Green Public Spending Shocks: Composition Effects and State-Dependent Heterogeneity Across Countries

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Summary

- We quantify “green fiscal multipliers” by constructing country-specific, residual-based shocks to environmental protection outlays (COFOG) and tracing their effects on macroeconomic outcomes in a multi-country panel.
- Reduced-form estimates imply that an unexpected 1-pp-of-GDP increase in environmental spending lowers contemporaneous real GDP per-capita growth by about 2.6 pp globally; IV estimates are larger in magnitude (≈–4 pp globally; ≈–7 pp in EMDEs).
- Local projections show a small short-run dip that troughs around year 2 at –0.05% and fades thereafter, with mild medium-run rebound. Heterogeneity is pronounced: EMDEs drive the near-term contraction; effects are more negative at high public debt and in surplus/open economies and are mitigated where adaptive capacity is high.
- Subcomponent shocks reveal the clearest short-run costs for pollution abatement, with similar but less precise patterns for R&D, waste management, and wastewater. Robustness checks (panel Granger, pre-trends, placebos) support the shocks’ exogeneity.

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Motivation

Why study green multipliers?

- Green outlays can carry front-loaded costs while benefits arrive with a lag. Emerging markets and developing economies account for a growing share of the increase
- Compliance mandates and infrastructure build-outs tend to be capital-intensive, import-heavy, and administratively complex; productivity and resilience gains materialize only after equipment is installed, networks are connected, and firms and households adapt. This paper quantifies those near-term trade-offs and the conditions under which they are attenuated or amplified.
- Environmental protection (COFOG 05) is small in levels but volatile at the margin. Median spending is roughly 0.55–0.70% of GDP in advanced economies (AEs) and 0.25–0.35% in EMDEs, with a wide interquartile range; a one-percentage-point-of-GDP change is therefore large relative to typical budget shares.
- The composition is uneven: waste and wastewater dominate everywhere, pollution abatement rises with stringency (especially in AEs), and environmental R&D remains modest. These facts hint that composition and country circumstances should matter for macro effects.

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Conceptual Framework

How can environmental outlays affect output?

- Positive multipliers: Environmental spending should raise output per capita.
- Heterogeneity by vulnerability : Effects are larger where χ is high (greater damages per unit of output) and where θ is low (spending less effective), i.e., in countries with high ND-GAIN vulnerability.
- Role of fiscal space: Crowding out of traditional investment or high debt service may dampen short-run effects.
- Dynamic gains dominate static trade-offs: Growth effects are expected to be stronger in the medium run, as productivity and resilience benefits accumulate, compared to the immediate period.

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Related Empirical Evidence

- Empirical research on fiscal multipliers has grown extensively, but the subset focusing on “green” multipliers remains limited.
- Hepburn et al. (2020) show that green investment programs following the global financial crisis produced employment and growth benefits comparable to or greater than traditional stimulus.
- Batini et al. (2021) estimate that public investment in climate adaptation yields larger long-run multipliers in climate-vulnerable economies. Similarly, IMF (2022) evidence suggests that green spending not only stimulates output but also enhances resilience to climate shocks, leading to more stable growth paths.
- Empirical evidence also points to important sources of heterogeneity. Multipliers are larger in economies with spare capacity, accommodative monetary policy, or strong institutions (Ilzetzki et al., 2013). For green multipliers specifically, vulnerability indices such as ND-GAIN have been shown to condition effectiveness, with more exposed countries deriving greater benefits from environmental spending (Hallegatte et al., 2016).

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Data and Sample

Country coverage

Advanced Economies (AEs)
United States, Austria, Belgium, Denmark, Luxembourg, Norway, Sweden, Switzerland, Canada, Japan, Finland, Greece, Iceland, Ireland, Malta, Spain, Cyprus, Israel, Hong Kong SAR, Korea (Republic of), Singapore, Czech Republic, Slovak Republic, Estonia, Slovenia.

Emerging Markets & Developing Economies (EMDEs)
South Africa, Argentina, Bolivia, Brazil, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Mexico, Nicaragua, Paraguay, Peru, Uruguay, Venezuela (Republica Bolivariana de), Bahamas (The), Belize, Bahrain, Iran (Islamic Republic of), Iraq, Kuwait, Lebanon, Oman, Saudi Arabia, Syria, Bangladesh, Bhutan, Brunei Darussalam, Sri Lanka, India, Timor Leste, Malaysia, Maldives, Nepal, Pakistan, Thailand, Vietnam, Djibouti, Algeria, Burundi, Cameroon, Cape Verde, Chad, Comoros, Congo (Republic of), Benin, Eritrea, Gabon, Gambia (The), Ghana, Guinea, Kenya, Lesotho, Libya, Madagascar, Mali, Mauritania, Morocco, Mozambique, Niger, Zimbabwe, Senegal, Sierra Leone, Namibia, Sudan, Swaziland, Togo, Tunisia, Uganda, Burkina Faso, Solomon Islands, Vanuatu, Samoa, Tonga, Albania, Kazakhstan, Kyrgyz Republic, Russian Federation, Ukraine, Montenegro, Hungary, Mongolia, Croatia, Macedonia (FYR), Bosnia & Herzegovina, Poland, Romania.

