

## Leveraging Public-Private Partnerships for Climate-Resilient Infrastructure: A Global Analysis

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### Abstract

The research investigates the role of Public-Private Partnerships (PPPs) and various kinds of public and private climate funding in driving investments in climate-resilient infrastructure between 2016 and 2022. The study uses secondary data from the Organization for Economic Cooperation and Development (OECD) to assess the contributions made by bilateral and multilateral public finance, export credits, and mobilized private capital. The analysis finds strong positive connections between public finance—particularly bilateral and multilateral sources—and the mobilization of private sector investments, emphasizing the critical role of public funding in risk mitigation and attracting private capital. The findings emphasize the increasing significance of international collaboration and multilateral investment in climate resilience, as well as the increased involvement of private investors fuelled by public sector support. This study advances our understanding of how PPPs may be used effectively to solve the finance constraints of climate change adaptation.

**Keywords:** Public-Private Partnerships (PPPs), climate finance, bilateral public finance, multilateral public finance, mobilized private capital, climate-resilient infrastructure, export credits, climate change adaptation.

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### 1. Introduction

As the world grapples with the growing consequences of climate change, the demand for resilient infrastructure has never been greater. Climate resilience, characterised as the ability to predict, prepare for, and adapt to hazardous scenarios, has become an important concern for governments and organisations around the world. However, financing such large-scale, climate-adaptive initiatives remains a considerable challenge, especially in areas most susceptible to the impacts of climate change. Conventional financial systems, mostly led by the public sector, frequently fail because of limited resources and the increasing complexity of climate concerns. In this scenario, Public-Private Partnerships (PPPs) may be an effective alternative to traditional government initiatives. PPPs provide better benefits in terms of investment and effort. This is due to direct government participation in decision-making, which emphasises social rewards in the project's final results (Buso & Stenger, 2018).

To effectively coordinate investment and protection decisions, considerable governmental competence is required, particularly when estimating private sector actions and undertaking cost-benefit assessments. In the face of confusion, governments should examine the ability to change protection levels over time. Leaders can maximize investment in protection by carefully evaluating the risks and matching spending with the predicted level of investments at risk (Kousky et al., 2006).

A key obstacle to using PPPs in climate resilience projects is a lack of unique financing options that reduce risk and ensure long-term viability. To overcome this gap, an emerging category of innovative financial instruments are gaining traction, including climate resilience bonds, catastrophe bonds, and sustainability-linked bonds. Green finance instruments, particularly green bonds, have seen significant growth, with their global issuance reaching approximately \$1.1 trillion by September 2021. (González & Núñez, 2021). These instruments have been created to address various financial risks linked to climate change.

This study aims to investigate how various innovative financial tools might be better used inside PPP frameworks to finance climate-resilient infrastructure. By examining the purpose, the benefits and challenges they bring, and how they affect private sector engagement, this study seeks to provide insights into ensuring a sustainable future in the face of escalating climate change concerns.

## 2. Theoretical Background

### 2.1 Public-Private Partnerships (PPPs) for Climate Resilience

Public-Private Partnerships (PPPs) have achieved significant acceptability in public sector management, thanks to the idea of New Public Management as an efficient management tool (Khanom, 2010). These are a type of liberalization in public service delivery that allows the public and private sectors to work together to provide services that were previously only administered by the public sector (Broadbent & Laughlin, 2003). It brings together sponsors such as philanthropists, governments, academia, industry, and non-profit organizations. Although not legal joint ventures, they do have several characteristics, mainly a common goal. Partners have a variety of motivations, contributions, and expected rewards, including joint decision-making and taking risks (Widdus, 2005).

Major projects for infrastructure such as roads, airports, drinking water systems, and healthcare are increasingly being provided through public-private partnerships. In such agreements, private investors finance, develop, and oversee the project, maintaining and managing the facilities for 20-30 years ultimately returning ownership to the government (Engel et al., 2010). Over the last two decades, administrations have increasingly embraced public-private partnerships (PPPs) to build and operate infrastructure, assuring cost-effective, efficient projects while meeting monetary constraints (Trebilcock & Rosenstock, 2015).

