

Article

Does Government Environmental Spending Crowd in Green Investment? The Role of Carbon Pricing and the Limits of Fiscal Policy Alone

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Abstract

Governments around the world are spending more on environmental protection, but it is far from obvious that this spending pulls private capital into green assets. This paper asks whether government environmental expenditure crowds in green investment at the country level, whether carbon pricing moderates this relationship, and through what channels it operates. Using an unbalanced panel of 33 countries observed from 2010 to 2021 and estimated with two-way fixed effects, we find that environmental spending on its own does not significantly predict green investment, proxied by the renewable energy share of generation capacity—a result that holds across multiple specifications, a dynamic system-GMM estimator, and an extensive battery of robustness checks. The interaction between fiscal spending and carbon pricing is positive—the marginal effect of government expenditure points from negative to positive moving from no-carbon-pricing to carbon-pricing country-years—but neither the interaction term nor either marginal effect, tested individually by a simple-slope test, is statistically distinguishable from zero, so this evidence is exploratory rather than confirmatory. Bootstrapped mediation tests show that government spending significantly deepens financial markets but this deepening does not automatically translate into green capital allocation, pointing to a gap between aggregate financial depth and green financial capacity. Azerbaijan, which hosted COP29 in 2024, is discussed as an illustrative policy case (Section An Illustrative Policy Case: Azerbaijan): its environmental expenditure is well below the sample average, it lacks carbon pricing, and its institutional quality score is below zero—a combination that helps illustrate why the country's green investment lags behind its stated ambitions. The findings do not support a strong causal claim that fiscal spending and carbon pricing act as complements, but they are directionally consistent with that hypothesis, and they indicate that governments hoping to mobilise private green capital cannot rely on fiscal spending alone—they also need functioning green financial infrastructure.



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1. Introduction

The arithmetic of the green transition does not add up. The International Energy Agency estimates that annual clean energy investment needs to triple by 2030 if the world is to stay anywhere near a net-zero trajectory (IEA, 2023). Developing and resource-dependent economies face the sharpest version of this problem: their financing gaps are widest precisely where the institutional and market conditions for closing them are weakest (UNEP, 2023). Against this background, two questions keep coming back in both policy circles and academic journals. First, can government spending on environmental protection catalyse private green investment, or does it merely substitute for it? Second, what other policy conditions need to be in place for such catalysis to work?

The theoretical case for a crowding-in effect is intuitive. Government expenditure on renewable energy infrastructure, pollution abatement, and environmental governance ought to reduce the technology and policy risks that deter private investors, build the physical and institutional infrastructure that green projects depend on, and signal long-term commitment to the transition (Mazzucato & Semieniuk, 2018; Polzin et al., 2019). But the empirical record is less tidy. Eyraud et al. (2013) find positive effects of fiscal interventions on green investment across 35 countries, yet Hong et al. (2022) show that fiscal environmental spending can actually crowd out corporate environmental investment under certain ownership structures. Y. Hu et al. (2023) report a nonlinear relationship, with diminishing returns at higher spending levels. The picture that emerges is one of conditional effectiveness: fiscal spending may or may not crowd in green capital, depending on what else is going on in the policy environment.

This paper takes that conditional logic seriously. It asks not just whether government environmental expenditure predicts green investment, but whether carbon pricing—a conceptually distinct instrument that works by repricing risk rather than by spending money—amplifies or weakens the fiscal effect. It also examines two potential transmission channels: institutional governance quality and financial market development. Throughout, the dependent variable is the renewable-energy share of generation capacity, used here as a proxy for green investment; Section Dependent Variable: Construct Validity and Justification sets out the construct-validity case and its limits, and the term “green investment” should be read in that restricted, capacity-based sense. Azerbaijan recurs as a policy illustration—developed in the Discussion (Section An Illustrative Policy Case: Azerbaijan) rather than as a formal element of the research design—because it shows with unusual clarity what happens when fiscal commitment is low, carbon pricing is absent, and institutions are weak.

The motivation for this paper can be traced to a documented financing gap in transition economies. Abdulhasanova (2025) identifies a “green financing paradox” in Azerbaijan, in which the banking sector holds substantial liquidity while green projects receive a negligible share of domestic credit, with the annual green-investment gap estimated at approximately \$2.3 billion. Aliyev et al. (2024), in a separate study covering Azerbaijan and Iceland, establish a causal link between renewable energy consumption and GDP growth, confirming that the economic case for the green transition is empirically grounded. What this earlier work leaves open—and what motivates the present paper—is whether a shift in government fiscal priorities can bridge such financing gaps by drawing institutional capital into the green space, or whether something more is needed.

The analysis uses an unbalanced panel of 33 countries observed annually from 2010 to 2021, with government environmental expenditure data drawn from the IMF’s Climate Indicators database. The econometric workhorse is a two-way fixed-effects model with standard errors clustered at the country level. We also estimate moderation models ($GGE \times \text{carbon pricing}$), run a bootstrapped causal mediation analysis for institutional

quality and financial development, split the sample by development status to examine heterogeneity, and subject the central result to a dynamic system-GMM estimator and a battery of robustness checks.

The results can be summarised in three sentences. Government environmental spending, by itself, does not significantly predict green investment in any specification. The data are directionally consistent with carbon pricing activating the fiscal channel—the marginal effect of government spending is negative without carbon pricing and positive with it—but this pattern is not statistically significant by any of the tests applied, so it is best read as a hypothesis; the data do not reject rather than one they confirm. And fiscal spending deepens financial markets but this deepening does not automatically translate into green investment—a finding that resonates directly with the Azerbaijani paradox of liquid banks and empty green portfolios.

These findings contribute to a literature that has been moving away from simple “does X affect Y” questions toward a more nuanced understanding of policy complementarity (Liew et al., 2025; Dasgupta & De Cian, 2018). They also carry immediate policy relevance for countries—including Azerbaijan—that are designing green fiscal packages in the wake of COP29.

The paper proceeds as follows. Section 2 reviews the theoretical and empirical landscape and develops the hypotheses. Section 3 describes the data, variables, and estimation strategy. Section 4 reports results. Section 5 discusses their implications. Section 6 concludes.

2. Background and Hypotheses

2.1. Green Investment and the Institutional Investors That Drive It

Green investment—capital allocated to projects, technologies, and assets with positive environmental outcomes—has grown rapidly. Annual global investment in renewable energy capacity exceeded \$500 billion in 2023 (IRENA, 2024), and ESG-labelled assets surpassed \$35 trillion (GSIA, 2024). Yet these headline numbers obscure a concentration problem: roughly 90% of transition investment flows to advanced economies and China, leaving the rest of the developing world behind (IRENA, 2025).

Institutional investors—pension funds, sovereign wealth funds, insurers—are central to any plausible solution. They manage over \$100 trillion in assets and, in principle, have the long time horizons that green infrastructure demands (OECD, 2023; Della Croce et al., 2011). In practice, their green allocations have been modest. Yang et al. (2023) show that government policy signals do shift institutional preferences toward green firms in China, but the response depends on ownership type and information quality. Zhao et al. (2023) find that long-term, stable institutional investors promote green innovation more effectively than short-term ones. Duppati (2025) extends this logic to sovereign wealth funds, whose green investment choices mirror home-country policy orientation. The recurring theme is that institutional investors respond to policy—but selectively, and through mechanisms that are not yet fully understood.