Period: 1990 to 2025
Key variables: Government spending by COFOG 05 and subcomponents (pollution abatement, environmental R&D, waste management, wastewater) with standard macro controls and environmental outcomes (emissions per capita, energy intensity, renewable electricity share).
State variables: Fiscal space (public debt), Trade openness, Adaptive capacity

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Methodology (1)

Construction of Residual-Based Environmental Spending Shocks:

Separate regression for each country *i,* relating environmental protection spending (as a share of GDP) to its own persistence and a set of lagged domestic fundamentals, taking the residuals from the following regression:

$$EP_{i,t} = \alpha_i + \phi_i(L)EP_{i,t-1} + \beta_i' X_{i,t-1} + u_{i,t}$$

- constructed for total environmental protection expenditure and for its four main COFOG subcomponents: i) Pollution abatement; ii) Environmental R&D; iii) Waste management; iv) Wastewater management.

Reduced-Form Panel Regressions

$$\Delta y_{i,t} = \theta\, Shocki_{i,t}^{EP} + \lambda' W_{i,t-1} + \mu_i + \tau_t + \varepsilon_{i,t}$$

Estimated with country and year fixed effects and Driscoll–Kraay standard errors to allow for heteroskedasticity, serial correlation, and cross-sectional dependence.

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Methodology (2)

Dynamic Effects via Local Projections

We estimate dynamic responses using Jordà (2005):

$$\Delta y_{i,t+h} = \alpha_{i,h} + \delta_{t,h} + Shocki_{i,t}^{EP} + \sum_{c=0}^{1} \pi_{c,h} X_{i,t-c} + \sum_{m=0}^{h} \kappa_{m,h} Shocki_{i,t+m}^{EP} + u_{i,t+h}$$

State dependence

$$\Delta y_{i,t+h} = \alpha_{i,h} + \delta_{t,h} + \beta_{0,h}^{L} F(z_{i,t}) * Shocki_{i,t}^{EP} + \beta_{0,h}^{H} (1 - F(z_{i,t})) * Shocki_{i,t}^{EP} + \sum_{c=0}^{1} \pi_{c,h} X_{i,t-c} + \sum_{m=0}^{h} \kappa_{m,h} Shocki_{i,t+m}^{EP} + u_{i,t+h}$$

This allows multipliers to vary with fiscal and structural conditions.

Why this approach

- Flexible dynamic responses
- Robust to misspecification
- Well suited for heterogeneous EMDE panels

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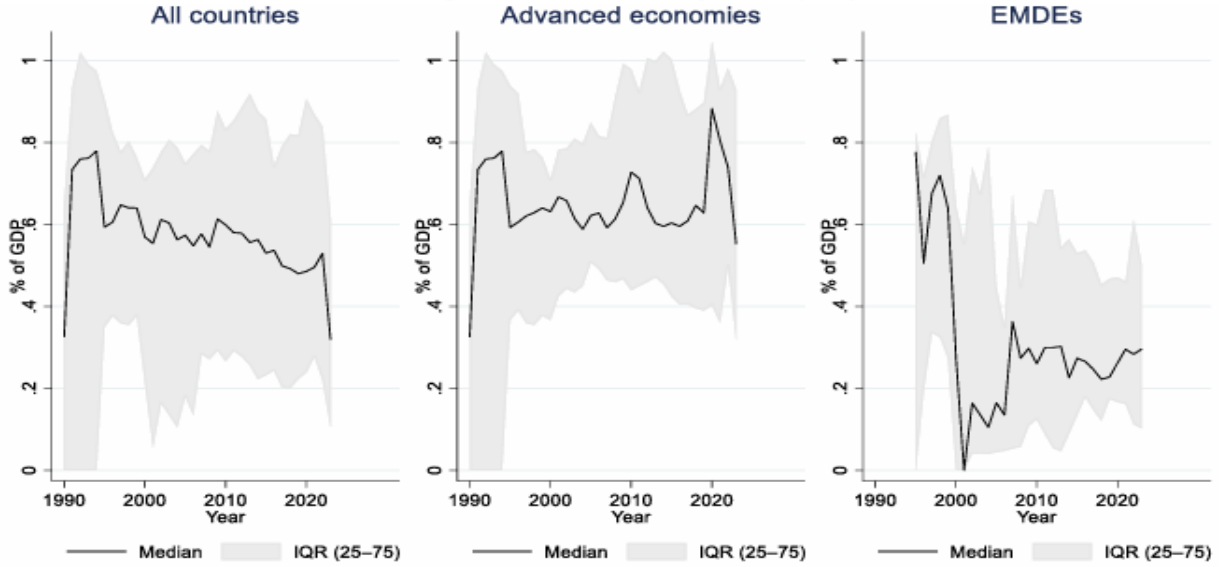
Stylized Facts 1 - Environmental Spending as a Share of GDP

- Levels differ markedly by income group
- Dispersion is sizable and asymmetric
- Trends are flat to mildly declining globally; EMDEs stabilize at lower levels

What this signals: Large cross-country heterogeneity → motivates conditional analysis

Figure 1. Environmental Protection Expenditure as a Share of GDP: Median and Interquartile Range Across Country Groups (1990–2023)



Note: Median is the solid black line. 25th and 75th percentiles denoted by the grey bands. Axes are common across panels.
Source: Authors using COFOG data.

