (0.0142 for renewable share, 0.0123 for renewable count) and GMM (0.0151 for renewable share, 0.0131 for renewable count) specifications. Consequently, not only is public contribution to climate finance associated with higher shares of RE PPP, but also increasing public RE investment enables energy transition. This highlights the catalytic role of public capital in mobilizing private participation for energy

infrastructure (Meckling et al., 2022). Literature shows that public investment provides crucial early-stage risk mitigation by absorbing initial costs and uncertainties that typically deter private investors in emerging markets (Ameli et al., 2020); it signals government commitment to renewable energy policy stability; and it creates demonstration effects that validate technology viability and market potential (Azhgaliyeva et al., 2023).

This enabling relationship of public finance is corroborated by the statistically significant positive coefficients for the investment and R&D policy factor (*Inv*) in Table 5. The static association (from the Tobit model) is strongest for low-income countries, in which case 1-unit increase in public finance policy factor is related to 0.17 units larger share of RE PPP investments and 0.21 units larger share of RE PPP project numbers. However, the dynamic relation (from the GMM model) is statistically significant only in case of upper-middle income countries, indicating long foundational phases for emerging markets before climate investment policy can be effectively operationalized (Kim, 2020). This result is supported by study by Ragosa & Warren, (2019) that show that while policies drive the early decision to invest, international public finance is what might ultimately push investors to provide more RE capital. The stronger explanatory power of direct investment over finance policy demonstrates the effectiveness of immediate over planned action. While the magnitude of the effect of investment *policies* is higher, it is not always significant, that is, corresponding policy outcomes are context-dependent, and the efficacy of such interventions may not be uniformly realized. This is not the case with direct public finance, which consistently results in statistically significant, albeit small, private RE investment.

Table 3: Results from Tobit and Generalized Method of Moments (GMM) model specification 1

	Tobit Ren_share	**Tobit Ren_count**	**GMM Ren_share**	**GMM Ren_count**
Energy Access	-0.0013	0.0000	0.00131***	0.00136***
	(0.0008)	(0.0007)	(0.000331)	(0.000269)
Plan	0.0295*	0.0176	0.00198	0.00361
	(0.0129)	(0.0116)	(0.00225)	(0.00228)
Int_sup x Low income	0.1276***	0.0817***	0.0216**	0.0258**
	(0.0209)	(0.0185)	(0.0128)	(0.0151)
Int_sup x Lower middle income	0.0206**	0.0164**	0.0134*	0.00901*
	(0.0059)	(0.0054)	(0.00715)	(0.00518)
Int_sup x Upper middle income	0.0303**	0.0496***	0.00236*	0.000251*
	(0.0088)	(0.0079)	(0.00694)	(0.00763)
Tools	0.0150***	0.0093**	-0.00269	0.000903
	(0.0031)	(0.0028)	(0.00308)	(0.00277)
Public investment*	0.0149***	0.0128***	0.00385**	0.00312**
	(0.0037)	(0.0033)	(0.00151)	(0.00131)
Fossil fuel energy cons. (%) *	0.1330	0.2803**	0.0135*	0.0919*
	(0.0869)	(0.0766)	(0.0471)	(0.0348)
RE electricity prod. (kwh) *	0.0263***	0.0245***		
	(0.0052)	(0.0046)		
Constant			0.0589**	0.0652***
			(0.0250)	(0.0173)

Regulation controls	YES	YES	YES	YES
Macroeconomic controls	YES	YES	YES	YES
Lagged DV	NO	NO	YES	YES
Observations	777	777	792	792
Number of countries	61	61	46	46

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for Tobit and GMM models for share of renewable PPP investments (*ren_share*) and share of renewable PPP volumes (*ren_count*) respectively. Only marginal effects from the Tobit model are shown here. All variables for GMM specification are lagged by 1 degree. *L.Depvar* is the corresponding lagged dependent variable for the GMM model. *Int_sup* is the international support indicator. *Access* is the energy access policy indicator, and *Plan* is the planning and framework policy indicator.

Local and International Support

Project-specific MDB support (*Int_sup*) and domestic government tools (*Tools*) also exhibit consistently strong and statistically significant positive associations with the share and count of renewable energy PPPs. 1-unit higher MDB support is associated with 0.013 higher shares on average (Tables 3 -6) and this link dynamically increases over time, reflecting the compounding nature of targeted support. Also, while being statistically significant across all income levels, the magnitude of coefficients is strongest for low-income countries and for RE PPP shares of monetary investments (Table 3). The pattern is corroborated by the extant literature. (Fleta-Asín & Muñoz, 2021a) show that both international and local financial support, as well as the deployment of risk-mitigation instruments (such as guarantees, subsidies, and blended finance), are crucial for attracting private investment in RE infrastructure. In developing countries where market and policy risks are higher, supportive mechanisms and multilateral backing act as universal drivers for renewable PPP adoption.

Furthermore, note that the magnitude of the coefficients for local and international support and even public finance and investment policy is larger for share of renewable PPP investments than project volumes (Tables 3-6). This somewhat explains the puzzling decoupling of the two variables experienced by countries like India, Turkey and Ukraine (Figure 6). Climate policies and infrastructure support drive private participation in renewable projects. However, such projects (in most cases, solar PV) tend to be smaller in size. Kim, (2020) explains this through easier division of technology in the cases of solar PV and onshore wind; but it may also be the case that the projects lack technical and financial government support more necessary for scaling up investments.