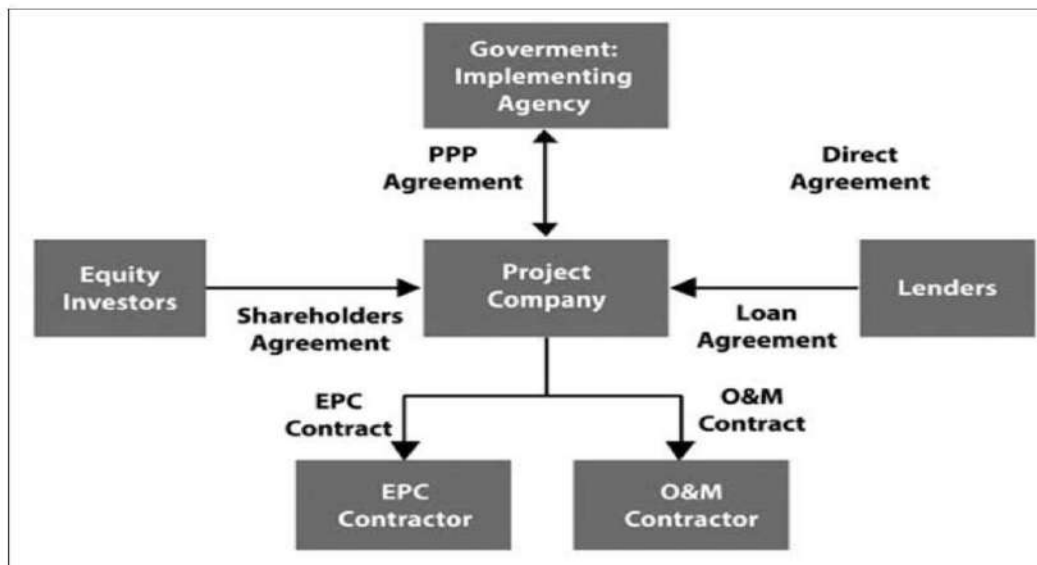


Figure 1: Typical Model of a Public Private Partnership Project (Ahmad, 2022)

A government agency is responsible for authorization, procurement, and funding. Sponsors create proposals and hold approximately 20% equity. The Construction Contractor ensures timely and cost-effective delivery, while the O&M Contractor oversees long-term operations. Banks lend debt after risk assessment, while

equity investors desire substantial returns. Insurers, vendors, and consultants provide assistance. All parties are bound by agreements that assign risks and duties (Ahmad, 2022).

## 2.2 Climate Resilience and Adaptation

Climate change resilience is an emerging concept for local planners; however, the framework makes it easier to understand by relating it to established sectors existing vulnerabilities (Tyler & Moench, 2012). Climate vulnerability methods are typically focused on new-build assets, necessitating project-level assessments and adjustments that can bring actual positive benefits (Hayes et al., 2019). Therefore, creating resilience in essential infrastructure through new technologies is critical to reaching the Sustainable Development Goals, particularly SDG 9 (climate-resilient infrastructure), SDG 11 (sustainable manufacturing), and SDG 13 (climate resilience) (Argyroudis et al., 2021).



**Figure 2: Destination Region of Climate Finance by Public/Private (USD billion, 2019/2020 Annual Average)**  
(Buchner et al., 2021)

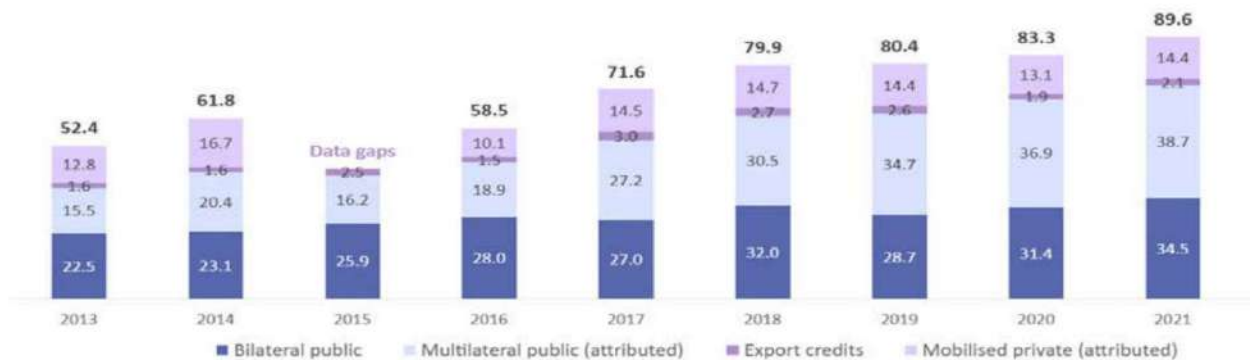
Climate finance is primarily focused in East Asia (46%), Western Europe, and North America, with China leading due to strong policies. Wealthy regions rely on private funding, whereas disadvantaged places, such as Sub-Saharan Africa, rely on public funds (88%). Non-OECD countries fund 64% of global flows, with the majority coming from domestic sources. Mitigation is the primary priority, particularly in high-emitting zones (Buchner et al., 2021).