2.2. The Crowding-In Debate

The question of whether government spending crowds in or crowds out private investment dates back to Aschauer (1989) and Friedman (1979). In the green investment context, crowding in has three plausible channels. First, government spending de-risks green projects by co-financing, guaranteeing, or insuring them. Second, it builds enabling infrastructure—grid connections, permitting systems, research facilities—that private projects depend on. Third, it sends a policy signal: when a government puts fiscal

resources behind environmental objectives, private investors read this as a credible commitment that reduces the risk of policy reversal (Mbanyele et al., 2025; Polzin et al., 2019).

The empirical evidence is mixed. Mazzucato and Semieniuk (2018) show that public financial institutions played a catalytic role in early renewable energy markets. Liew et al. (2025), analysing 40 countries over 2010–2022, find that government capital expenditure positively influences institutional green investment allocations when moderated by carbon mitigation policies. On the other side, Hong et al. (2022) document crowding out in state-owned firms, and Ağazade (2024) reports that the environmental impact of government spending among OECD countries is not uniformly positive. Fan and Shi (2025) detect an inverted U-shaped relationship between fiscal incentives and green innovation. A parallel public-finance study finds that green public expenditure can carry sizeable output multipliers (Batini et al., 2022), and Zhang et al. (2021) show that the growth payoff of public spending is contingent on the depth of green finance. Yet a recurring theme in this work is that spending succeeds only alongside functioning financial institutions: Campiglio (2016) argues that mobilising private climate capital requires banking and monetary coordination rather than fiscal or price signals alone, and Polzin's (2017) systematic review catalogues the institutional barriers through which public action does or does not crowd in private green finance. Solodoha et al. (2023), drawing on a natural experiment, provide causal evidence that government incentives can meaningfully shift private investment behaviour, while cautioning that the effect depends on design. Taken together, these findings suggest that crowding-in is conditional rather than automatic.

2.3. Carbon Pricing as a Moderator

Carbon pricing works through a different channel than fiscal spending. Where government expenditure pushes capital toward green projects by reducing their cost, carbon pricing pulls capital away from brown projects by raising theirs (Hepburn et al., 2020). The two instruments are theoretically complementary: spending makes green investments viable, pricing makes fossil fuel investments unattractive, and the relative return on green assets improves from both directions.

Empirical work supports this logic indirectly. Chen et al. (2023) document that China's emissions trading scheme promoted corporate green investment, with stronger effects among SOEs and firms in strictly regulated regions. Billand et al. (2025) find that inclusion of carbon markets in portfolios enhances risk-adjusted returns. Dechezleprêtre et al. (2023) provide rigorous evidence that the EU Emissions Trading System cut emissions without harming economic performance, establishing that well-designed carbon markets work; and H. Hu et al. (2025), exploiting China's environmental-tax reform as a quasi-natural experiment, show that price-based environmental policy can drive corporate green-technology innovation. But Xie et al. (2025) warn that carbon price uncertainty can delay green investment, and Li et al. (2022) confirm that policy ambiguity dampens long-term commitments. What has not been tested is whether carbon pricing amplifies the crowding-in effect of fiscal spending—the specific question this paper addresses.

2.4. Two Potential Channels: Institutional Quality and Financial Depth

If government spending does promote green investment, through what mechanisms? Two candidates deserve attention. The first is institutional governance quality—rule of law, regulatory predictability, control of corruption (North, 1990; Dasgupta & De Cian, 2018). Government spending on environmental governance could improve these conditions over time, making the country a more attractive destination for green capital. Wang and Wang (2023) show that provincial green governance quality predicts enterprise green investment in China.

The second candidate is financial market development. A deep financial system can translate policy signals into investment flows more efficiently than a shallow one. Green bonds need functioning bond markets; project finance needs banks capable of long-term lending. Evidence from Azerbaijan illustrates the other side of this coin: the banking sector held adequate liquidity but lacked the instruments, expertise, and maturity structure to finance green projects (Abdulhasanova, 2025). Ahmadova and Sadigova (2025), documenting the parallel digital transformation of Azerbaijan's economy, note that managing multiple structural transitions simultaneously strains institutional capacity—an observation that applies to the green financial transition as well.

2.5. Theoretical Contribution

The contribution of this paper is to test, rather than assume, the complementarity between fiscal and price-based climate instruments at the macro level, and to do so within a framework that takes transmission channels seriously. Three literatures meet here but rarely speak to one another: public finance, which models government-spending multipliers (Batini et al., 2022); green-finance scholarship, which stresses that mobilising private capital depends on functioning financial institutions rather than pricing alone (Campiglio, 2016; Polzin, 2017; Zhang et al., 2021); and the carbon-pricing literature, which evaluates the effectiveness of taxes and trading systems (Dechezleprêtre et al., 2023; H. Hu et al., 2025). The gap addressed here is the joint question they leave open—whether fiscal environmental spending crowds in renewable-energy capacity, and whether that effect is conditional on a carbon price. By estimating the interaction directly and decomposing the institutional-quality and financial-development channels, the paper moves the complementarity argument from theory to evidence and qualifies it: the data are consistent with complementarity at the extensive margin of carbon pricing, but not with treating fiscal spending as a stand-alone lever.

2.6. Hypotheses

The review yields the following propositions.

Hypothesis 1 (H1). *Government environmental expenditure is positively associated with green investment (crowding-in).*

Hypothesis 2 (H2). *Carbon pricing positively moderates the GGE–green investment relationship.*

Hypothesis 3a (H3a). *Institutional quality mediates the GGE–green investment relationship.*

Hypothesis 3b (H3b). *Financial development mediates the GGE–green investment relationship.*

Hypothesis 4 (H4). *The effects are heterogeneous across developed and developing economies.*

3. Data and Methods

3.1. Sample

The dataset is an unbalanced panel of 33 countries observed annually from 2010 to 2021. Of a possible 396 country-years (33 countries $\times$ 12 years), 349 (88%) have complete data on all model variables and enter the estimation sample after listwise deletion; the panel is unbalanced because government environmental expenditure and a few control series are missing for some country-years. The missingness is plausibly missing-at-random with respect to the outcome—it is driven by the staggered country coverage of the IMF Climate Indicators database and of World Bank credit series rather than by green-investment performance—so listwise deletion yields consistent fixed-effects estimates; we nonetheless

verify this with a multiple-imputation robustness check (Section 4.6) that recovers the observations lost only to missing controls. Countries were selected on the basis of data availability across all key variables. The sample includes 20 developed and 13 developing economies, covering a wide range of carbon pricing regimes: 64% of observations correspond to country-years with operational carbon pricing.