Energy Access

Energy access (*Access*) policies are not significantly associated with static PPP share (in the Tobit model) but become strongly positive and highly significant ($p<0.01$) in the dynamic GMM model (Table 1). The magnitude of coefficients is however small. Table 1 results show that a unit increase in policies targeted at inclusive growth is associated with a rise in both investment and volume shares by about 0.0013 units.

Consequently, the impact of energy access policies on renewable PPP deployment is realized over time, likely due to cumulative effects and lagged responses in private sector participation. In contrast, planning and framework policies do not show significance in both models. These findings indicate that actionable, inclusive energy policies-rather than non-binding plans like the NDCs-are stronger determinants of energy transition in PPPs (Ragosa & Warren, 2019; Yin & Qamruzzaman, 2024b).

Table 4: Results from Tobit and Generalized Method of Moments (GMM) model specification 2

	Tobit Ren_share	**Tobit Ren_count**	**GMM Ren_share**	**GMM Ren_count**
Reg x Low income	0.0084	0.0093	0.00409	0.0151
	(0.0404)	(0.0368)	(0.00276)	(0.0110)
Reg x Lower middle income	-0.0085	-0.0083	0.00428	0.00582*
	(0.0060)	(0.0054)	(0.00330)	(0.00302)
Reg x Upper middle income	0.0084**	0.0088**	0.00293***	0.00271***
	(0.0030)	(0.0028)	(0.000834)	(0.000805)
Int_sup	0.0383***	0.0375***	0.0129***	0.0113***
	(0.0066)	(0.0058)	(0.00450)	(0.00426)
Tools	0.0109**	0.0085*	0.00205	0.00376**
	(0.0037)	(0.0034)	(0.00178)	(0.00181)
Public investment*	0.0117*	0.0101*	0.00360**	0.00281**
	(0.0048)	(0.0042)	(0.00165)	(0.00135)
Fossil fuel energy cons. (%) *	0.2827*	0.5829**	0.0125*	0.0847*
	(0.1306)	(0.1174)	(0.0444)	(0.0332)
RE electricity prod. (kwh)*	0.0233***	0.0243***		
	(0.0056)	(0.0050)		
GE*	-0.0357	-0.0453*	-0.00803	-0.00782
	(0.0217)	(0.0189)	(0.0199)	(0.0111)
VA*	0.0102	0.0102		
	(0.0220)	(0.0201)		
PV*	0.0002	0.0017		
	(0.0120)	(0.0108)		
Constant			0.0458**	0.0559***
			(0.0219)	(0.0170)
Macroeconomic controls	YES	YES	YES	YES
Lagged DV	NO	NO	YES	YES
Observations	519	519	792	792
Number of countries	51	51	46	46

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for Tobit and GMM models for share of renewable PPP investments (*ren_share*) and share of renewable PPP volumes (*ren_count*) respectively. Only marginal effects from the Tobit model are shown here. All variables for GMM specification are lagged by 1 degree. *L.Depvar* is the corresponding lagged dependent variable for the GMM model. *Int_sup* is the international support indicator. *Reg* is the regulation policy indicator.

A related finding is the robust and positive association of renewable electricity production with both dependent variables across all model specifications. The coefficients are also relatively higher in magnitude, predicting 0.0263 higher monetary investment shares and 0.0245 higher project volume shares for 1-unit increase in electricity production (Tables 3 -6). Electricity production in literature serves as a proxy for greater technological diffusion and more developed energy infrastructure (Kim, 2020). The

results are in with line with (Mitra & Al Farhad, 2023) who argue that advancing electricity sectors facilitate renewable integration by providing the necessary grid infrastructure, technical expertise, and institutional capacity required for large-scale deployment. A higher magnitude of this association compared to the energy access policy indicator highlights the efficacy of realized infrastructural investments over planned.

Table 5: Results from Tobit and Generalized Method of Moments (GMM) model specification 3

	Tobit	**Tobit**	**GMM**	**GMM**
	Ren_share	**Ren_count**	**Ren_share**	**Ren_count**
Inv x Low income	0.1783*	0.2134**	0.0466	0.0300
	(0.0773)	(0.0730)	(0.0369)	(0.0207)
Inv x Lower middle income	0.0091*	0.0019	0.00201	0.00560
	(0.0045)	(0.0041)	(0.00263)	(0.00431)
Inv x Upper middle income	0.0083*	0.0085**	0.00141**	0.000769*
	(0.0034)	(0.0031)	(0.000592)	(0.000454)
Trade	0.0060*	0.0055**	0.00199	0.00406***
	(0.0024)	(0.0018)	(0.00122)	(0.00153)
Int_sup	0.0256***	0.0248***	0.0116***	0.00877***
	(0.0059)	(0.0053)	(0.00433)	(0.00438)
Tools	0.0142***	0.0110***	0.00127	0.00175
	(0.0033)	(0.0030)	(0.00190)	(0.00187)
Public investment*	0.0169***	0.0155***	0.00358**	0.00257**
	(0.0037)	(0.0034)	(0.00152)	(0.00127)
Fossil fuel energy cons. (%) *	0.2389**	0.2822**	0.0121*	0.0934*
	(0.0837)	(0.0744)	(0.0456)	(0.0367)
RE electricity prod. (kwh) *	0.0217***	0.0271***		
	(0.0051)	(0.0045)		
Constant			0.0428*	0.0490***
			(0.0221)	(0.0181)
Regulation controls	YES	YES	YES	YES
Macroeconomic controls	YES	YES	YES	YES
Lagged DV	NO	NO	YES	YES
Observations	777	777	792	792
Number of countries	61	61	46	46

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for Tobit and GMM models for share of renewable PPP investments (*ren_share*) and share of renewable PPP volumes (*ren_count*) respectively. Only marginal effects from the Tobit model are shown here. All variables for GMM specification are lagged by 1 degree. *L.Depvar* is the corresponding lagged dependent variable for the GMM model. *Int_sup* is the international support indicator. *Inv* is the investment policy indicator.