## 3. The Role of Financial Instruments in Climate Resilience

Addressing climate change impacts is critical, and market insurance and financial risk-transfer mechanisms can reduce vulnerability. These tools help protect vulnerable countries from extreme weather, incentivize resilience, promote local learning, and reduce greenhouse gas emissions, thereby mitigating climate change and its consequences (Hermann et al., 2016). Though insurance provides financial protection during disasters, protecting societal and developmental progress, it should also be part of a larger disaster-risk finance system that includes reserves, budgets, catastrophic debt alternatives, and international assistance (Jarzabkowski et al., 2019).

Financial management methods enable timely restoration funding and reduce economic impact from disasters. The reinsurance industry has expanded due to greater capital and new products such as catastrophe

bonds, which increase market capacity by moving risk to capital markets (Wolfram & Yokoi-Arai, 2016). Also, micro insurance improves catastrophe risk reduction and climate change adaptations, particularly for low to moderate risks. It improves resilience by lowering exposure and vulnerability to extreme weather events, which complements larger risk mitigation efforts (Linnerooth-Bayer & Hochrainer-Stigler, 2014). Hence, insurance and risk-spreading systems are emerging as critical tools for combating climate change through collaborative decision-making by public organizations (Collier & Cox, 2021).



**Figure 3: Climate Finance provided and mobilized in 2013-2022 (USD billion) (OECD, 2024)**

The graph depicts the evolution of climate financing commitments from 2013 to 2021, organised into four major categories: bilateral public finance, multilateral public finance, export credits, and mobilized private capital. The overall trend demonstrates a consistent increase in total climate funding over time, with substantial increases in both public and private sector allocations.

#### 4. Research Objectives

- To examine the impact of bilateral and multilateral public finance on the mobilization of private sector investments for climate-resilient infrastructure projects between 2016 and 2022.
- To explore the relationship between different forms of public financing (bilateral, multilateral) and the combined influence they have on mobilizing private finance for climate-resilient infrastructure through Public-Private Partnerships (PPPs).

#### 5. Research Methodology

This study looks at how multiple forms of public and private climate funding, such as bilateral financing, multilateral public finance, export credits, and mobilized private capital, have helped to fund climate-resilient infrastructure projects. The research takes a quantitative approach, using descriptive, correlational, and regression analysis to investigate trends, linkages, and impacts from 2016 to 2022.

##### 5.1 Research Design

The study employs a method of quantitative investigation based on secondary data obtained from the Organization for Economic Co-Operation and Development (OECD) about climate financing contributions. The information includes annual figures for bilateral and multilateral public finance, export credits, and mobilized

private finance between 2016 to 2022. These variables are examined to determine their relative contributions and linkages, as well as their combined influence on attracting private investment in climate-related initiatives.

## 5.2 Data Collection

The data for this study were gathered from the OECD and cover developed countries' climate financing contributions from 2016 to 2022. This data was chosen because it is extensive and reliable in capturing current global climate financing developments.

The variables used in this dataset are Bilateral Public Finance (USD billion) refers to commitments made through collaboration between governments that represent direct financial assistance from a single nation to another. Multinational Public Finance (USD billion) involves contributions from international institutions, such as development banks, which fund massive infrastructure and climate-resilient projects in many nations. Export Credits (USD billion) are government export credit guarantees, a type of financial instruments that encourage national exports through offering insurance or guarantees to exporters. Finally, Mobilized Private Finance (USD billion) describes private-sector investments used for financing climate-resilient infrastructure, typically as a consequence of public-sector initiatives or assurances that lower investment risks for private organisations.