Sample Selection and Country Coverage

The candidate pool consisted of 34 countries for which renewable-energy capacity data (the dependent variable) and the core macroeconomic controls were available. One country, Canada, was excluded entirely because no observation of financial development (domestic credit to the private sector) was available for it in the World Bank series for any sample year, leaving private-sector credit unobserved throughout 2010–2021; Table 1 summarises the selection process. No other country was dropped outright—the remaining attrition, from 396 possible country-years for the 33 retained countries to the 349 used in estimation, reflects scattered missing values within otherwise-included countries (Table 2), predominantly in government environmental expenditure and, for a handful of country-years, in financial development.

Table 1. Sample selection.

Stage	Countries	Reason/Detail
Candidate countries (GI and macro controls available)	34	Initial pool with renewable-capacity and World Development Indicator coverage
Excluded: no financial-development data	−1 (Canada)	Domestic credit to private sector unavailable for any year, 2010–2021
Final country panel	33	20 developed, 13 developing economies
Possible country-years (33 × 12 years, 2010–2021)	396	Full balanced frame for the retained countries
Estimation sample after listwise deletion	349 (88%)	47 country-year cells dropped to scattered missingness in GGE and, less often, FD

Notes: GI = green investment (RE capacity share); FD = financial development. The 34-country candidate pool and the exclusion of Canada are both data-availability decisions made prior to estimation, not selected on the outcome.

Table 2. Country-year coverage in the estimation sample (2010–2021, 33 countries).

Country	Years Present	Missing Years
Argentina	3/12	Missing 2010–2018 (inflation gap through 2017; GGE gap through 2013)
Azerbaijan	6/12	Missing 2010–2015
Brazil	6/12	Missing 2010–2014, 2021
Egypt	6/12	Missing 2016–2021
Philippines	6/12	Missing 2010–2014, 2021
Switzerland	7/12	Missing 2017–2021
New Zealand	8/12	Missing 2010–2013
Thailand	9/12	Missing 2010–2012
China	11/12	Missing 2021
Colombia	11/12	Missing 2021
Remaining 23 countries	12/12 each	Full coverage

Notes: The remaining 23 countries (Australia, Austria, Belgium, Chile, Czech Republic, Denmark, Finland, France, Germany, Indonesia, Ireland, Israel, Italy, Japan, Norway, Poland, Portugal, South Africa, Spain, Sweden, Turkey, Ukraine, United Kingdom) each contribute the full 12 years. Total country-years = 349.

Table 2 reports, for each of the 33 retained countries, how many of the 12 sample years (2010–2021) enter the estimation sample. Twenty-three countries have complete 12/12 coverage; ten have partial coverage, ranging from 3/12 (Argentina, where inflation and

GGE both have early-year gaps) to 11/12 (Colombia and China, each missing only 2021). This staggered pattern across different countries and different years is consistent with the missing-at-random argument in Section 3.1: the gaps track database reporting lags rather than green-investment outcomes.

3.2. Variables

The dependent variable, green investment (GI), is the renewable energy share of total electricity generation capacity, sourced from IRENA's Renewable Energy Statistics 2025. This measure captures the structural orientation of the electricity system toward renewables and is available for over 150 countries annually. It is a proxy: it reflects the cumulative outcome of green investment decisions in the power sector rather than financial flows directly, and results should be read with that construct-validity caveat in mind (Carley, 2009; Brunnschweiler, 2010).

The main independent variable, government green expenditure (GGE), is environmental protection expenditure as a percentage of GDP, from the IMF's Climate Indicators database (COFOG Division 05). This covers spending on pollution abatement, biodiversity protection, waste management, and environmental R&D.

The moderator, carbon pricing (CP), is operationalised as a binary indicator equal to one if a country operates a carbon tax or emissions trading system, sourced from the World Bank's Carbon Pricing Dashboard.

The mediators are institutional quality (IQ) and financial development (FD). IQ is the simple average of the six Worldwide Governance Indicator dimensions: voice and accountability (perceptions of citizens' ability to select their government and exercise civil liberties), political stability and absence of violence, government effectiveness (quality of public services and policy implementation), regulatory quality (the government's capacity to formulate sound market-friendly policy), rule of law (confidence in and adherence to societal rules, including contract enforcement and property rights), and control of corruption (Kaufmann et al., 2011). Averaging the six dimensions into a single composite, rather than entering them separately, follows common practice in the cross-country governance literature and is supported by Langbein and Knack's (2010) factor-analytic finding that the six WGI dimensions load heavily onto a single underlying governance construct rather than measuring six independent concepts; the simple average is therefore a defensible summary measure, while a model with six separate, highly collinear governance regressors would not be identified reliably in a panel of this size. FD is measured as domestic credit to the private sector as a share of GDP, the standard financial-depth measure introduced by King and Levine (1993) and used throughout the finance-and-growth literature (Levine, 2005); in the renewable-energy literature specifically, Wu and Broadstock (2015) use the same measure and find that financial development is associated with greater renewable energy uptake in emerging economies, which motivates its inclusion here as a channel variable.

Controls include GDP growth, log GDP per capita, inflation, trade openness, FDI inflows, and population growth, all from the World Bank's World Development Indicators. Oil price (Brent crude, annual average) is absorbed by the year fixed effects.

Dependent Variable: Construct Validity and Justification

A reasonable concern, raised across the environmental-economics literature, is whether the renewable-energy share of generation capacity adequately proxies for green investment. Strictly, green investment denotes financial flows committed to environmentally sustainable assets, whereas the RE capacity share is a stock measure of the power system's structural orientation that reflects the cumulative outcome of past investment, technology-cost declines, and the retirement of conventional plant. The measure is, however, an established

one: capacity- and deployment-based indicators of this kind are used throughout the empirical literature on renewable energy determinants, and Bourcet's (2020) systematic review of forty-eight quantitative studies catalogues exactly this family of measures, including the renewable share of installed capacity, alongside government policy, income, and financial-development covariates very similar to those used here. Three considerations justify its use in the present study while bounding the interpretation. First, in the absence of harmonised cross-country data on green financial flows for a panel of this breadth and length, capacity-based proxies are standard (Carley, 2009; Brunnschweiler, 2010; Bourcet, 2020), and renewable capacity is the single largest component of energy-transition investment (IRENA, 2024). Second, because the variable enters a within-country fixed-effects specification, year-on-year changes in the RE share track the flow of new renewable capacity reasonably well at the margin. Third, the result is shown to survive a logit transformation of the bounded share as an alternative dependent variable (Section 4.6).

A further limit concerns what else moves the RE capacity share besides investment decisions. The measure can also shift with a country's industrial structure (electricity-intensive industries crowd out renewables' share even at constant renewable investment); its underlying energy mix and resource endowment (hydro-rich or wind-rich geographies reach high renewable shares with comparatively little new spending, while resource-poor countries need more investment for the same share); and government policy beyond environmental expenditure itself, such as feed-in tariffs, renewable portfolio standards, or grid-access rules that are not captured by GGE. The country and year fixed effects absorb the time-invariant component of these confounds (a country's hydro endowment, for instance) and the controls absorb some of the time-varying component (GDP per capita, trade openness), but residual confounding from policy instruments other than environmental expenditure cannot be ruled out, and this is one reason the estimated coefficients are interpreted as conditional associations rather than causal effects throughout the paper.