Governance and Regulation

Results reveal nuanced effects of governance quality and regulatory policies (*Reg*) on renewable energy PPP development. Unlike investment policies, regulatory policies demonstrate a clear income-gradient effect (Table 4). In both Tobit and GMM models, the variables show statistically significant explanatory power (p>0.01) only in the case of upper-middle income countries. This suggests that regulatory frameworks require a certain threshold of institutional capacity to effectively mobilize private renewable investment. Governance indicators (Table 4) are also not statistically significant in any specification.

Although existing literature emphasizes the role of governance quality in facilitating private capital mobility (L. Wang et al., 2024), the results presented here suggest that governance alone does not account for the reallocation of private investment from fossil fuels to renewable energy.

Table 6: Results from Tobit and Generalized Method of Moments (GMM) model specification 4

	Tobit Ren_share	**Tobit Ren_count**	**GMM Ren_share**	**GMM Ren_count**
Market x AFR	0.1328***	0.1103***	0.0388***	0.0355***
	(0.0233)	(0.0206)	(0.0125)	(0.0122)
Market x EAP	-0.0019	0.0022	0.00731***	0.00713***
	(0.0094)	(0.0084)	(0.00255)	(0.00212)
Market x ECA	0.1486***	0.0411	-0.00378	-0.000710
	(0.0275)	(0.0287)	(0.00966)	(0.00634)
Market x LAC	0.0405*	0.0349*	-0.0184	-0.0184
	(0.0186)	(0.0167)	(0.0165)	(0.0129)
Market x MENA	0.1532***	0.2646***	-0.0496	-0.00759
	(0.0346)	(0.0306)	(0.246)	(0.145)
Market x SAR	-0.0294	0.0236	-0.00285	0.0290
	(0.0173)	(0.0155)	(0.0154)	(0.0283)
Trade	0.0047*	0.0028	0.00172*	0.00366***
	(0.0024)	(0.0018)	(0.000990)	(0.00139)
Int_sup	0.0239***	0.0234***	0.0131***	0.00907**
	(0.0056)	(0.0049)	(0.00439)	(0.00384)
Tools	0.0116**	0.0102**	0.00263	0.00263
	(0.0034)	(0.0030)	(0.00225)	(0.00194)
Public investment *	0.0106**	0.0091**	0.00375**	0.00282**
	(0.0036)	(0.0032)	(0.00162)	(0.00130)
Fossil fuel energy cons. (%) *	0.3030**	0.2963**	0.120**	0.0960**
	(0.0811)	(0.0700)	(0.0427)	(0.0347)
RE electricity prod. (kwh) *	0.0211***	0.0281***		
	(0.0048)	(0.0042)		
Constant			0.0463**	0.0549***
			(0.0213)	(0.0175)
Regulation controls	YES	YES	YES	YES
Macroeconomic controls	YES	YES	YES	YES
Lagged DV	NO	NO	YES	YES
Observations	777	777	792	792
Number of countries	61	61	46	46

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for Tobit and GMM models for share of renewable PPP investments (*ren_share*) and share of renewable PPP volumes (*ren_count*) respectively. Only marginal effects from the Tobit model are shown here. All variables for GMM specification are lagged by 1 degree. *L.Depvar* is the corresponding lagged dependent variable for the GMM model. *Int_sup* is the international support indicator. *Market* is the market mechanism policy indicator and *Trade* is the trade policy indicator.

Regional variation in market mechanisms

Market-based mechanisms are analyzed through regional rather than income interactions based on literature (Alloisio & Carraro, 2015a). Results (Table 6) demonstrate heterogeneous effects, reflecting that market instruments like feed-in tariffs and carbon pricing depend heavily on localized market structures and complementary institutional frameworks. The AFR (African) region shows the most statistically significant association across all models. However, the MENA (Middle East and North

African) region exhibits the strongest explanatory power: 1-unit more of market instruments is related to 0.15 units higher investment shares and 0.21 units higher project volumes (Table 6). The LAC (Latin American and Caribbean) region also shows somewhat significant and positive relation ($p>0.01$). Market policies in ECA (European and Central Asia) are associated with more investment shares but not volumes. Only the dynamic associations in the case of EAP (East Asia and Pacific region) are statistically significant ($p<0.001$). The results collectively suggest that policy effectiveness is contextual, requiring careful calibration to country-specific institutional environments (Li et al., 2020). Meanwhile, trade policies appear to be statistically significant ($p<0.001$) for renewable PPP volumes in the dynamic GMM model (Table 6). It follows that clean energy provisions in FTAs function strongly in temporally pushing up renewable PPP volumes, but not so much in the case of investments.