## 6. Data Analysis

**Table 1: Climate finance provided and mobilised in 2016-2022 (USD billion) (OECD, 2024)**

Year	Bilateral Public	Multilateral Public	Export Credits	Mobilised Private
2016	28	18.9	1.5	10.1
2017	27	27.2	3	14.5
2018	32	30.5	2.7	14.7
2019	28.7	34.7	2.6	14.4
2020	31.4	36.9	1.9	13.1
2021	34.5	38.7	2.1	14.4
2022	41	50.6	2.4	21.9

### 6.1 Descriptive Analysis of Climate Finance Contributions

In order to gain an improved comprehension of the funding provided to climate resilient infrastructure through Public-Private Partnerships (PPPs), we ran a descriptive analysis using the dataset from 2016 to 2022. The analysis focused on four major variables: Bilateral Public Finance, Multilateral Public Finance, Export Credits, and Mobilized Private Finance. The findings are outlined in Table X below:

	N	Minimum	Maximum	Mean	Std. Deviation
<b>Bilateral Public Finance (USD bn)</b>	7	27.0	41.0	31.800	4.8170
<b>Multilateral Public Finance (USD bn)</b>	7	18.9	50.6	33.929	9.9416
<b>Export Credits (USD bn)</b>	7	1.5	3.0	2.314	.5146
<b>Mobilized Private Finance (USD bn)</b>	7	10.1	21.9	14.729	3.5537
<b>Valid N (listwise)</b>	7				

Table 2: Descriptive Statistics

Bilateral Public Finance averaged \$31.8B each year with moderate fluctuation ( $\pm \$4.81B$ ), ranging from \$27B to \$41B, demonstrating consistent but fluctuating commitments. In 2022, multilateral public finance fluctuated between \$18.9B and \$50.6B, with an average of \$33.93B and a greater variance ( $\pm \$9.94B$ ). This rise represents increased international funding for climate infrastructure, particularly in recent years, as led by international agencies and development banks. Export credits averaged \$2.31B per year with modest variability ( $\pm \$0.51B$ ), ranging from \$1.5B to \$3B. This stability suggests a steady but lesser role in climate infrastructure, primarily as an addition to address financing shortfalls or give project assurance. Mobilised Private Finance averaged \$14.73 billion each year, with significant variability ( $\pm \$3.55$  billion), ranging from \$10.1 billion to a high of \$21.9 billion in 2022. This higher trend reflects the expanding private sector involvement in climate-resilient infrastructure, as well as increased participation in PPP-led projects.

## 6.2 Trend Analysis of Climate Finance Contributions

The overall pattern study of funding provided to infrastructure that is climate resilient through Public-Private Partnerships (PPPs) demonstrates significant changes in the allocation of resources from bilateral public, multilateral public, export credit, and mobilized private funding between 2016 and 2022.

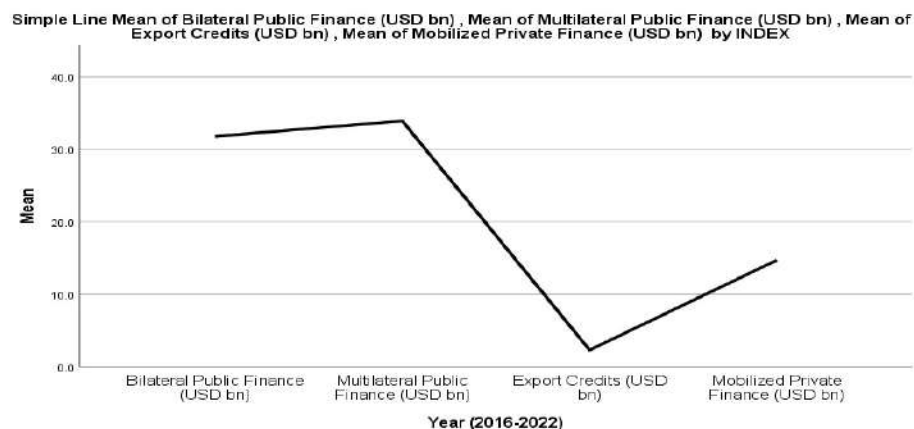


Figure 4: Simple Line Mean of Bilateral and Multilateral Public Finance, Export Credit and Mobilized Private Finance

The line chart depicts the average funding trends for climate-resilient infrastructure through PPPs from 2016 to 2022. Bilateral public funding averages more than \$30 billion, indicating consistent government-to-government

assistance. Multilateral public finance, which averages more than \$40 billion, demonstrates the expanding significance of international organisations in addressing global climate concerns through collective spending.

