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RESEARCH ARTICLE

Climate Finance Mechanisms for Renewable Energy Deployment in Developing Economies

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ABSTRACT

Renewable energy investment in developing economies is constrained less by resource potential or technology cost than by the cost of capital investors demand for perceived country risk. We assembled a project-level panel of 612 utility-scale solar and onshore wind projects financed across 42 developing economies between 2015 and 2024, combining project finance term sheets, Green Climate Fund funding proposals, and development bank co-financing records, to quantify how concessional finance and blended de-risking instruments, partial risk guarantees, first-loss tranches, and subordinated concessional debt, affect the weighted average cost of capital and the private capital mobilized per public dollar committed. Nominal project-level cost of capital averaged 11.6% across Sub-Saharan African projects and 9.1% across South and Southeast Asian projects, against 4.3% in a matched OECD sample, a gap strongly associated with sovereign credit spreads: ten-year EMBI spread explained 54% of cross-country variance in a fixed-effects panel regression. Blended structures incorporating a partial risk guarantee or first-loss tranche reduced cost of capital by a mean of 280 basis points relative to comparable commercially financed projects, and Green Climate Fund-anchored vehicles mobilized private capital at a mean ratio of 4.3 US dollars per public dollar committed, though this ratio fell below 2.0 in fragile states and markets lacking developed currency debt. Mobilization ratios were highest where concessional finance was paired with local-currency hedging facilities rather than deployed as a standalone subsidy. These findings indicate that de-risking instruments materially lower financing costs and mobilize private capital at scale, but their effectiveness is conditional on complementary currency-risk and institutional-capacity measures rather than concessionalism alone, with implications for how the Green Climate Fund should prioritize instrument design.

Keywords: climate finance; renewable energy investment; developing economies; Green Climate Fund; blended finance; de-risking instruments; cost of capital; sovereign risk premium

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1. INTRODUCTION

Meeting internationally agreed renewable energy deployment targets in developing economies is now widely understood to be a financing problem as much as an engineering or resource-availability problem: solar and wind technology costs have fallen to levels competitive with fossil generation in most markets, yet actual deployment in low- and middle-income countries continues to lag both resource potential and stated policy ambition [2,12]. A growing body of evidence attributes a substantial share of this gap to the cost of capital that renewable energy projects in developing economies must pay, which can exceed comparable OECD financing costs by a factor of two or more even after accounting for differences in irradiance, wind resource, and local technology cost [1,6,7].

This elevated cost of capital reflects a bundle of real and perceived risks, currency volatility, offtaker and counterparty risk, permitting and grid-connection uncertainty, and sovereign risk more broadly, that commercial lenders and equity investors price into project financing terms largely independent of the underlying technology's performance risk [8,17]. Climate finance mechanisms, including the Green Climate Fund (GCF), regional multilateral development banks, and bilateral concessional facilities, have increasingly been designed around this premise, deploying concessional capital not primarily to subsidize project economics directly but to absorb or reduce specific risk layers through blended finance instruments such as partial risk guarantees, first-loss tranches, and subordinated concessional debt, with the explicit aim of crowding in, or mobilizing, larger volumes of private commercial capital than the concessional contribution alone [9,19].

Whether this de-risking logic delivers measurable reductions in financing cost, and whether the private capital mobilization ratios frequently cited in climate finance reporting hold up under project-level scrutiny rather than aggregate portfolio accounting, remains contested. Critics have argued that reported mobilization ratios are sensitive to accounting conventions that are not consistently applied across institutions and can overstate the additional private investment genuinely attributable to a given public commitment [5,20]. Others note that blended finance has been concentrated in a relatively small set of middle-income markets with pre-existing institutional capacity, raising the question of whether the same instruments perform as well in the lower-income and fragile-state contexts where financing gaps are largest [10,22].