Another interesting outcome of the study is the consistently positive association between share of fossil fuel consumption and energy transition across all specifications. In literature, this relation is explained through complementary technological and strategic mechanisms. Othman & Khallaf, (2022) suggests that countries with higher fossil fuel dependency tend to develop more robust renewable PPP frameworks as part of a diversification strategy to address future energy security concerns. The technological complementarity hypothesis proposed by Verdolini et al., (2016). They demonstrate that fast-reacting fossil fuel generation systems provide critical backup capacity. Another possible explanation is that in most emerging markets, growth is still fossil fuel led even with heavy investment in clean pathways. (Aziz & Jahan, 2023) argues that high energy dependence has a positive impact on PPI, and that energy poverty does not always attract funds.

5.3. Policy Insights

Three overarching insights can be drawn from this study. First, the findings suggest that quantifiable policy actions like targeted support and realized public investments are stronger mobilizers of private participation than the less tangible policies. This is not to say that policies are discardable; policies, especially those designed for catalyzing affordability of energy and human capital development are essential to form country priorities and PPP framework (Kerr & Hu, 2025b). However, such mitigation efforts must be supported by active public finance to make them impactful, credible, and equitable.

Secondly, the findings confirm the multidimensionality of a supportive environment (Kerr & Hu, 2025b; L. Wang et al., 2024) to drive private participation in renewable infrastructure. Most importantly, international and local support targeted at specific projects for risk-mitigation as well as active public investment in renewable electricity generation to build foundational infrastructure support facilitates investment reallocation. But energy access policies, carbon pricing and feed-in-tariffs that stimulate

renewable electricity demand, and clean energy R&D that induces knowledge dissemination and skill creation also play a role in targeted energy transition. Moreover, obligation schemes and anti-dumping measures, while also encouraging inflow of renewable capital through FTAs' can be useful tools to attract cross-border investments.

However, the third overarching insight draws from the path dependency theory of energy transition in PPP investment (Ciplet et al., 2022). Results confirm that not only is private sector involvement regionally heterogenous, but it is also reliant on predetermined income and infrastructure capacities. Upper middle-income countries account for about 66% of all renewable PPP projects, even when their own within-country renewable shares are less than that of low-income (Table 1). The need for radical clean energy policy frameworks is highlighted by their stronger associations in low-income countries. However, for such policies to be practicably operationalized requires initial groundwork through public finance (Kim, 2020). This itself is constrained by limited resources of such countries, which also augments their risk profile. The argument is supported by the theory of climate investment trap given by (Ameli et al., 2021) that higher capital costs are reinforced in underdeveloped markets. Through their spatial study, Ciplet et al., (2022) argue that climate finance to some extent reproduces relations of dependency. They show that funding flows somewhat neglect economically peripheral, climate vulnerable countries, while favoring strong administrative capacity. However, positive associations between energy access policies and private participation in renewable infrastructure provide possible readjustment channels.

6. Conclusion

In this study, I examine the drivers of transition to renewable energy within the framework of PPPs in EMDEs. Motivated by the increasing share of renewable projects in PPP investments and the persistent gaps in energy access and clean infrastructure financing in emerging economies, I ask how the compositional shift in PPPs respond to distinct policy, institutional, and macroeconomic factors.

To address this question, I employ a mixed-method strategy that combines project-level analysis with country-level econometric modeling. I combine data from the comprehensive World Bank PPI dataset, CPI climate policy database, the WGI governance indicators and other macroeconomic variables. I first use text-based keyword extraction of policy content from project documentation to populate the data on local government support provided in the PPI dataset. I then run a probit regression using over 2,000 project-level observations to identify structural characteristics that differentiate renewable PPPs from non-renewable ones. In the second stage, I estimate Tobit and difference GMM model specifications using a panel of 72 countries from 1996 to 2023. I construct cumulative measures of access, regulatory,

investment, trade and market-based policy instruments, and interact them with country income levels and regions. These models allow me to assess both contemporaneous drivers and intertemporal dynamics of renewable PPP participation in terms of project volumes and monetary investments.

My findings indicate that there is no singular factor explaining the growth of renewable PPPs. Rather, the transition is enabled by a combination of access policies, international financial support, public investment, and project-based policy tools—each with varying importance across income groups and regions. Dynamic panel models show that prior levels of renewable participation strongly predict current engagement, reinforcing the path-dependent nature of clean infrastructure development. Notably, international support has the strongest and most consistent effect in low- and lower-middle-income countries, while regulatory and market-based instruments are more effective in middle-income and institutionally stronger contexts. Public investment and the availability of risk-sharing tools play a central role in both initiating and sustaining renewable energy PPPs.

These results offer several important policy insights. First, countries seeking to scale renewable energy PPPs must adopt a coordinated, long-term strategy that bundles regulatory clarity, public capital, and private de-risking instruments. Second, international support—particularly in blended or concessional form—remains essential for crowding in private actors in markets where risks are high and energy access gaps persist. Third, regional and institutional heterogeneity must inform policy design, as the same policy instrument may yield very different outcomes depending on the enabling environment. By shifting the analytical lens from absolute investment volumes to the evolving composition of PPP portfolios, this study contributes a novel perspective to the literature on infrastructure finance and energy transition. It is the first study, to my knowledge, that analyzes renewable energy participation in PPPs through a dynamic share-based framework, integrating project characteristics with country-level policy contexts. In doing so, I provide not only empirical insights but also a diagnostic tool for policymakers aiming to build greener, more inclusive energy systems through public-private collaboration.