Two further limits follow, and they shape how the findings should be read. The proxy does not capture energy efficiency, green buildings, sustainable agriculture, or green financial instruments such as green bonds and ESG funds; and capacity additions may lag the investment decisions that produced them. Accordingly, this study is best understood as evidence on renewable-energy capacity scaling specifically, rather than on cross-sector green-asset allocation, and the term "green investment" is used throughout in that restricted sense.

3.3. Estimation

The baseline model is:

$$GI_{it} = \alpha + \beta_1 GGE_{it} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where μ_i captures time-invariant country characteristics and λ_t absorbs year-specific global shocks. Standard errors are clustered at the country level to accommodate serial correlation and heteroskedasticity within country panels (Petersen, 2009). The moderation model adds the $GGE \times CP$ interaction; the marginal effect of GGE under carbon pricing is then $\beta_1 + \beta$ on the interaction term.

The mediation analysis uses bootstrapped causal mediation rather than the older causal-steps procedure. For each channel we estimate the average causal mediation effect (ACME) as the product of the GGE-to-mediator path (a) and the mediator-to-GI path (b), both within the two-way fixed-effects framework, and obtain 95% confidence intervals from 600 country-level block-bootstrap replications (Preacher & Hayes, 2008; Imai et al., 2010). This modernises the Baron and Kenny (1986) approach and yields valid inference on the indirect effect.

Identification is the central threat to any such analysis: governments may raise green spending in response to investor demand (reverse causality), and unobserved political factors may drive both. Four strategies address this. First, country and year fixed effects absorb time-invariant heterogeneity and common shocks. Second, we estimate a dynamic system-GMM model (Arellano & Bover, 1995; Blundell & Bond, 1998) that instruments the lagged dependent variable and GGE with their own lags, with instrument validity assessed by the Hansen J test and the Arellano–Bond AR(2) test and with collapsed instruments to limit proliferation (Roodman, 2009). Third, a one-period lag of GGE reduces simultaneity. Fourth, quantile regression, winsorisation, sample-composition checks, leave-one-country-out estimation, a logit-transformed dependent variable, and multiple imputation of observations lost to the missing controls’ test sensitivity. The choice of fixed over random effects is confirmed by a Hausman test, and multicollinearity is assessed through variance inflation factors. We also re-estimate the moderation using the continuous effective carbon price (USD per tonne) in place of the binary indicator, to separate the extensive margin of carbon pricing (whether a price exists) from its intensive margin (how high it is). Heterogeneity is assessed through sub-sample estimation by development status.

4. Results

4.1. Descriptive Overview

The average country in the sample devotes 0.58% of GDP to environmental protection (Table 3), but the range is striking: Belgium and Japan allocate over 1% while Chile, the Philippines, and Thailand spend below 0.10%. The mean RE share of electricity capacity is 39.7%, driven upward by countries like Norway (96%), Brazil (82%), and New Zealand (77%), and pulled down by Israel (6.5%), South Africa (7.4%), and Egypt (11.1%). Institutional quality ranges from −0.96 to 1.92, and 64% of observations have operational carbon pricing.

Table 3. Descriptive statistics (33 countries, 2010–2021, N = 349).

Variable	N	Mean	SD	Min	Median	Max
GI (%)	349	39.66	23.88	0.76	36.58	97.79
GGE (% GDP)	349	0.582	0.338	0.017	0.561	1.576
IQ (index)	349	0.807	0.841	−0.960	1.005	1.924
FD (% GDP)	349	97.31	44.96	13.26	94.84	195.27
CP	349	0.639	0.481	0	1	1
GDP growth (%)	349	2.296	3.773	−10.94	2.207	24.62
ln GDP p.c.	349	9.920	1.014	7.647	10.37	11.44
Inflation (%)	349	3.140	5.725	−1.144	1.922	53.55
Trade (% GDP)	349	78.92	41.75	24.32	67.01	258.78
FDI (% GDP)	349	3.319	6.331	−7.666	2.301	74.82
Pop. growth (%)	349	0.675	0.696	−1.854	0.589	2.305

Notes: GI = RE share of electricity capacity; GGE = government environmental expenditure (COFOG Div. 05); IQ = WGI composite; FD = domestic credit to private sector; CP = carbon pricing (binary indicator). Statistics are computed on the estimation sample (N = 349).

Table 4 reports the full pairwise correlation matrix for the eleven main variables, addressing concerns about unobserved bivariate relationships and potential multicollinearity directly rather than through isolated examples. The correlation between GGE and green investment is positive but modest ($r = 0.12$), suggesting that unconditional bivariate associations are not the whole story. Institutional quality correlates strongly with GDP per capita ($r = 0.92$) and with carbon pricing ($r = 0.73$), reflecting the well-documented tendency for richer, better-governed countries to also adopt carbon pricing; GGE itself correlates moderately with carbon pricing ($r = 0.49$) and income ($r = 0.53$). None of these pairwise

correlations among the regressors entering the same specification exceeds the FD–IQ or IQ–lnGDPpc pairs already flagged, and the fixed-effects specification absorbs most of this cross-sectional variation; the VIF diagnostics reported below confirm that multicollinearity does not materially affect the regression estimates.

Table 4. Correlation matrix, main variables (Pearson, N = 349).

	GI	GGE	CP	IQ	FD	GDPg	lnGDPpc	Infl	Trade	FDI
GGE	0.12									
CP	0.39	0.49								
IQ	0.42	0.44	0.73							
FD	0.29	0.27	0.28	0.50						
GDPg	−0.09	−0.13	−0.19	−0.09	−0.15					
lnGDPpc	0.44	0.53	0.69	0.92	0.48	−0.05				
Infl	−0.13	−0.31	−0.24	−0.41	−0.34	−0.06	−0.37			
Trade	−0.03	0.08	0.34	0.27	−0.14	0.13	0.28	−0.16		
FDI	−0.08	−0.05	0.06	0.08	−0.12	0.33	0.11	−0.07	0.43	
PopG	0.02	−0.24	−0.33	−0.06	−0.08	0.21	−0.02	0.03	−0.16	0.09

Notes: Lower triangle shown (matrix is symmetric); diagonal = 1 omitted. GDPg = GDP growth; lnGDPpc = ln GDP per capita; Infl = inflation; PopG = population growth. N = 349 throughout.

Two preliminary diagnostics support the estimation choices. A Hausman test rejects random effects in favour of fixed effects ($\chi^2 = 26.15$, $p < 0.01$), confirming that country-specific effects are correlated with the regressors. Multicollinearity is not a serious concern: the largest variance inflation factor among the regressors is 8.3 (for institutional quality, which correlates with income per capita), below the conventional threshold of 10.

4.2. Does Government Spending Crowd in Green Investment?

It does not—at least not by itself. The GGE coefficient is negative and statistically insignificant across all baseline specifications (Table 5): -7.31 ($p = 0.27$) without controls, -1.99 ($p = 0.74$) with key covariates, and -0.76 ($p = 0.90$) with the full control set. Hypothesis 1 is not supported. Before dismissing fiscal spending as irrelevant, however, two observations are in order.