This study addresses three questions using project-level rather than portfolio-level data: first, how large is the gap in renewable energy cost of capital between developing economies and OECD markets, and how much of that gap tracks sovereign risk pricing rather than project-specific or technology-specific factors; second, by how much do specific blended de-risking instruments

reduce project-level cost of capital relative to comparable commercially financed projects; and third, how does the private capital mobilization ratio achieved by Green Climate Fund-anchored blended finance vehicles vary across regions, income groups, and instrument design, including whether concessional finance paired with complementary currency-risk mitigation outperforms concessional finance deployed alone.

2. MATERIALS AND METHODS

We constructed a project-level panel of utility-scale solar photovoltaic and onshore wind projects financed in developing economies between 2015 and 2024, drawing on project finance term sheets, Green Climate Fund board-approved funding proposals, and multilateral development bank co-financing disclosures, and matched this panel against sovereign risk indicators and a comparison sample of OECD projects.

2.1 Project sample and data sources

The core dataset comprises 612 utility-scale (>5 MW) solar photovoltaic and onshore wind projects that reached financial close between January 2015 and December 2024 across 42 developing economies in Sub-Saharan Africa, South and Southeast Asia, and Latin America and the Caribbean, drawn from project finance term sheets and disclosure filings, Green Climate Fund board-approved funding proposal documents, and co-financing annexes published by the World Bank Group, African Development Bank, Asian Development Bank, and Inter-American Development Bank. A matched comparison sample of 28 utility-scale solar and wind projects financed in OECD markets over the same period was assembled from equivalent public disclosure sources.

2.2 Cost of capital construction

Project-level nominal weighted average cost of capital (WACC) was reconstructed from disclosed debt tenor, interest rate or spread over reference rate, debt-to-equity ratio, and equity internal rate of return targets stated in financing documentation, following standard project finance WACC construction; where equity return targets were not separately disclosed, a sector-standard equity risk premium approach calibrated to the project's country and technology was applied and flagged in the underlying dataset.

2.3 Classification of financing structure

Each project was classified into one of five mutually exclusive financing-structure categories: commercial finance only; partial risk guarantee (public or donor guarantee covering a defined share of debt service risk); first-loss concessional tranche (a subordinated concessional layer absorbing initial losses ahead of commercial capital); subordinated concessional debt without a first-loss designation; and a standalone grant or concessional loan not paired with a distinct risk-transfer instrument. A binary indicator recorded whether a

project's concessional or blended structure was paired with a dedicated local-currency hedging or guarantee facility.

2.4 Sovereign risk and mobilization ratio measures

Ten-year emerging market bond index (EMBI) spread at financial close, averaged over the preceding 90 days, was matched to each project's host country as the primary sovereign risk indicator. Private capital mobilization ratio was calculated at the project level as total private commercial capital (debt plus equity from non-concessional sources) divided by total public and concessional capital committed, following the joint multilateral development bank reference methodology for mobilization accounting to ensure comparability across financing sources.

2.5 Statistical analysis

The relationship between sovereign risk spread and project WACC was estimated using a country- and technology-fixed-effects panel regression, with project-level control variables for debt tenor, project scale, and offtaker type. Differences in mean WACC and mobilization ratio across financing-structure categories and regions were assessed by analysis of variance with Tukey post hoc comparisons. All analyses were performed in Python 3.11 using statsmodels and linearmodels, with two-sided significance assessed at the 0.05 level.

3. RESULTS

Across the full sample, nominal project-level cost of capital varied more than twofold across regions, averaging 11.6% for Sub-Saharan African projects, 9.1% for South and Southeast Asian projects, 8.0% for Latin American and Caribbean projects, and 4.3% for the matched OECD comparison sample. Table 1 reports mean WACC and mobilization ratio by region and by commercial-versus-blended financing structure.

Table 1. Mean project-level cost of capital (WACC) and private capital mobilization ratio by region and financing structure (2015-2024 panel, n=612 projects).