Acknowledgement

The study was supported by the Department of Economics, Colorado State University (CSU), Fort Collins, while the author was a PhD candidate at the department up till May 2025. The author thanks Dr Ramaa Vasudevan for her guidance in the formulation of theoretical framework and regression model, Dr Pratyoosh Kashyap for his invaluable support in language writing and proof-reading, and Dr Daniele Tavani for his important insights on the interpretation of empirical results.

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Appendix

Distribution of PPP projects

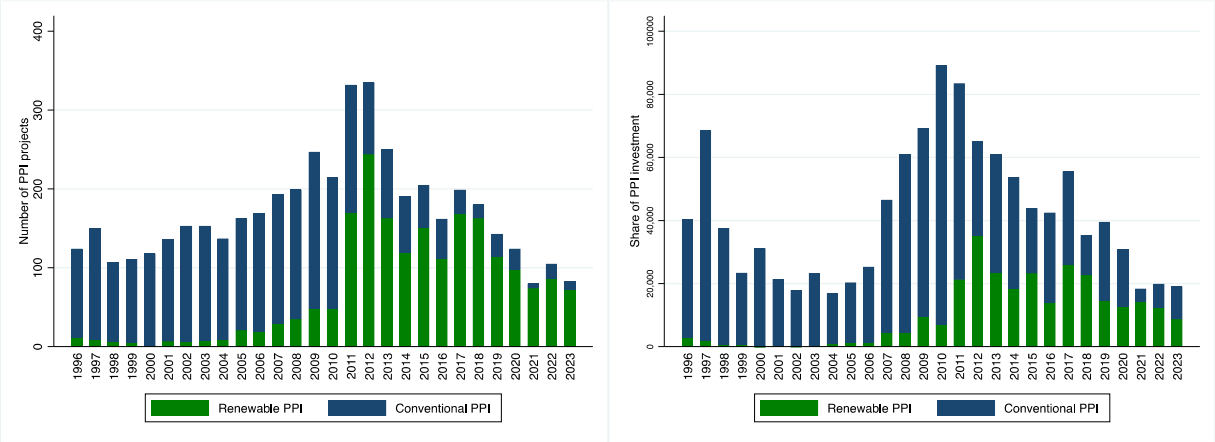


Figure A1: Distribution of PPP investments (left) and number of projects (right) across renewable (green) and conventional (blue) energy infrastructure.

Histogram: Share of renewable projects

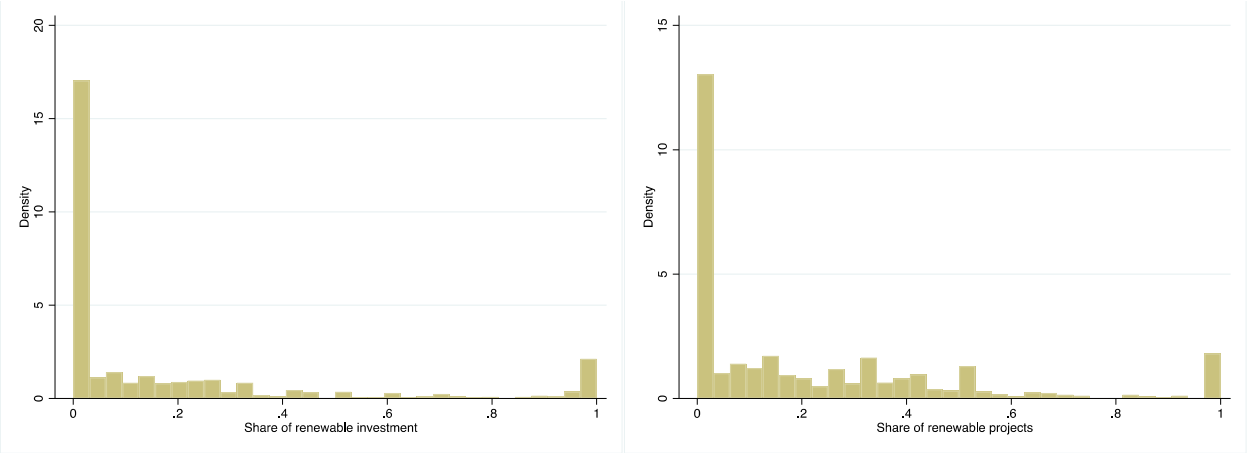


Figure A2: Histogram showing the skewed distribution of share of renewable energy PPP investments and project volume, clustered at 0.

Marginal Effects: Project-level Probit Analysis

Table A1: Marginal effects from Probit model.