First, the within-country variation in GGE over twelve years is quite small for most countries. A panel fixed-effects estimator identifies the coefficient from temporal variation within each country, and when governments change environmental budgets slowly, there is limited variation for the estimator to exploit. This is a data limitation, not necessarily evidence that spending does not matter.

Second, the control variables tell an instructive story. Trade openness is positive and significant ($\beta = 0.13$, $p < 0.05$), consistent with the view that integration into global supply chains and technology markets promotes renewable energy adoption. Inflation is negative and significant ($\beta = -0.13$, $p < 0.05$), capturing the broader point that macroeconomic instability discourages long-horizon investment of any kind—a finding that echoes Li et al.’s (2022) work on policy uncertainty and green commitment.

A note on explanatory power is warranted. The within R^2 values are modest, between 0.02 and 0.03 in the full specifications. This is common in macro-panel analyses, where country and year fixed effects already absorb most of the variation and the residual within-country movement in slow-moving fiscal and institutional variables is small. It does, however, counsel against over-interpreting the model’s explanatory reach: the framework identifies which factors move renewable-energy capacity at the margin—not a complete account of its determinants—and the policy implications below are framed accordingly.

Table 5. Two-way FE regression results (dependent variable: green investment, %).

	(1)	(2)	(3)	(4) GGE × CP	(5) GGE × IQ
GGE	−7.308 (6.574)	−1.985 (6.028)	−0.763 (6.150)	−4.550 (6.014)	1.001 (7.132)
CP		−3.650 *** (1.324)	−3.263 *** (1.239)	−5.893 *** (1.853)	−3.153 ** (1.248)
IQ		−2.812 (5.395)	−0.686 (4.916)	−1.952 (4.919)	0.266 (5.106)
FD		−0.058 (0.041)	−0.033 (0.047)	−0.036 (0.047)	−0.032 (0.046)
GGE × CP				4.805 (2.991)	
GGE × IQ					−2.258 (5.335)
GDP growth			0.011 (0.142)	0.004 (0.141)	0.014 (0.138)
ln GDP per capita			−4.036 (7.492)	−3.372 (7.547)	−4.552 (7.396)
Inflation			−0.125 ** (0.053)	−0.142 *** (0.053)	−0.117 ** (0.048)
Trade			0.131 ** (0.062)	0.121 ** (0.057)	0.131 ** (0.062)
FDI			−0.072 (0.047)	−0.075 (0.047)	−0.070 (0.047)
Population growth			−0.404 (1.070)	−0.270 (1.085)	−0.410 (1.074)
Controls	No	No	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	349	349	349	349	349
R ² (within)	0.030	0.028	0.025	0.018	0.022

Notes: Clustered SE at country level in parentheses. *** $p < 0.01$, ** $p < 0.05$. All control-variable coefficients are reported in full; none of GDP growth, ln GDP per capita, FDI, or population growth attains conventional significance in any specification. Oil price is absorbed by year fixed effects.

4.3. Does Carbon Pricing Change the Picture?

The interaction term itself is positive ($\beta = 4.81$) but does not reach conventional significance ($p = 0.11$), so the evidence here should be read as exploratory. Two further tests sharpen the picture and counsel caution rather than support a strong complementarity reading.

First, a simple slope test (delta method) evaluates the marginal effect of GGE separately at each level of carbon pricing rather than relying on the interaction coefficient alone. Without carbon pricing, the marginal effect of GGE is -4.55 (SE 6.01, $p = 0.45$); with carbon pricing, it is $+0.26$ (SE 6.07, $p = 0.97$). Neither marginal effect is statistically distinguishable from zero, and the marginal effect under carbon pricing is, in particular, indistinguishable from zero despite its positive sign. Second, splitting the sample by carbon-pricing status and re-estimating the baseline model separately in each subsample gives the same qualitative pattern with the same caveat: among country-years with carbon pricing ($N = 223$, 23 countries), $GGE = 1.30$ (SE 7.60, $p = 0.87$); among country-years without it ($N = 126$, 15 countries), $GGE = -3.69$ (SE 6.51, $p = 0.57$). The sign flips in the direction Hypothesis 2 predicts, but neither subsample coefficient is significant, and the subsample sizes are modest once the panel is split.

Taken together, these results do not establish that carbon pricing significantly strengthens the GGE–green investment relationship; they show a positive but statistically inconclusive interaction, corroborated by a consistent sign pattern across two independent ways of

probing it (simple slopes and subsample splits), none of which reaches significance. This is a materially weaker claim than crowding-in being conditionally activated by carbon pricing, and the paper's language is calibrated accordingly: the complementarity hypothesis is not rejected, but it is not confirmed either, and Hypothesis 2 is best described as receiving directionally consistent but statistically inconclusive support.

The carbon pricing main effect itself is negative and strongly significant ($\beta = -5.89$, $p < 0.01$). This is not as paradoxical as it first appears. Within a fixed-effects framework, this coefficient reflects the within-country change in green investment when a country introduces carbon pricing, holding everything else constant. Countries that adopt carbon pricing tend to be those that already have high RE shares—they are the Swedens and Denmarks, not the Egypts or Ukraines—and the subsequent growth rate of RE capacity naturally decelerates at high penetration levels. An additional possibility, documented by Xie et al. (2025), is that the early years of carbon pricing involve adjustment costs and market uncertainty that temporarily dampen new investment.

To probe whether what matters is the existence of a carbon price or its level, we re-estimate the model replacing the binary indicator with the effective carbon price in US dollars per tonne. The continuous price carries an insignificant coefficient ($p = 0.61$), as does its interaction with GGE ($p = 0.39$). The contrast with the binary specification is instructive: the suggestive complementarity operates at the extensive margin—whether a country prices carbon at all—rather than at the intensive margin of how high the price is. This is consistent with a signalling interpretation, in which the introduction of a carbon price shifts investor expectations more than marginal changes in its level, and it reinforces the cautious reading of Hypothesis 2.

4.4. Transmission Channels

The mediation analysis (Table 6) produces one null result and one partial result that together tell a coherent story.

Table 6. Bootstrapped causal mediation (ACME), two-way FE, 600 country-block replications.

Channel	a-Path (M~GGE)	b-Path (GI~M)	ACME (a $\times$ b) [95% CI]	Mediation?
Institutional quality (IQ)	0.033	0.330	0.011 [−0.70, 1.81]	No
Financial development (FD)	46.75 *	−0.032	−1.50 [−8.35, 1.55]	No

Notes: All paths estimated with country and year fixed effects and full controls. ACME = average causal mediation effect (indirect effect); 95% CIs from 600 country-level block-bootstrap replications. * The a-path 95% CI for FD excludes zero (8.05, 88.99); all other paths and both ACMEs have CIs spanning zero.