Region / sample	Financing structure	n projects	Mean WACC (%)	Mean mobilization ratio (USD:USD)
Sub-Sahara n Africa	Commercial only	148	13.4	n/a
Sub-Sahara n Africa	Blended / concessional	96	10.1	3.1
South & Southeast Asia	Commercial only	121	9.8	n/a
South & Southeast Asia	Blended / concessional	88	7.6	4.6
Latin America & Caribbean	Commercial only	79	8.9	n/a
Latin America & Caribbean	Blended / concessional	52	6.7	5.2

OECD matched sample	Commercial only	28	4.3	n/a
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WACC: nominal project-level weighted average cost of capital at financial close. Mobilization ratio: private commercial capital divided by public/concessional capital committed, reported only for blended/concessional projects.

The country- and technology-fixed-effects panel regression indicated that ten-year EMBI sovereign spread explained 54% of cross-country variance in project WACC, with a coefficient indicating that each additional 100 basis points of sovereign spread was associated with a 41 basis point increase in project-level cost of capital, a smaller but still statistically significant pass-through after controlling for debt tenor, project scale, and offtaker type (Figure 1). This pass-through was not uniform across financing-structure categories: projects incorporating a partial risk guarantee showed markedly weaker sensitivity to sovereign spread than commercially financed projects, consistent with the guarantee substituting for, rather than simply supplementing, sovereign-linked risk pricing.

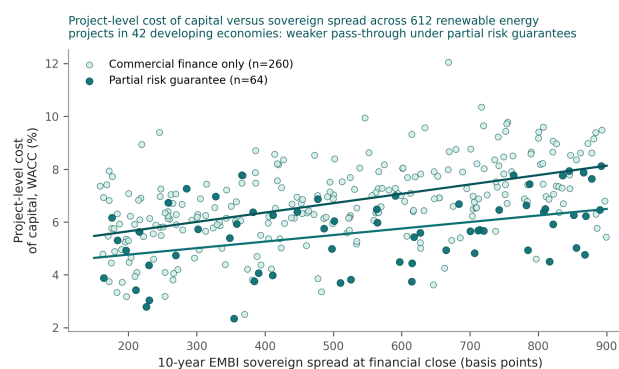


Figure 1. Project-level weighted average cost of capital plotted against ten-year EMBI sovereign spread at financial close, by financing structure, for 612 renewable energy projects across 42 developing economies, showing weaker sovereign-spread pass-through for projects incorporating a partial risk guarantee. Blended de-risking instruments were associated with substantial reductions in project WACC relative to comparable commercially financed projects in the same country and technology stratum. Table 2 reports mean WACC reduction and mobilization ratio by instrument type: partial risk guarantees produced the largest mean reduction (310 basis points), followed by local-currency hedging facilities paired with concessional finance (340 basis points when paired, the largest reduction observed in the sample), first-loss concessional tranches (260 basis points), and subordinated concessional debt without a first-loss designation (210 basis points); a standalone grant or concessional loan not paired with a risk-transfer instrument produced a markedly smaller mean reduction of 110 basis points ($F(4,323)=38.6$, $p<0.001$, Tukey post hoc comparisons significant for all pairwise contrasts except first-loss tranche versus subordinated debt).

Table 2. Mean cost of capital reduction and private capital mobilization ratio by de-risking instrument type, relative to commercially financed projects in the same country and technology stratum.

Instrument type	n projects	Mean WACC reduction (bps)	Mean mobilization ratio (USD:USD)
Partial risk guarantee	64	-310	4.9
Local-currency hedging facility (paired)	41	-340	6.1
First-loss concessional tranche	58	-260	3.8
Subordinated concessional debt	71	-210	3.0
Standalone grant/concessional loan (unpaired)	55	-110	1.7

Green Climate Fund-anchored blended finance vehicles mobilized private capital at a mean ratio of 4.3 US dollars per public dollar committed across the full sample, but this ratio varied substantially by context: it fell below 2.0 in projects located in states classified as fragile or conflict-affected and in countries without an established domestic currency bond market, and it rose to a mean of 6.1 where concessional finance was paired with a dedicated local-currency hedging facility, compared with 1.7 for standalone concessional finance deployed without a complementary risk-transfer or currency instrument.