Export credits have fallen dramatically, averaging less than \$5 billion, emphasising their small importance in climate infrastructure funding. In contrast, mobilised private finance has increased significantly, particularly following the reduction in export credits, indicating greater private sector participation. While public finance—primarily bilateral and multilateral—remains the dominant force, more private investment indicates a favourable transition towards stronger public-private collaboration in addressing climate concerns.

### 6.3 Correlation Analysis

		Bilateral Public Finance (USD bn)	Multilateral Public Finance (USD bn)	Export Credits (USD bn)	Mobilized Private Finance (USD bn)
Bilateral Public Finance (USD bn)	Pearson Correlation	1	.875**	-.042	.832*
	Sig. (2-tailed)		.010	.928	.020
	N	7	7	7	7
Multilateral Public Finance (USD bn)	Pearson Correlation	.875**	1	.186	.868*
	Sig. (2-tailed)	.010		.690	.011
	N	7	7	7	7
Export Credits (USD bn)	Pearson Correlation	-.042	.186	1	.444
	Sig. (2-tailed)	.928	.690		.319
	N	7	7	7	7
Mobilized Private Finance (USD bn)	Pearson Correlation	.832*	.868*	.444	1
	Sig. (2-tailed)	.020	.011	.319	
	N	7	7	7	7
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

**Table 3: Correlations**

There is a high positive correlation between bilateral and multilateral public finance ( $r = 0.875$ ,  $p = 0.010$ ), demonstrating that global attempts are coordinated—when bilateral spending increases, multilateral support follows suit. Similarly, bilateral public finance is substantially related to deployed private capital ( $r = 0.832$ ,  $p = 0.020$ ), indicating that increased public investment attracts private sector funding, particularly in cases when private investors require governmental support to mitigate risks. These findings highlight the role of public money in promoting foreign and private sector participation in climate projects.

Multilateral public funding has a strong, statistically significant relationship to mobilised private finance ( $r = 0.868$ ,  $p = 0.011$ ), implying that international institutional investments effectively encourage private sector engagement. Export credits, on the other hand, show weak and statistically insignificant ties to both bilateral ( $r = -0.042$ ,  $p = 0.928$ ) and multilateral finance ( $r = 0.186$ ,  $p = 0.690$ ), implying that they operate independently of large

public funding sources. Their small, non-significant association with private finance ( $r = 0.444$ ,  $p = 0.319$ ) suggests that they are less effective at luring private investment than public sector funding.

#### 6.4 Regression Analysis

Variables Entered/Removed			
Model	Variables Entered	Variables Removed	Method
1	Export Credits (USD bn), Bilateral Public Finance (USD bn), Multilateral Public Finance (USD bn) <sup>b</sup>	.	Enter
a. Dependent Variable: Mobilized Private Finance (USD bn)			
b. All requested variables entered.			

**Table 4: Variables**

The regression study attempts to determine how Export Credits, Bilateral Public Finance, and Multilateral Public Finance affect Mobilized Private Finance. The variables table shows that all required independent variables were included in the model, with Mobilised Private Finance serving as the dependent variable.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.963 <sup>a</sup>	.928	.856	1.3496	.928	12.867	3	3	.032
a. Predictors: (Constant), Export Credits (USD bn) , Bilateral Public Finance (USD bn) , Multilateral Public Finance (USD bn)									

**Table 5: Model Summary of the given variables**

The regression model has a strong fit, with a R value of 0.963 suggesting a significant positive link between export credits, bilateral and multilateral finance, and mobilized private finance. The  $R^2$  score of 0.928 indicates that these factors accurately predict 92.8% of the variation in private financing deployment. The corrected  $R^2$  of 0.856 validates the model's strength after adjusting for predictor count. A low standard error (1.35) indicates good precision. The model is statistically significant ( $F = 12.867$ ,  $p = 0.032$ ), indicating that the combined public finance variables can successfully predict private sector investments.