Institutional quality does not mediate the relationship. GGE does not significantly move the WGI composite ($a = 0.033$, CI spanning zero), and institutional quality does not significantly predict green investment conditional on GGE ($b = 0.33$, CI spanning zero). The indirect effect is null (ACME = 0.01, 95% CI [−0.70, 1.81]). This is perhaps unsurprising. Institutional change is slow—North (1990) famously argued that informal institutions can take generations to shift—and a twelve-year panel may simply be too short to detect fiscal spillovers onto governance quality.

Financial development tells a more interesting story. The a-path is significant: a one-percentage-point increase in GGE is associated with roughly a 47-point increase in the domestic-credit-to-GDP ratio, with a bootstrap confidence interval that excludes zero. But the b-path is not: financial depth does not predict green investment conditional on GGE ($b = -0.03$, CI spanning zero). As a result, the indirect effect is null (ACME = −1.50, 95% CI [−8.35, 1.55]). What does this mean? Government spending deepens financial markets in the aggregate—more credit flows through the system—but this additional liquidity does not find its way into green projects. The gap between financial depth and green financial

capacity is real and consequential, and the policy case in Section An Illustrative Policy Case: Azerbaijan illustrates concretely what this gap looks like on the ground.

4.5. Developed Versus Developing Countries

When the sample is split, the pattern diverges. In developed countries ($N = 231$, 20 countries), none of the key variables is significant and the within R^2 is 0.12. In developing countries ($N = 118$, 13 countries), the model explains 41% of within-country variation; income per capita carries the largest coefficient ($\beta \approx 21.6$), although with only thirteen countries it is estimated imprecisely ($p = 0.10$), and GGE remains insignificant ($\beta = -3.75$, $p = 0.51$).

This divergence has a natural interpretation. In developed economies, RE penetration is already high and its evolution is driven by technology costs and regulatory fine-tuning rather than by aggregate fiscal or institutional variables. In developing economies, the transition is at an earlier stage, and income level appears to be the dominant predictor—wealthier developing countries can simply afford more renewable capacity—even if the small number of countries makes the estimate imprecise. The insignificance of GGE in both sub-samples reinforces the main finding: spending alone does not drive the transition. Hypothesis 4 is partially supported in that the determinants of green investment differ by development stage, even if GGE is not significant in either group.

4.6. Robustness

The central null result on GGE is robust. Table 7 collects the checks. The coefficient on government environmental expenditure remains statistically insignificant when GGE is lagged one period, when the model is estimated by dynamic system-GMM, when carbon pricing is measured by its effective price rather than the binary indicator, when the bounded dependent variable is replaced by its logit transform, when continuous variables are winsorised at the 1st and 99th percentiles, when the three highest-RE countries are excluded, and across the full leave-one-country-out exercise. A multiple-imputation procedure that recovers the 32 observations lost only to missing controls ($N = 381$) likewise leaves the coefficient insignificant, confirming that listwise deletion does not drive the result; furthermore, as reported above, a Hausman test supports the fixed-effects specification while variance inflation factors rule out serious multicollinearity.

Table 7. Robustness of the GGE coefficient (dependent variable: green investment, %).

Specification	GGE Coef.	SE	<i>p</i>	Sample
Baseline two-way FE (full controls)	−0.763	(6.150)	0.901	$N = 349$
One-period lag, GGE ($t-1$)	−0.309	(6.747)	0.963	$N = 316$
Dynamic system-GMM (Blundell–Bond)	2.196	(3.094)	0.478	33 grp/283 obs
Quantile regression, Q25	1.518	—	0.407	$N = 349$
Quantile regression, Q50	0.729	—	0.696	$N = 349$
Quantile regression, Q75	−4.406	—	0.016	$N = 349$
Winsorised (1st/99th pct)	−0.585	(6.541)	0.929	$N = 349$
Exclude top-3 RE countries	0.557	(6.148)	0.928	$N = 323$
Leave-one-country-out (range)	[−6.28, 2.20]	—	ns	33 fits
Carbon price intensity (USD/tCO ₂)	−1.111	—	0.861	$N = 349$
Alternative DV: logit (RE share)	−0.170	(0.392)	0.665	$N = 349$
Multiple imputation (missing controls)	−4.142	(6.807)	ns	$N = 381$

Notes: Each row reports the GGE coefficient from a separate specification; all FE rows include country and year fixed effects with country-clustered SE. The system-GMM model treats the lagged dependent variable and GGE as endogenous, uses collapsed lagged instruments, and passes both diagnostic tests (Hansen J $p = 0.14$; AR(2) $p = 0.14$), indicating valid instruments and no second-order serial correlation. The multiple-imputation row pools five imputations by Rubin’s rules. “ns” = not significant (leave-one-out coefficient insignificant in every fit; multiple-imputation $t = -0.61$).

Two features of this table deserve comment. First, the system-GMM estimate is the most demanding test of the main result: by instrumenting both the lagged dependent

variable and GGE with their own lags, it addresses reverse causality and the persistence of renewable-capacity shares, and the Hansen and AR(2) diagnostics confirm that the instruments are valid. Even under this estimator, GGE is insignificant. Second, the only specification in which GGE attains significance is the 75th-percentile quantile regression, where the coefficient is negative (-4.41 , $p = 0.02$). This concentrates the weak negative association among countries that are already at high renewable-energy shares—precisely the deceleration-at-saturation mechanism discussed in Section 4.3—rather than overturning the central finding.

5. Discussion

The central finding of this paper—that government environmental spending does not, on its own, predict green investment—may disappoint those looking for a simple fiscal lever. But simplicity was never realistic. The green transition involves long-lived assets, uncertain technologies, contested regulations, and heterogeneous investors. The idea that a single policy instrument could reliably move capital from brown to green was always more assumption than evidence.

What the results do suggest is that fiscal spending is a component of a policy package, not the package itself. The positive (if imprecisely estimated) interaction with carbon pricing points toward a complementarity that has theoretical grounding in Liew et al. (2025) and practical resonance in countries that have combined both instruments. Sweden, which has the world's highest carbon tax alongside substantial environmental expenditure, also has one of the highest RE shares in the sample. Azerbaijan, which has neither carbon pricing nor substantial environmental spending, has one of the lowest. Correlation is not causation, but the pattern is consistent with the conditional interpretation.

The financial development finding deserves particular attention. That government spending deepens financial markets but not green financial markets is not a failure of fiscal policy—it is a failure of financial architecture. If banks do not have green lending units, green risk assessment tools, green taxonomies to classify eligible projects, or the ability to issue long-maturity instruments, then more liquidity simply means more conventional lending. This pattern is documented in Azerbaijan (Abdulhasanova, 2025) and is unlikely to be unique to that country. Policymakers would do well to distinguish between financial inclusion (making credit available) and green financial inclusion (making green credit available)—two objectives that overlap but are not identical.

An Illustrative Policy Case: Azerbaijan

The cross-country findings take on concrete meaning in Azerbaijan, which is best read as a policy illustration rather than a formal element of the research design. The country sits at the intersection of the three gaps the analysis identifies. Its environmental expenditure—averaging about 0.16% of GDP over the years it enters the sample, roughly a quarter of the sample mean of 0.58%—is among the lowest in the panel; it operates no carbon-pricing instrument; and its institutional-quality score (-0.58 on average) is well below the sample mean of $+0.81$. This triple deficit places Azerbaijan precisely where neither fiscal spending nor its complementary conditions are working in its favour.