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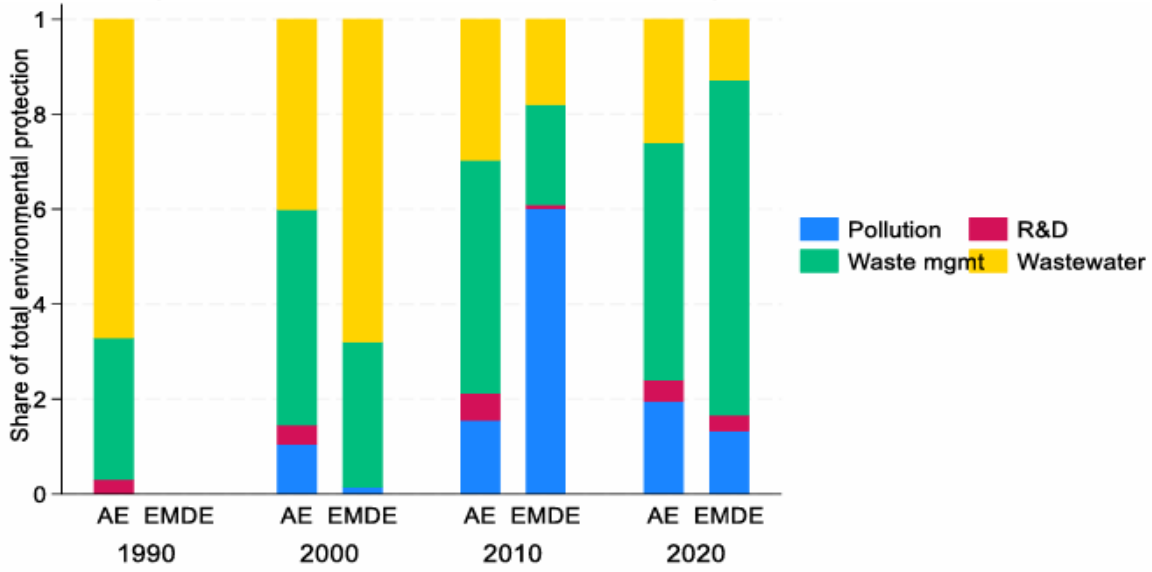
Stylized Facts 2 - Composition of Environmental Spending

- Environmental budgets differ markedly in functional composition
- Waste-related items dominate
- AEs allocate a visibly larger fraction to pollution abatement
- **What this signals:** Can aid interpretation of results – pollution abatement more on compliance and short-run output drag, waste-related are infrastructure-heavy with lags.

Figure 2. Composition of Environmental Protection Expenditure by Function (Share of Total Environmental Protection), 1990–2020



Note: Bars report the share of each component in total environmental protection expenditure. Blue = Military, Red = Civil, Green = R&D, Yellow = Foreign aid. Figures shown for Advanced Economies (AE) and Emerging Markets and Developing Economies (EMDEs) in benchmark years 1990, 2000, 2010, and 2020.
Source: Authors using IMF COFOG data.

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Results – Reduced form panel estimates

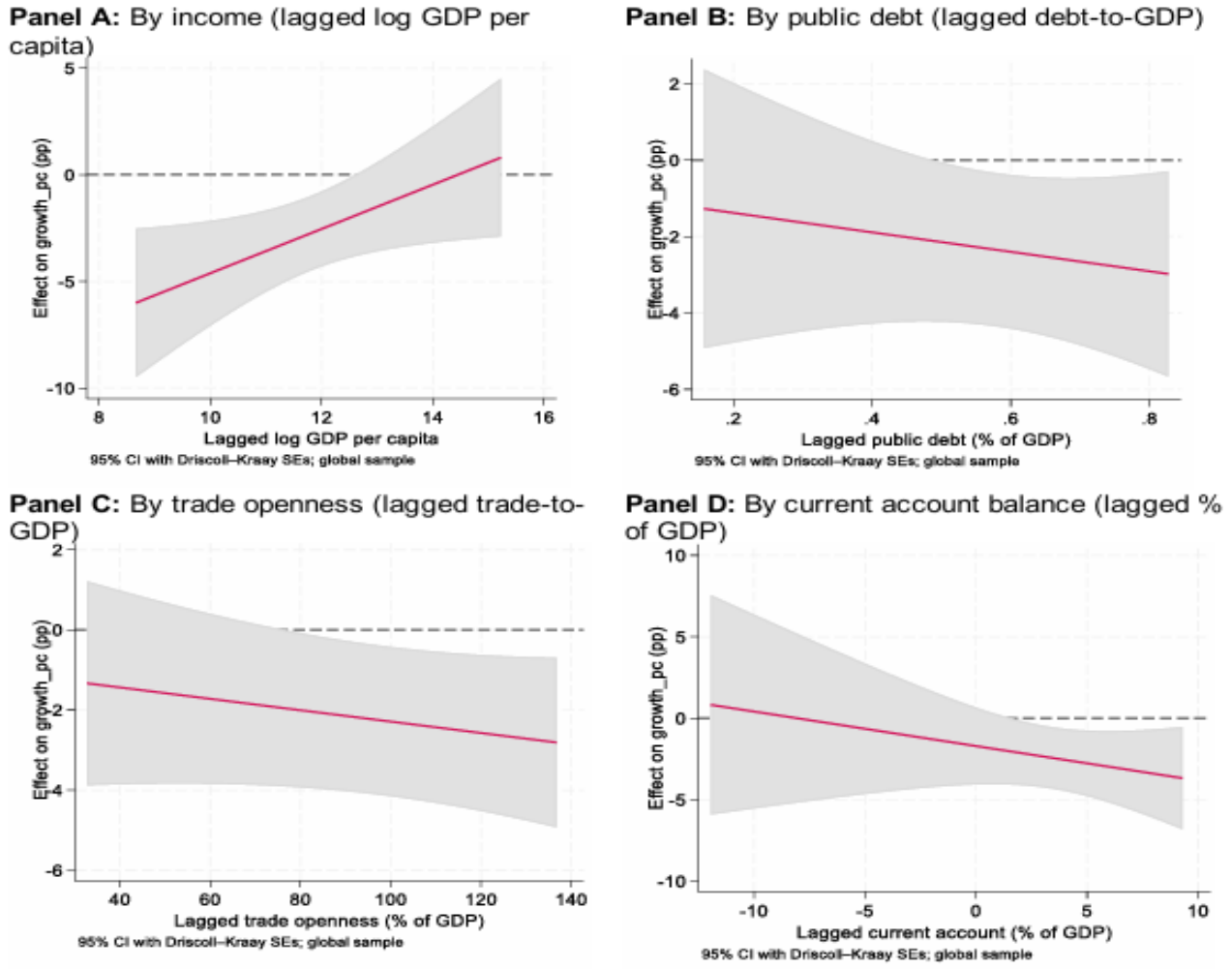
Table 2. Instrumental-variables (2SLS) Panel Estimates: Causal Effect of Environmental Spending Innovations on Growth