	Marginal Effects	Std. Err.	P-value	95% Conf. Interval
Income Level				

Low income	0.1015	0.0305	0.0010	0.0417	0.1613
Lower middle income	0.2722	0.0284	0.0000	0.2165	0.3278
Upper middle income	0.3210	0.0197	0.0000	0.2825	0.3596
Region					
AFR	0.4425	0.0479	0.0000	0.3486	0.5365
EAP	0.2091	0.0204	0.0000	0.1691	0.2490
ECA	0.5554	0.0660	0.0000	0.4259	0.6848
LAC	0.3019	0.0216	0.0000	0.2596	0.3443
MENA	0.4727	0.0751	0.0000	0.3254	0.6199
SAR	0.2556	0.0339	0.0000	0.1891	0.3222
Bilateral & Multilateral Support					
No support	0.2791	0.0173	0.0000	0.2452	0.3131
Either/Or	0.2945	0.0273	0.0000	0.2410	0.3480
Both	0.6148	0.0644	0.0000	0.4886	0.7411
Project Status					
Active	0.3116	0.0168	0.0000	0.2787	0.3444
Cancelled	0.0713	0.0418	0.0880	-0.0105	0.1532
Concluded	0.0647	0.0290	0.0260	0.0078	0.1215
Project Type					
Brownfield	0.0205	0.0060	0.0010	0.0087	0.0323
Divestiture	0.0676	0.0392	0.0840	-0.0091	0.1444
Greenfield	0.5169	0.0135	0.0000	0.4904	0.5434
Other continuous variables					
Tool count	0.0675	0.0087	0.0000	0.0505	0.0846
Investment (US $m)	-0.0004	0.0000	0.0000	-0.0005	-0.0003
Private participation	.0039199	.000579	6.77	0.000	.002785

Note: AFR stands for Sub-Saharan Africa, EAP for East Asia and Pacific, ECA for Europe and Central Asia, LAC for Latin America and the Caribbean, MENA for Middle East and North Africa, and SAR for South Asia Region.

Local support tool count for conventional PPP projects

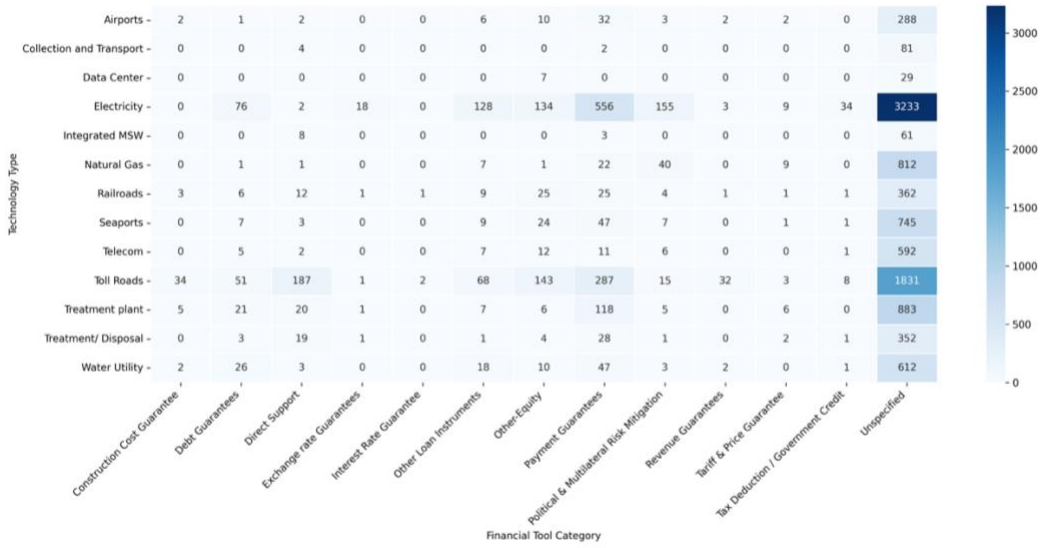


Figure A3: Heat map of conventional energy project-specific local support tool count categorized according to instrument (x-axis) and technology (y-axis). Tool count is calculated from the World Bank private participation in infrastructure database by summing up the local support data and tools extracted from the project description using a keyword extraction process.

Correlation Matrix for policy and institutional variables:

Table A2: Correlation Matrix for policy and institutional variables

	Reg	Market	Plan	Inv	Trade	Access	VA	CC	GE	PV	RL	RQ
Reg	1.00											
Market	0.69	1.00										
Plan	0.64	0.56	1.00									
Inv	0.62	0.64	0.59	1.00								
Trade	0.38	0.30	0.29	0.24	1.00							
Access	0.67	0.63	0.49	0.67	0.30	1.00						
VA	0.10	0.10	0.03	0.18	0.09	-0.05	1.00					
CC	0.05	0.03	0.04	0.10	0.16	0.09	0.53	1.00				
GE	0.19	0.18	0.14	0.19	0.30	0.25	0.49	0.77	1.00			
PV	-0.03	-0.07	-0.01	-0.05	-0.01	-0.04	0.33	0.44	0.35	1.00		
RL	0.09	0.07	0.10	0.12	0.20	0.13	0.56	0.81	0.81	0.43	1.00	
RQ	0.12	0.08	0.11	0.10	0.30	0.07	0.66	0.70	0.79	0.37	0.76	1.00

Results: Tobit Model

Table A3: Result from Tobit model specifications for share of renewable investments.