The trajectory bears this out. Azerbaijan's renewable-energy share of capacity rose from 15.6% in 2010 to 20.3% by 2023, with momentum from the 230 MW Garadagh Solar Plant and planned wind capacity in the Khizi–Absheron corridor, but the gap to the sample average of 39.7% did not narrow. Hosting COP29 in November 2024 created visibility and political momentum, yet the structural constraints documented here—and the green financing paradox of liquid banks and empty green portfolios documented in Abdulhasanova (2025)—remain binding. This is the financial-development channel in microcosm: aggregate

liquidity exists, but the instruments, maturities, and green-assessment capacity to direct it into renewable projects do not. (One data caveat: Azerbaijan's reported expenditure ratio is inflated by an anomalous 2020–2021 reading in the IMF series; in the pre-pandemic years its reported spending was below 0.04% of GDP, which only sharpens the point about fiscal under-commitment).

The investor heterogeneity literature offers a useful lens for interpreting these results at the micro level. Yang et al. (2023) show that institutional investor responses to government policy depend on ownership type and information quality. Qiu and Chen (2025) find that investment horizon matters: long-term investors promote green innovation while short-term ones respond to immediate signals. The country-level analysis in this paper cannot distinguish between these investor types, and this is a limitation. But it suggests that the macro conditions—fiscal commitment, carbon pricing, institutional quality—set the stage on which micro-level investor decisions play out. Getting the macro conditions wrong makes it harder for even well-intentioned investors to deploy capital greenly.

6. Conclusions

This paper asked a straightforward question: does government environmental spending crowd in green investment? The answer is not straightforward at all. Using panel data from 33 countries over 2010–2021, we find no evidence that fiscal spending, by itself, significantly increases the renewable energy share of electricity capacity. But this null result is not the end of the story.

Three findings stand out. First, fiscal spending and carbon pricing show a pattern directionally consistent with complementarity—the marginal effect of government spending is negative without carbon pricing and positive with it—but neither the interaction term nor either marginal effect is statistically significant, and a subsample split tells the same inconclusive story. The honest summary is that the data do not rule out complementarity, but they do not establish it either; policymakers should treat the case for pairing fiscal spending with carbon pricing as theoretically motivated and suggestive rather than empirically proven by this study. Second, fiscal spending deepens financial markets in the aggregate, but this liquidity does not automatically flow into green projects—a result that is statistically robust. The gap between financial depth and green financial capacity is a binding constraint, especially in developing countries where banking systems are conventional by design. Third, Azerbaijan's triple deficit—minimal environmental expenditure, no carbon pricing, below-average institutions—illustrates what the regression coefficients mean in practice. Despite hosting COP29 and setting ambitious renewable energy targets, the country's structural conditions make it difficult for private capital to follow public ambition.

What should Azerbaijan—and countries in similar positions—do? The regression results point to three priorities. Raise environmental expenditure from its currently low level toward the sample median of 0.56% of GDP, to signal fiscal commitment. Consider a carbon pricing mechanism, even a modest one, since the directional pattern in the data—though not statistically conclusive—is consistent with carbon pricing complementing fiscal spending rather than substituting for it. And invest specifically in green financial infrastructure—a national green taxonomy, mandatory ESG disclosure for banks, a sovereign green bond framework—so that existing banking liquidity can be channelled into green lending rather than conventional credit.

The study has limitations. Government environmental expenditure data are available only through 2021 and are incomplete for several countries within that window, so the estimation sample is unbalanced. The RE share of electricity capacity is only one dimension of green investment. The 33-country sample, while diverse, excludes some major economies.

And the panel fixed-effects approach, while controlling for unobserved heterogeneity, relies on within-country variation that is limited for slowly moving fiscal variables. Future work should exploit the staggered adoption of carbon pricing for more credible causal identification, operationalise green financial capacity more precisely (green bond issuance, ESG fund penetration, climate lending ratios), and use firm-level portfolio data to test whether the country-level patterns observed here operate through the long-term investor channel documented by [Qiu and Chen \(2025\)](#) and [Cao et al. \(2024\)](#).

The green transition will not be funded by governments alone. But neither will it happen without them. The task for fiscal policy is not simply to spend more, but to spend in ways that activate the complementary conditions—carbon pricing, institutional quality, green financial infrastructure—on which private capital depends.

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References

- Abdulhasanova, R. (2025). Bridging the finance gap: Mobilizing capital for Azerbaijan's green economy transition. *Scientific Work International Scientific Journal*, 19(6), 29–33.
- Ağazade, S. (2024). The effect of government investments on the environment: An empirical investigation of OECD countries. *Journal of Cleaner Production*, 477, 143822. [\[CrossRef\]](#)
- Ahmadova, S., & Sadigova, G. (2025). Development of the digital economy: The impact of digitalization on the labor market and production. *Scientific Work International Scientific Journal*, 19(8), 28–31.
- Aliyev, S., Hasanov, R. I., Aghayeva, K., Gasimov, J. Y., & Ahmadova, S. E. (2024). The relationship between renewable energy consumption and economic growth: Insights from Iceland and Azerbaijan. *International Journal of Energy Economics and Policy*, 14(5), 229–235. [\[CrossRef\]](#)
- Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 68(1), 29–51. [\[CrossRef\]](#)
- Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics*, 23(2), 177–200. [\[CrossRef\]](#)
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research. *Journal of Personality and Social Psychology*, 51(6), 1173–1182. [\[CrossRef\]](#) [\[PubMed\]](#)
- Batini, N., Di Serio, M., Fragetta, M., Melina, G., & Waldron, A. (2022). Building back better: How big are green spending multipliers? *Ecological Economics*, 193, 107305. [\[CrossRef\]](#)
- Billand, A., Nagl, M., & Rösch, D. (2025). Carbon markets—Catalyst for portfolio growth and responsible investing. *Journal of Alternative Investments*, 28(2), 7–63. [\[CrossRef\]](#)
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115–143. [\[CrossRef\]](#)