Specification	(1)	(2)	(3)
Sample	Global	AE	EMDE
Environmental spending shock	-4.004*	-4.198	-7.224***
	(1.982)	(3.530)	(2.323)
Log real GDP per capita (t-1)	-5.113**	-3.413	-5.523***
	(1.870)	(3.007)	(1.953)
Public debt (% of GDP) (t-1)	0.736	-0.058	1.591
	(1.125)	(1.030)	(1.270)
Trade openness (% of GDP) (t-1)	0.040***	0.020**	0.065***
	(0.014)	(0.009)	(0.021)
Consumer price inflation (annual %) (t-1)	-0.050**	-0.037	-0.051**
	(0.021)	(0.060)	(0.022)
Private sector credit (% of GDP) (t-1)	-0.011	-0.014	0.013
	(0.009)	(0.009)	(0.025)
Change in terms of trade (t-1)	0.168***	0.011	0.168**
	(0.055)	(0.139)	(0.063)
Current-account balance (% of GDP) (t-1)	-0.077**	-0.093	-0.078**
	(0.030)	(0.071)	(0.033)
Observations	1,035	212	815
R-squared	0.418	0.712	0.415
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Note: The dependent variable is annual real GDP per-capita growth (percentage points). The potentially endogenous regressor is Environmental spending shock (defined as in Table 1), instrumented with its first and second lags. The control set, fixed effects, and variable definitions match Table 1. Results are obtained by two-stage least squares with country and year fixed effects. Standard errors are computed with a covariance estimator that is robust to heteroskedasticity, serial correlation, and cross-sectional dependence, using a three-year window and a finite-sample adjustment. The reported R2 refers to the second-stage regression. First-stage diagnostics (available on request) include the Kleibergen–Paap rk Wald F-statistic, Stock–Yogo weak-IV critical values, and Anderson–Rubin confidence sets, which are robust to weak instruments. "Global," "AE," and "EMDE" denote the full sample and income-group splits; the panel is unbalanced.
Standard errors are in parentheses; significance levels: * p<0.10, ** p<0.05, *** p<0.01.

Results – Marginal effects

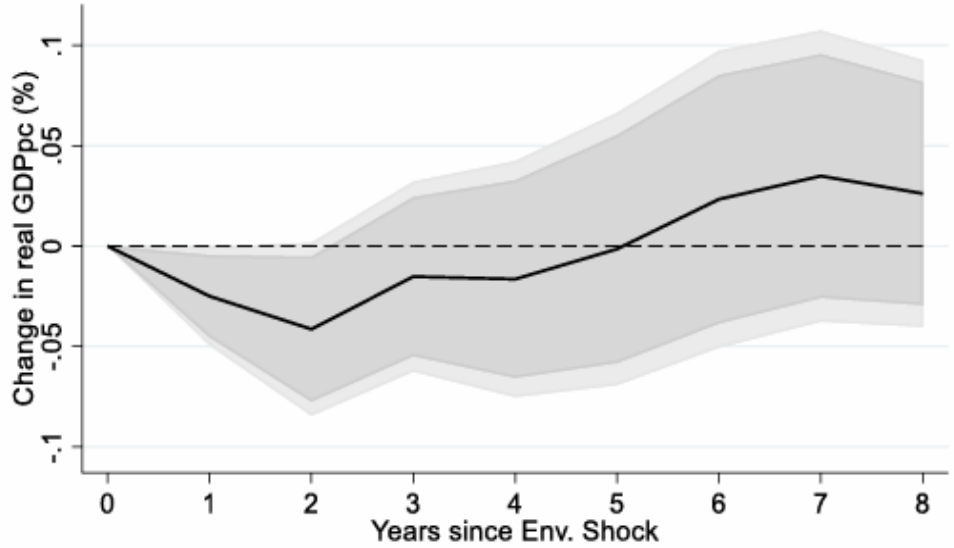
Figure 3. Marginal Effect of a One–percentage-point-of-GDP Environmental Spending Shock on Real GDP per-capita growth, by Initial Conditions



Results – Unconditional global baseline

Interpretation:
Output falls on impact and reaches its trough around year 2 at about –0.05%, a magnitude that is economically small.