	1	**2**	**3**	**4**
Access	0.000977			
	(0.000718)			
Plan	0.0290**			
	(0.0117)			
Reg x Low income		0.00881		
		(0.0368)		
Reg x Lower middle income		-0.00773		
		(0.00546)		
Reg x Upper middle income		0.00788***		
		(0.00275)		
Inv x Low income			0.163**	
			(0.0705)	
Inv x Lower middle income			0.00822**	
			(0.00414)	
Inv x Upper middle income			0.00810***	
			(0.00308)	
Market x AFR				0.116***
				(0.0213)
Market x EAP				-0.000350
				(0.00861)
Market x ECA				0.140***
				(0.0251)
Market x LAC				0.0412**
				(0.0171)
Market x MENA				0.147***
				(0.0316)
Market x SAR				0.0267*
				(0.0158)
Trade			0.00554**	0.00445**
			(0.00217)	(0.00216)
Int_sup		0.0358***	0.0243***	0.0229***
		(0.00602)	(0.00535)	(0.00509)
Int_sup x Low income	0.118***			
	(0.0191)			
Int_sup x Lower middle income	0.0176***			

	(0.00549)			
Int_sup x Upper middle income	0.0293***			
	(0.00784)			
Tools	0.0134***	0.00950***	0.0130***	0.0108***
	(0.00281)	(0.00341)	(0.00306)	(0.00314)
Public investment *	0.0140***	0.0109**	0.0157***	0.00991***
	(0.00340)	(0.00437)	(0.00342)	(0.00331)
Fossil fuel energy cons. (%) *	0.0887	0.278**	0.227**	0.287**
	(0.0804)	(0.119)	(0.0765)	(0.0741)
RE electricity prod. (kwh) *	0.0246***	0.0219***	0.0208***	0.0202***
	(0.00475)	(0.00507)	(0.00462)	(0.00443)
GE*	-0.0314**	-0.0312	-0.0301*	-0.0239
	(0.0157)	(0.0198)	(0.0155)	(0.0148)
VA*		0.0111		
		(0.0200)		
PV*		0.000483		
		(0.0110)		
GDP*	-0.0270	-0.0297*	-0.0308*	-0.0255
	(0.0112)	(0.0124)	(0.0112)	(0.0107)
CPI*	0.0149	0.0157	0.0110	0.00374
	(0.0107)	(0.0141)	(0.0107)	(0.0102)
FDI*	0.0205	0.00686	0.0147	0.00270
	(0.0145)	(0.0163)	(0.0143)	(0.0139)
Constant	-0.863	-0.778	-0.884	-0.789
	(23.03)	(29.37)	(30.15)	(25.51)
Year FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Log-likelihood	271.8262	194.6813	265.7130	296.8272
LR-χ2	883.21***	620.72***	870.98***	933.21***
Observations	777	519	777	777
Number of countries	61	51	61	61

Note: ***Significant at $p < 0.01$, **Significant at $p < 0.05$, *Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for Tobit model specifications for share of renewable PPP investments. Model 1 tests for energy access and planning policy, Model 2 for regulatory policy and governance institutions, model 3 for investment policy and model 4 for market and trade policy. All models test for support and public finance variables. *Int_sup* is the international support indicator.

Table A4: Result from Tobit model specifications for share of renewable project volumes.

	1	**2**	**3**	**4**
Access	0.0001			
	(0.000711)			
Plan	0.0176			
	(0.0116)			
Reg x Low income		0.00931		
		(0.0368)		
Reg x Lower middle income		-0.00829		
		(0.00543)		
Reg x Upper middle income		0.00879***		
		(0.00276)		
Inv x Low income			0.213***	
			(0.0730)	
Inv x Lower middle income			0.00190*	
			(0.00415)	
Inv x Upper middle income			0.00848***	
			(0.00309)	
Market x AFR				0.110***

				(0.0206)
Market x EAP				0.00218
				(0.00838)
Market x ECA				0.0411
				(0.0287)
Market x LAC				0.0349**
				(0.0167)
Market x MENA				0.265***
				(0.0306)
Market x SAR				0.0236
				(0.0155)
Trade			0.00549***	-0.00277
			(0.00181)	(0.00175)
Int_sup		0.0375***	0.0248***	0.0234***
		(0.00584)	(0.00528)	(0.00493)
Int_sup x Low income	0.0817***			
	(0.0185)			
Int_sup x Lower middle income	0.0164***			
	(0.00538)			
Int_sup x Upper middle income	0.0496***			
	(0.00788)			
Tools	0.00930***	0.00850**	0.0110***	0.0102***
	(0.00278)	(0.00338)	(0.00303)	(0.00303)
Public investment *	0.0128***	0.0101**	0.0155***	0.00907***
	(0.00330)	(0.00419)	(0.00335)	(0.00317)
Fossil fuel energy cons. (%) *	0.280***	0.583***	0.282***	0.296***
	(0.0766)	(0.117)	(0.0744)	(0.0700)
RE electricity prod. (kwh) *	0.0245***	0.0243***	0.0271***	0.0281***
	(0.00457)	(0.00496)	(0.00453)	(0.00422)
GE*	-0.0471*	-0.0453	-0.0554*	-0.0491*
	(0.0146)	(0.0189)	(0.0146)	(0.0137)
VA*		0.0102		
		(0.0201)		
PV*		0.00169		
		(0.0108)		
GDP*	-0.0114	-0.0137	-0.0180	-0.0184*
	(0.0111)	(0.0124)	(0.0112)	(0.0104)
CPI*	0.0156	0.0147	0.00682	-0.000585
	(0.0104)	(0.0136)	(0.0104)	(0.00973)
FDI*	-0.00964	-0.0319**	-0.0188	-0.0314**
	(0.0142)	(0.0159)	(0.0141)	(0.0133)
Constant	-0.867	-0.831	-0.897	-0.799
	(24.00)	(35.30)	(23.24)	(27.40)
Year FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Log-likelihood	309.8246	224.9273	304.0783	343.5910
LR-$\chi 2$	1038.47***	728.12***	1026.98***	1106.00***
Observations	777	519	777	777
Number of countries	61	51	61	61

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for Tobit model specifications for share of renewable PPP project volumes. Model 1 tests for energy access and planning policy, Model 2 for regulatory policy and governance institutions, model 3 for investment policy and model 4 for market and trade policy. All models test for support and public finance variables. *Int_sup* is the international support indicator.