- Bourcet, C. (2020). Empirical determinants of renewable energy deployment: A systematic literature review. *Energy Economics*, 85, 104563. [\[CrossRef\]](#)
- Brunnschweiler, C. N. (2010). Finance for renewable energy: An empirical analysis of developing and transition economies. *Environment and Development Economics*, 15(3), 241–274. [\[CrossRef\]](#)
- Campiglio, E. (2016). Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy. *Ecological Economics*, 121, 220–230. [\[CrossRef\]](#)
- Cao, Y., Li, Y., Xia, Z., & Zhang, Y. (2024). Sustainable institutional investors and green innovation: Evidence from Chinese listed firms. *Emerging Markets Finance and Trade*, 61(4), 925–939. [\[CrossRef\]](#)
- Carley, S. (2009). State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy*, 37(8), 3071–3081. [\[CrossRef\]](#)
- Chen, J., Geng, Y., & Liu, R. (2023). Carbon emissions trading and corporate green investment: The perspective of external pressure and internal incentive. *Business Strategy and the Environment*, 32(6), 3014–3026.
- Dasgupta, S., & De Cian, E. (2018). The influence of institutions, governance, and public opinion on the environment. *Energy Research and Social Science*, 43, 173–181. [\[CrossRef\]](#)
- Dechezleprêtre, A., Nachtigall, D., & Venmans, F. (2023). The joint impact of the European union emissions trading system on carbon emissions and economic performance. *Journal of Environmental Economics and Management*, 118, 102758. [\[CrossRef\]](#)
- Della Croce, R., Stewart, F., & Yermo, J. (2011). Promoting longer-term investment by institutional investors. *OECD Journal: Financial Market Trends*, 2011(1), 145–164. [\[CrossRef\]](#)
- Duppati, G. R. (2025). Understanding the green investment choices of SWFs. *Journal of Financial Reporting and Accounting*. [\[CrossRef\]](#)
- Eyraud, L., Clements, B., & Wane, A. (2013). Green investment: Trends and determinants. *Energy Policy*, 60, 852–865. [\[CrossRef\]](#)
- Fan, Y., & Shi, L. (2025). The role of government fiscal incentives in green technological innovation. *International Review of Economics and Finance*, 103, 104529. [\[CrossRef\]](#)
- Friedman, M. (1979). *Free to choose*. Harcourt.
- GSIA. (2024). *Global sustainable investment review 2024*. Global Sustainable Investment Alliance.
- Hepburn, C., Qi, Y., Stern, N., Stiglitz, J., & Zenghelis, D. (2020). Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? *Oxford Review of Economic Policy*, 36(S1), S359–S381. [\[CrossRef\]](#)
- Hong, Y., Jiang, X., Shi, B., & Yu, C. (2022). Do fiscal environmental protection expenditures crowd out corporate environmental protection investments? *Sustainability*, 14(20), 13608. [\[CrossRef\]](#)
- Hu, H., Zhu, Y., Ye, L., & Wang, Y. (2025). How does environmental tax reform drive corporate innovation to green technologies? quasi-natural experimental evidence from China. *Journal of Business Economics and Management*, 26(4), 798–824. [\[CrossRef\]](#)
- Hu, Y., Ding, Y., Liu, J., Zhang, Q., & Pan, Z. (2023). Does carbon mitigation depend on green fiscal policy or green investment? *Environmental Research Letters*, 18, 045005. [\[CrossRef\]](#)
- IEA. (2023). *World energy investment 2023*. International Energy Agency.
- Imai, K., Keele, L., & Tingley, D. (2010). A general approach to causal mediation analysis. *Psychological Methods*, 15(4), 309–334. [\[CrossRef\]](#) [\[PubMed\]](#)
- IRENA. (2024). *Renewable energy finance flows 2024*. International Renewable Energy Agency.
- IRENA. (2025). *Global landscape of energy transition finance 2025*. International Renewable Energy Agency.
- Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law*, 3(2), 220–246. [\[CrossRef\]](#)
- King, R. G., & Levine, R. (1993). Finance and growth: Schumpeter might be right. *The Quarterly Journal of Economics*, 108(3), 717–737. [\[CrossRef\]](#)
- Langbein, L., & Knack, S. (2010). The worldwide governance indicators: Six, one, or none? *Journal of Development Studies*, 46(2), 350–370. [\[CrossRef\]](#)
- Levine, R. (2005). Finance and growth: Theory and evidence. In P. Aghion, & S. Durlauf (Eds.), *Handbook of economic growth* (Vol. 1, pp. 865–934). Elsevier.
- Li, R., Xu, G., & Ramanathan, R. (2022). The impact of environmental investments on green innovation: An integration of factors that increase or decrease uncertainty. *Business Strategy and the Environment*, 31(7), 3388–3405. [\[CrossRef\]](#)
- Liew, C. Y., Duppati, G., & Santhana Rajan, M. E. (2025). The determinants of green investments by institutional investors: The role of government carbon mitigation strategies and policies. *International Review of Economics and Finance*, 104, 104788. [\[CrossRef\]](#)
- Mazzucato, M., & Semieniuk, G. (2018). Financing renewable energy: Who is financing what and why it matters. *Technological Forecasting and Social Change*, 127, 8–22. [\[CrossRef\]](#)
- Mbanyele, W., Liu, Y., Qu, X., & Huang, H. (2025). How does green industrial policy influence institutional investor ownership? *Global Finance Journal*, 68, 101209. [\[CrossRef\]](#)
- North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.
- OECD. (2023). *Institutional investors and long-term investment*. OECD Publishing.

- Petersen, M. A. (2009). Estimating standard errors in finance panel data sets: Comparing approaches. *Review of Financial Studies*, 22(1), 435–480.
- Polzin, F. (2017). Mobilizing private finance for low-carbon innovation: A systematic review of barriers and solutions. *Renewable and Sustainable Energy Reviews*, 77, 525–535. [\[CrossRef\]](#)
- Polzin, F., Egli, F., Steffen, B., & Schmidt, T. S. (2019). How do policies mobilize private finance for renewable energy? *Applied Energy*, 236, 1249–1268. [\[CrossRef\]](#)
- Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, 40(3), 879–891. [\[CrossRef\]](#) [\[PubMed\]](#)
- Qiu, Q., & Chen, Y. (2025). Institutional investor horizon and corporate green innovation. *Sustainability*, 17(22), 10402. [\[CrossRef\]](#)
- Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal*, 9(1), 86–136. [\[CrossRef\]](#)
- Solodoha, E., Rosenzweig, S., & Harel, S. (2023). Incentivizing angels to invest in start-ups: Evidence from a natural experiment. *Research Policy*, 52(1), 104634. [\[CrossRef\]](#)
- UNEP. (2023). *Adaptation gap report 2023*. United Nations Environment Programme.
- Wang, W., & Wang, X. (2023). Does provincial green governance promote enterprise green investment? Based on the perspective of government vertical management. *Journal of Cleaner Production*, 412, 137444.
- Wu, L., & Broadstock, D. C. (2015). Does economic, financial and institutional development matter for renewable energy consumption? Evidence from emerging economies. *International Journal of Economic Policy in Emerging Economies*, 8(1), 20–39. [\[CrossRef\]](#)
- Xie, C., Wu, L., & Tong, Z. (2025). Do firms defer or accelerate green investment under carbon price uncertainty? *Borsa Istanbul Review*, 25(4), 824–837. [\[CrossRef\]](#)
- Yang, W.-E., Lai, P.-W., Han, Z.-Q., & Tang, Z.-P. (2023). Do government policies drive institutional preferences on green investment? *Environmental Science and Pollution Research*, 30, 38407–38424.
- Zhang, D., Mohsin, M., Rasheed, A. K., Chang, Y., & Taghizadeh-Hesary, F. (2021). Public spending and green economic growth: Does green finance matter? *Energy Economics*, 100, 105343.
- Zhao, J., Qu, J., Wei, J., Yin, H., & Xi, X. (2023). The effects of institutional investors on firms' green innovation. *Journal of Product Innovation Management*, 40(2), 195–230.

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