Figure 4. Unconditional Local Projection: Effect of a 1%-of-GDP Environmental Spending Shock on Real GDP per capita



Note: The solid line plots the cumulative change in real GDP per capita (percent) at horizon h after a shock in year t (year 0 = shock year; year 1 = first year after the shock). Shocks are first-differenced residual innovations in government environmental protection outlays (COFOG), scaled so that one unit equals 1 percentage point of GDP and winsorised at the 1st–99th percentiles. Local projections include country fixed effects and year–horizon fixed effects, with AIC-selected dynamics: the shock enters contemporaneously; controls enter at t and t−1; and anticipation leads of the shock are included to address overlapping horizons. Shaded areas show 90% (dark) and 95% (light) confidence intervals computed with a covariance estimator robust to heteroskedasticity, serial correlation, and cross-sectional dependence (three-year window). Global, unbalanced panel.

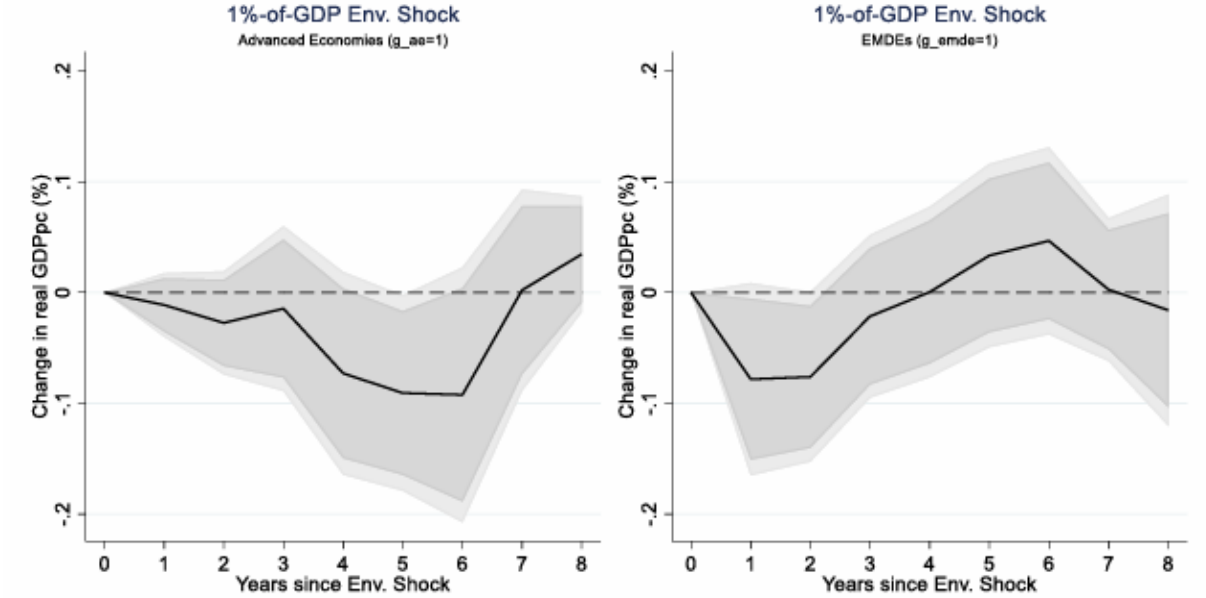
Results – EMDE vs Advanced Economies

Interpretation:
For AEs the short-run effect is negative but statistically indistinguishable from zero, and the medium-run recovery is likewise imprecise.

In EMDEs (right panel) the pattern is sharper. Output falls in the first two years—the 90% band lies (mostly) below zero.

Economic significance:
Consistent with mechanisms more prevalent in developing economies—tighter financing and external constraints, higher import content of green capital goods, and execution lags—while AEs' deeper financial markets and project pipelines dampen near-term output costs.

Figure 5. Unconditional Local Projection by Income Group: Effect of a 1%-of-GDP Environmental Spending Shock on Real GDP per capita



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Results – Functional Composition

A pollution-abatement shock delivers the clearest near-term contraction. The response falls below zero on impact and remains statistically negative through roughly years 2–3.