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	70.310	3	23.437	12.867	.032 <sup>b</sup>
	Residual	5.464	3	1.821		



	<b>Total</b>	75.774	6			
a. Dependent Variable: Mobilized Private Finance (USD bn)						
b. Predictors: (Constant), Export Credits (USD bn) , Bilateral Public Finance (USD bn), Multilateral Public Finance (USD bn)						

**Table 6: Analysis of Variance**

The ANOVA table evaluates the overall relevance of the regression approach. The sum of squares values compares the variance in mobilized private finance that has been explained by the model with the variation that stays unexplained. The Regression Sum of Squares (70.310) indicates the proportion of variability in private finance mobilization that can be attributed to independent variables, whereas the Residual Sum of Squares (5.464) depicts the part of variation that the model fails to capture. These sums demonstrate how well the model matches the data, with a Total Sum of Squares of 75.774 indicating the dataset's overall variability.

## 7. Results

This study's findings provide an in-depth investigation of how public-private partnerships (PPPs) helped attract private sector investment for climate-resilient infrastructure projects between 2016 and 2022. Several significant patterns and connections were observed using descriptive, correlation, and regression analysis.

Over the time, bilateral public finance commitments averaged \$31.8 billion per year, with multilateral public finance commitments slightly higher at \$33.9 billion. Both types of public finance fluctuated year after year, with multilateral funding showing greater volatility, especially in later years. The significant increase in multilateral contributions at the end of the period highlights the growing importance of world development banks along with other multilateral organisations in climate funding. This conclusion is crucial because it emphasises the change in duty from bilateral agreements to more global cooperation efforts to address climate resilience.

The evaluation of mobilized private financing, which reflects the contribution of investments made by the private sector, found an average yearly number of \$14.7 billion, with significant variances ranging from \$10.1 billion in 2016 to \$21.9 billion in 2022. The consistent increase, notably in the latter few years of the evaluation, indicates a rise in private sector involvement in climate-related initiatives, which is most likely driven by greater public investment and the development of innovative finance tools.

The correlation estimates revealed large and statistically significant positive correlations between public finance and mobilized private finance. Bilateral public finance had a substantial correlation with mobilized private finance ( $r = 0.832$ ,  $p = 0.020$ ), as did multilateral public finance ( $r = 0.868$ ,  $p = 0.011$ ). These findings indicate that as public investments rises—whether by means of bilateral government avenues or multilateral institutions—private sector contributions tend to rise, implying that public funding plays an essential role for minimising risks and drawing private investors to climate-resilient initiatives.

The regression analysis confirmed that bilateral public financing, multilateral public finance, and export credits contributed to 92.8% of the variation in mobilized private finance ( $R^2 = 0.928$ ). However, while bilateral and multilateral public finance had substantial impact on private sector mobilization, export credits had a limited and statistically small effect, implying that export credits might not be as effective in encouraging private sector investment in climate resilience.

## 8. Discussion

The findings of this study highlight the critical role that public finance plays in attracting private capital towards climate-resilient infrastructure. Public sector investments, particularly from bilateral and multilateral sources, play a major part in encouraging private investment by providing stability, lowering investment risk, and increasing the profitability of large-scale infrastructure projects targeted at combating climate change. The strong associations between public finance and mobilized private capital highlight the fact that as governments and international organisations expand their funding agreements, the private sector responds with increasing investment, making public-private partnerships an effective tool in climate financing.

Furthermore, the increased private sector participation in climate-related initiatives, as indicated by an upsurge in mobilized private capital near the end of the duration, is an encouraging development. This increase in involvement from the private sector could be related to the rising availability of financial instruments such as green bonds and climate resilience debt instruments, which offer new ways for private investors to get involved with sustainable infrastructure development. However, the very small impact of export credits on private investment implies that, while export credits might be useful in supporting specific initiatives, they are less effective as a general instrument for mobilizing private capital in the climate resilience domain.

The findings further emphasise the role of multilateral organisations in climate finance, especially in recent years. Multilateral lending institutions and other international organisations have become more engaged in financing climate-resilient infrastructure projects, especially in regions with insufficient fiscal capacity to fund such programs independently. The strong association between multilateral public finance and private sector mobilization shows that these organisations serve an important role in bridging the disconnect between public sector funding and private sector participation, hence providing chances for global collaboration.

## 9. Conflict of Interest Statement

The authors state that there are no conflicts of interest in the publishing of this study. The study used publicly available data from credible sources, such as the OECD, and the analysis was carried out independently and without bias. All data interpretations and findings are based on objective statistical methodologies, making sure that the results are unbiased and intended to contribute to the scholarly dialogue on climate financing and public-private partnerships.

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