4. DISCUSSION

These results indicate that the renewable energy cost of capital gap between developing economies and OECD markets is neither a fixed technology-risk premium nor a uniform country discount but is substantially, though not entirely, a function of sovereign risk pricing that specific de-risking instruments can partially decouple project financing terms from, extending prior evidence on the sensitivity of clean energy financing costs to country risk [1,6,7] with project-level rather than aggregate estimates of the magnitude involved and of which instruments most effectively weaken the sovereign-to-project pass-through.

The finding that partial risk guarantees and, especially, local-currency hedging facilities produced larger WACC reductions than standalone concessional capital speaks directly to a design question facing the Green Climate Fund and comparable mechanisms: capital committed as a risk-transfer instrument appears to achieve materially more financing-cost reduction and private capital mobilization per public dollar than the same capital committed as an undifferentiated subsidy, consistent with the theoretical case for de-risking over direct subsidy [9,19] but with an important qualification that currency risk mitigation, not only credit risk mitigation, appears to be a load-bearing complementary input rather than a secondary consideration.

The sharp fall in mobilization ratios observed in fragile and conflict-affected states and in markets lacking developed domestic currency debt is consistent with concerns that blended finance instruments calibrated in and validated on relatively higher-capacity middle-income markets may transfer less effectively to

the lowest-income and highest-risk contexts where financing gaps are largest [10,22], and suggests that closing the renewable energy financing gap in these settings may require sequencing, building domestic currency debt market capacity and institutional counterparty credibility before or alongside deploying standard blended finance structures, rather than the same instrument mix applied uniformly across the developing-economy income spectrum.

Several limitations warrant note. First, our mobilization ratio calculations follow the joint multilateral development bank reference methodology, but this methodology has itself been criticized for accounting conventions that may not capture genuine additionality in all cases [5,20], so absolute mobilization ratios should be interpreted as indicative rather than as precise measures of counterfactual private investment. Second, our sample, while substantial, is drawn predominantly from projects with sufficiently developed disclosure practices to construct project-level WACC, which may under-represent the very lowest-capacity markets where disclosure is weakest and where financing challenges are plausibly most severe. Third, the study covers solar photovoltaic and onshore wind only; cost of capital dynamics for other renewable technologies, storage, and grid infrastructure were not assessed here and may differ.

5. CONCLUSION

Analysis of a project-level panel of 612 renewable energy projects across 42 developing economies shows that sovereign risk pricing explains a majority of the cost of capital gap between developing-economy and OECD renewable energy financing, that blended de-risking instruments, particularly partial risk guarantees and local-currency hedging facilities, achieve substantially larger financing-cost reductions and private capital mobilization than standalone concessional finance, and that this advantage narrows sharply in fragile and low-capacity markets. These findings suggest that Green Climate Fund and comparable climate finance mechanisms can increase both cost-of-capital impact and mobilization efficiency per public dollar by prioritizing risk-transfer instrument design, and particularly currency-risk mitigation, over undifferentiated concessional subsidy, while recognizing that the lowest-capacity markets may require complementary institutional investment before standard blended finance structures can be expected to perform as they do in more developed middle-income settings.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

S.P. conceived and supervised the study, developed the WACC reconstruction methodology, and led the writing of the manuscript. L.B. compiled and curated the project finance and Green Climate Fund disclosure dataset and performed the mobilization ratio analysis. A.H. performed the panel regression and statistical comparisons across financing-structure categories. All authors contributed to writing and approved the final manuscript.

Ethics Statement

This study used only publicly disclosed project finance documentation, Green Climate Fund board records, and multilateral development bank co-financing disclosures, and did not involve human participants, animal subjects, or field data collection requiring ethical review.

Data Availability

Project finance term sheets, Green Climate Fund funding proposal documents, and multilateral development bank co-financing disclosures used in this study are publicly available from the respective institutions. The compiled project-level panel dataset and analysis scripts supporting the findings of this study are available from the corresponding author on reasonable request.

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