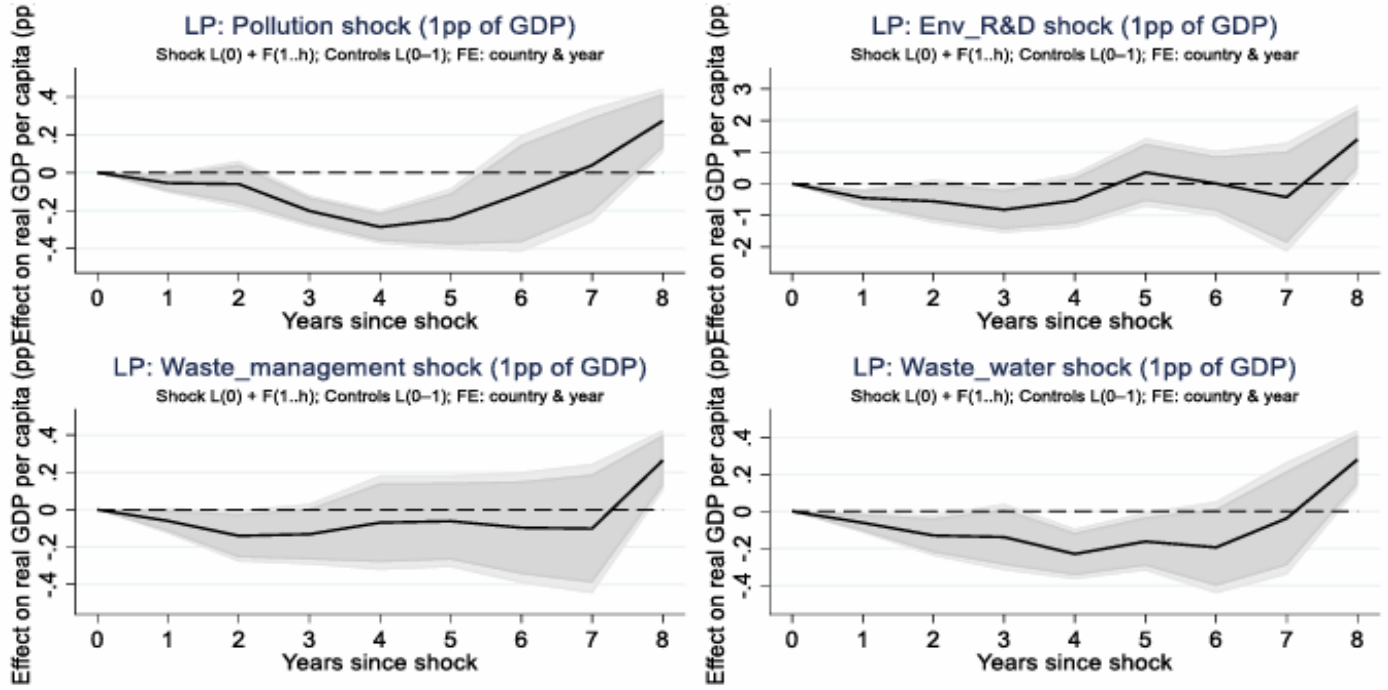
An environmental R&D shock is also negative and statistically significant in the early years, before drifting back toward zero later in the horizon.

For waste management, the response is negative and significant up to about year 3, after which it gradually reverts toward zero: planning and procurement bottlenecks mute the same-year demand impulse.

For wastewater, the initial contraction is somewhat more pronounced and longer-lived than for waste management; the band remains below zero into the mid-horizons before easing: large imported capital goods and execution lags typical of network investments

Short-run costs are best identified for pollution abatement, with R&D, waste management, and wastewater showing similarly negative early effects of smaller precision and shorter duration.

Figure 6. Unconditional Local Projection by Subcomponent: Effect of a 1%-of-GDP Environmental Spending Shock on Real GDP per capita