Robustness Check: Arellano & Bond GMM Model

Table A5: Robustness check. Results using Arellano & Bond Difference GMM model for share of renewable energy investments

	1	**2**	**3**	**4**
L.ren_share	0.734***	0.766***	0.765***	0.747***
	(0.0562)	(0.0534)	(0.0533)	(0.0546)
L.GDP*	-0.00175	-0.00130	-0.00112	-0.00122
	(0.00485)	(0.00491)	(0.00491)	(0.00487)
L.CPI*	0.00197	0.000886	0.00158	0.00164
	(0.00452)	(0.00450)	(0.00452)	(0.00448)
L.FDI*	0.00657	0.00633	0.00636	0.00681
	(0.00807)	(0.00818)	(0.00816)	(0.00812)
L.Fossil fuel energy cons. (%) *	0.150**	0.144**	0.144**	0.149**
	(0.0446)	(0.0451)	(0.0451)	(0.0449)
L.Public investment *	0.00375***	0.00349***	0.00356***	0.00350***
	(0.00160)	(0.00162)	(0.00162)	(0.00161)
L.GE*	-0.00760	-0.00674	-0.00432	-0.00575
	(0.0102)	(0.0103)	(0.0102)	(0.0102)
L.Access	0.000893**			
	(0.000360)			
L.Plan	0.000277			
	(0.00398)			
L.Int_sup	0.00931**	0.0120***	0.0110**	0.0104**
	(0.00478)	(0.00462)	(0.00468)	(0.00465)
L.Tools	0.00230	0.00239	0.00120	0.00134
	(0.00210)	(0.00212)	(0.00231)	(0.00228)
L.Reg		0.00299**		
		(0.00138)		
L.Inv			0.00240**	
			(0.0070)	
L.Trade			0.00200	0.00170
			(0.0139)	(0.00141)
L.Market				0.00755*
				(0.00446)
Sargan test	1.0000	1.0000	1.0000	1.0000
AR (1)	0.0000	0.0000	0.0000	0.0000
AR (2)	0.5109	0.4794	0.5137	0.5047
Observations	678	678	678	678
Number of countries	45	45	45	45

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for difference GMM specifications for share of renewable PPP investments *(ren_share*). Model 1 tests for energy access and planning policy, Model 2 for regulatory policy and governance institutions, model 3 for investment policy and model 4 for market and trade policy. All models test for support and public finance variables.

Table A6: Robustness check. Results using Arellano & Bond Difference GMM model for share of renewable energy investments

	1	**2**	**3**	**4**
L.ren_share	0.666***	0.668***	0.658***	0.660***
	(0.0368)	(0.0368)	(0.0369)	(0.0367)
L.GDP*	-0.00698*	-0.00693*	-0.00513	-0.00524
	(0.00401)	(0.00402)	(0.00402)	(0.00402)
L.CPI*	0.00330	0.00237	0.00199	0.00211
	(0.00378)	(0.00374)	(0.00371)	(0.00371)
L.FDI*	0.00779	0.00843	0.00865	0.00864

	(0.00665)	(0.00667)	(0.00662)	(0.00663)
L.Fossil fuel energy cons. (%) *	0.0577**	0.0625*	0.0649**	0.0642**
	(0.0392)	(0.0392)	(0.0390)	(0.0390)
L.Public investment *	0.00295**	0.00296**	0.00265**	0.00265**
	(0.00135)	(0.00136)	(0.00135)	(0.00135)
L.GE*	-0.00855	-0.00603	-0.00384	-0.00405
	(0.00829)	(0.00822)	(0.00816)	(0.00821)
L.Access	0.00139***			
	(0.000534)			
L.Plan	0.00269			
	(0.00335)			
L.Int_sup	0.00184***	0.00315***	0.000369**	0.000467***
	(0.00039)	(0.00038)	(0.00038)	(0.00038)
L.Tools	0.00373*	0.00512***	0.000913*	0.00100*
	(0.00209)	(0.00198)	(0.00228)	(0.00229)
L.Reg		0.00197**		
		(0.00045)		
L.Inv			0.00136***	
			(0.00075)	
L.Trade			0.00415*	0.00416*
			(0.00109)	(0.00109)
L.Market				0.00220**
				(0.00192)
Sargan test	0.6757	0.6602	0.8032	0.8041
AR (1)	0.0000	0.0000	0.0000	0.0000
AR (2)	0.1992	0.1754	0.2088	0.1992
Observations	678	678	678	678
Number of countries	45	45	45	45

Note: ∗∗∗Significant at $p < 0.01$, ∗∗Significant at $p < 0.05$, ∗Significant at $p < 0.1$. *All variables have been logged and centered. Results are presented for difference GMM specifications for share of renewable PPP project volu *(ren_count*). Model 1 tests for energy access and planning policy, Model 2 for regulatory policy and governance institutions, model 3 for investment policy and model 4 for market and trade policy