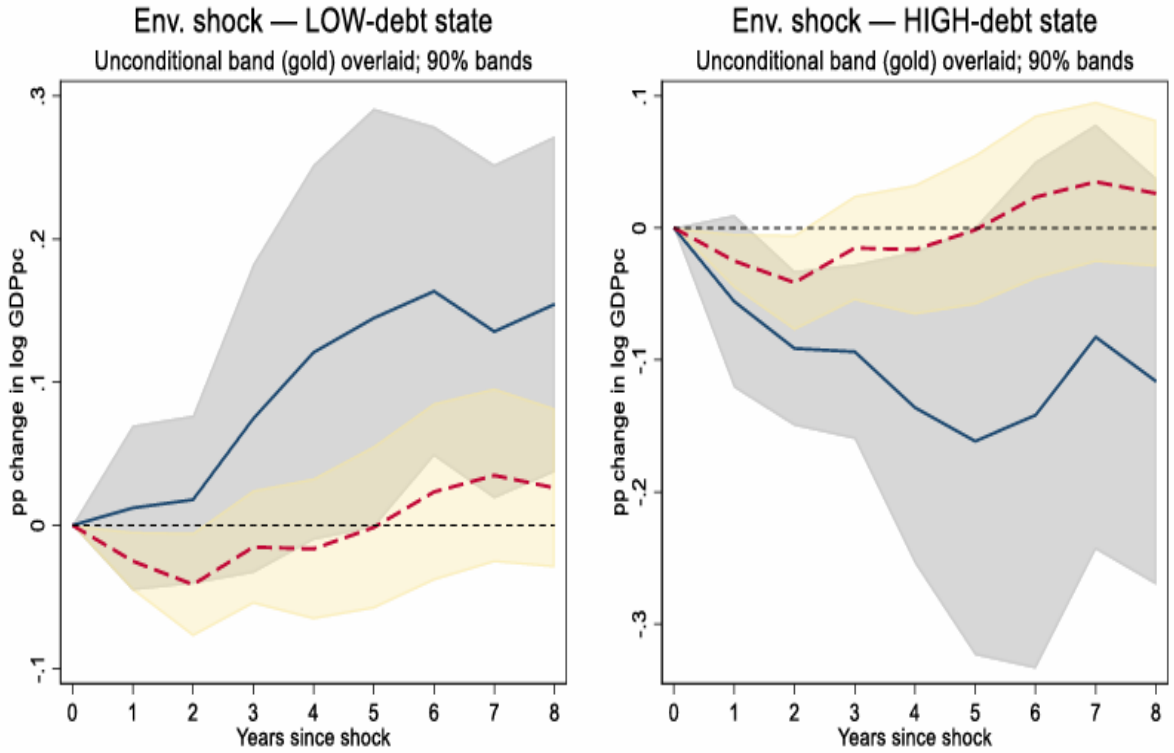


Note: The solid line plots the cumulative change in real GDP per capita (percent) at horizon h after a shock in year t (year 0 = shock year; year 1 = first year after the shock). Shocks are first-differenced residual innovations in government environmental protection outlays (COFOG), scaled so that one unit equals 1 percentage point of GDP and winsorised at the 1st–99th percentiles. Local projections include country fixed effects and year–horizon fixed effects, with AIC-selected dynamics: the shock enters contemporaneously; controls enter at t and t−1; and anticipation leads of the shock are included to address overlapping horizons. Shaded areas show 90% (dark) and 95% (light) confidence intervals computed with a covariance estimator robust to heteroskedasticity, serial correlation, and cross-sectional dependence (three-year window). Global, unbalanced panel.

Results – Debt State Dependence

Short-run costs are pervasive in the baseline but amplified when fiscal space is tight.

Conditional Local Projections by Fiscal Space (Public Debt): Effect of a 1%-of-GDP Environmental Spending Shock on Real GDP per capita

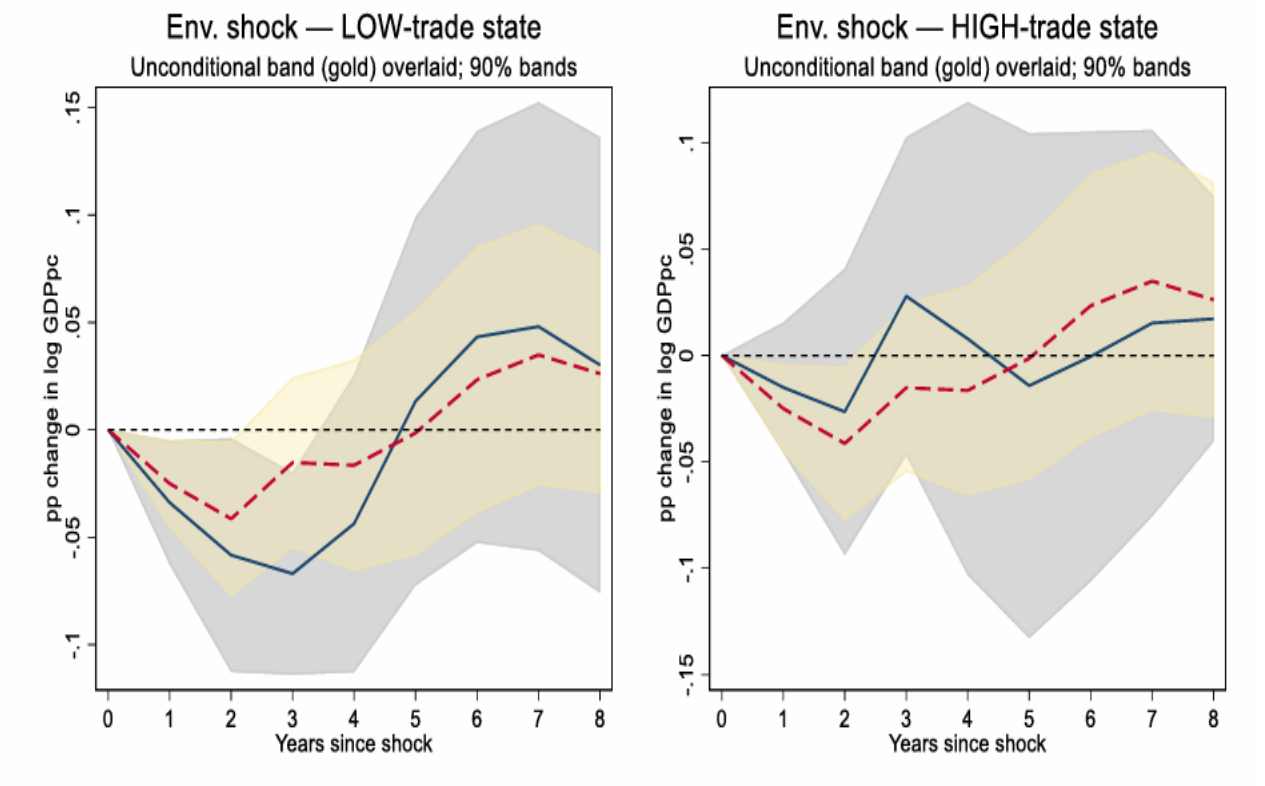


Note: The solid blue line denotes the conditional impulse response for the state indicated ed dashed line denotes the unconditional baseline response from the global specification.

Results – Openess State Dependence

Negative impacts are more pronounced in the low trade openness state.

Conditional Local Projections by External Exposure (Trade Openness): Effect of a 1%-of-GDP Environmental Spending Shock on Real GDP per capita

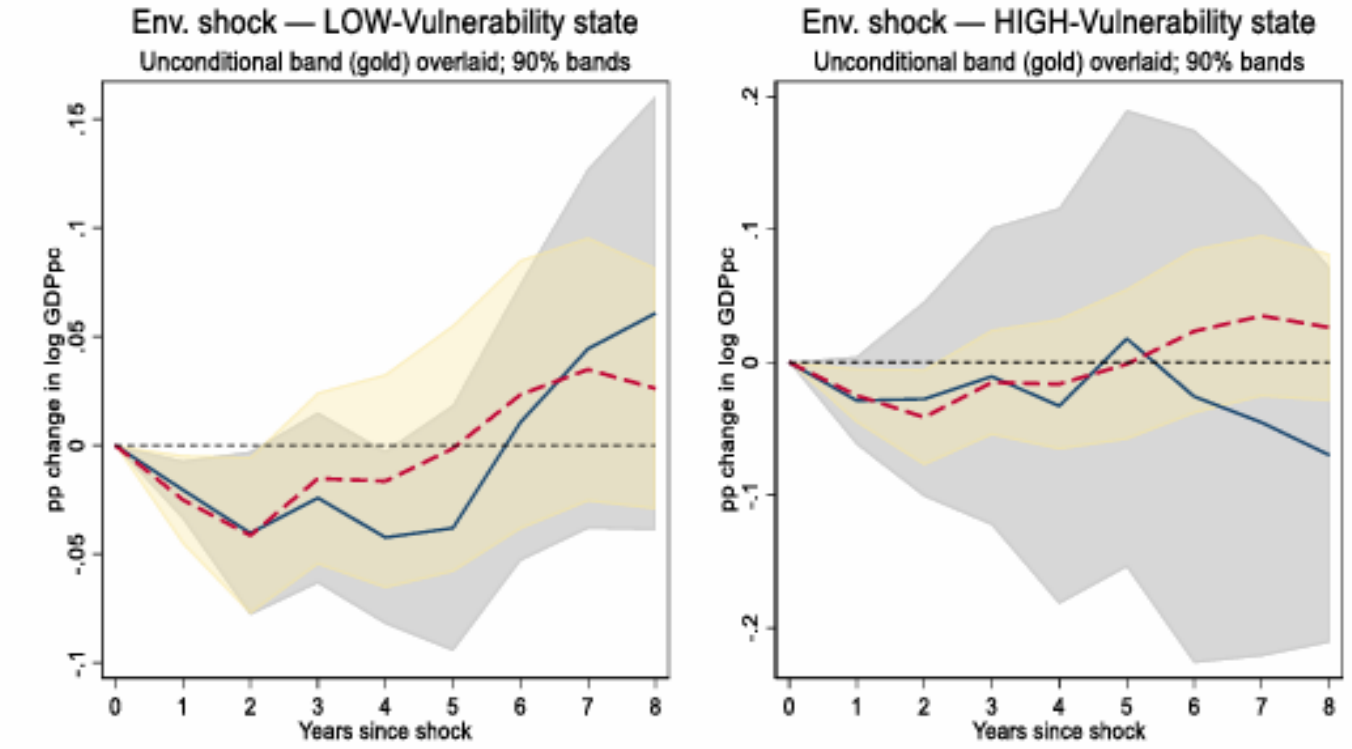


Note: The solid blue line denotes the conditional impulse response for the state indicated ed dashed line denotes the unconditional baseline response from the global specification.

Results – Adaptive Capacity State Dependence

Short-run costs are more quickly reversed where institutions are stronger.

Conditional Local Projections by Adaptive Capacity (ND-GAIN: Low vs. High Vulnerability: Effect of a 1%-of-GDP Environmental Spending Shock on Real GDP per capita



Note: The solid blue line denotes the conditional impulse response for the state indicated ed dashed line denotes the unconditional baseline response from the global specification.

Conclusions

- **Green public spending generates short-run economic costs but medium-run gains.** Unanticipated increases in environmental protection expenditure reduce per-capita growth initially, with effects strongest in the first 1–2 years, before fading and turning slightly positive over the medium term as productivity and resilience benefits materialize.
- **The short-run contraction is driven primarily by EMDEs**. Emerging market and developing economies experience significantly larger negative growth effects than advanced economies, reflecting tighter financing constraints, weaker fiscal capacity, and greater adjustment costs.
- **Spending composition matters.** Pollution-abatement expenditures produce the largest short-run contraction, while wastewater and waste-management spending have smaller negative effects. Environmental R&D exhibits delayed benefits due to longer implementation and innovation lags.
- **Institutional and macroeconomic conditions shape outcomes.** High public debt amplifies short-run economic costs, whereas greater trade openness and stronger adaptive capacity reduce the duration of negative effects and improve medium-run returns.

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Policy Implications

- **Expand fiscal space to support green investment.** Governments should pair environmental spending with concessional financing, credible medium-term fiscal frameworks, and debt-management strategies to reduce near-term crowding-out effects.
- **Prioritize efficient implementation of compliance-intensive projects**. Pollution-control and wastewater investments should be supported by strong procurement systems, project management, and delivery mechanisms to minimize delays and cost overruns.
- **Adopt state-contingent implementation strategies.** Countries with high debt burdens or weaker institutions should emphasize readiness-enhancing reforms, phased project rollouts, and capacity building to smooth short-run macroeconomic impacts.
- **Evaluate green spending over longer horizons.** Policymakers should use performance-based budgeting and medium-term evaluation frameworks that account for productivity, energy-efficiency, and resilience gains rather than judging programs solely on immediate GDP effects.

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Thank you!

QUESTIONS?

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