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Fiscal consequences of climate change

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Abstract

We study the consequences of rising temperatures for public finances in a global panel of countries. Using local projections and temperature shocks constructed from grid-level temperature data, we estimate the dynamic effects of local and global temperature shocks on government revenue, expenditure, the fiscal balance, and debt. We find that global temperature shocks have substantial fiscal consequences: they persistently lower output, erode tax revenue, deteriorate the fiscal balance, and raise government debt, while local temperature shocks leave public finances largely unaffected. These fiscal costs are regressive, as lower-income countries suffer large output and tax-revenue losses and are forced to run larger deficits and take on more debt, whereas high-income countries absorb the shock and experience more limited fiscal consequences. We show that this gradient operates through two interacting channels: *exposure and fiscal capacity*. We find that while exposure to rising temperature accounts for most of the differences, fiscal capacity also plays a non-negligible role. Our results imply that the fiscal burden of climate change's global externality falls disproportionately on the countries least responsible for generating it and least able to finance an effective response.

Keywords: Climate change, temperature shocks, public finances, fiscal capacity, government spending, cross-country heterogeneity

JEL classification: Q54, H30, H63, Q56

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1 Introduction

As climate scientists project continued increases in temperatures and extreme weather over the coming decades (IPCC, 2023), a growing literature has documented the substantial economic costs of climate change, including negative effects on GDP (e.g. Dell et al., 2012, 2014; Burke et al., 2015; Newell et al., 2021; Kahn et al., 2021; Nath, 2025), with damages varying in intensity across locations (Cruz & Rossi-Hansberg, 2023). The fiscal consequences of these costs, however, remain far less well understood (e.g. Deryugina, 2022; Pintus et al., 2024; Akyapı et al., 2025; Barrage, 2025). If rising temperatures depress output, they also erode the tax bases on which governments depend while at the same time raising demands on public spending for disaster relief, reconstruction, and adaptation. The result is a squeeze on public finances from both sides, with potentially significant implications for fiscal balances, government debt and, ultimately, debt sustainability.

This paper studies the fiscal consequences of temperature shocks and how they differ across countries of different income levels. Using local projections, we estimate the average effects of local and global temperature shocks on real GDP per capita, government expenditure, government (tax) revenue, the fiscal balance, and government debt. Following the World Bank's classification into high-, upper-middle-, lower-middle-, and low-income countries, we then test whether these effects vary with the degree of economic development. We then propose two interacting mechanisms that account for the differences in responses by country-income groups: the *exposure* to climate shocks and the *fiscal capacity* to respond to them.

To construct the temperature shocks, we draw on the ERA5 reanalysis dataset (Hersbach et al., 2023), which provides grid-level temperature data from which we derive measures of local and global temperature. Following Hamilton (2018), we isolate the shock component as the innovation from a regression of temperature on its own lags. We combine these shocks with public finance data from the Global Macro Database (GMD; Müller et al., 2025), yielding a global sample of 175 countries. The broad country coverage of the GMD allows us to study heterogeneity in the response to temperature shocks across income levels.

We first estimate the average effects of local and global temperature shocks on public finances using annual data. To do so, we employ a local projection setup in which we regress the public finance variable of interest on the identified local and global temperature shocks. Global and local temperature shocks are fundamentally different, as global temperature realisations are much more strongly linked with droughts, extreme winds, and heavy precipitation (Bilal & Känzig, 2024). Natural disasters specifically exert pressure on public finances, as governments have to cover these high and unexpected damages to a large extent, especially when insurance coverage is low (OECD & World Bank, 2019). Our results underline the distinction of local and global temperature innovations: global temperature shocks generate a stronger and more persistent decline in real GDP per capita, worsen the fiscal balance, and raise government debt; in stark contrast, local temperature shocks leave public finances largely unaffected.

Given that countries are unequally exposed to climate change, we then split the sample into high-, upper-middle-, lower-middle-, and low-income countries. We find that the fiscal burden of global warming is unequally distributed: low-income countries suffer large output and tax-revenue losses

but do not cut spending, forcing them to run larger deficits and take on more debt because they lack the fiscal capacity to absorb the shock; high-income countries, by contrast, experience negligible output effects and little impact on their budget balance. These patterns are consistent with the literature on fiscal cyclicality, in which richer countries respond counter-cyclically and poorer ones pro-cyclically (e.g. Lis & Nickel, 2010; Noy & Nualsri, 2011; Melecky & Raddatz, 2011, 2015).

We propose two conceptually distinct mechanisms through which the fiscal effects of a global temperature shock vary across countries: differential *exposure* and differential *fiscal capacity*. Exposure captures how strongly a global temperature shock translates into local warming. Poor countries are disproportionately located in areas exposed to climate change, such as the Sahel region, which experiences very high temperatures (Farid et al., 2016). The same global shock translates into higher local temperatures in these economies. Fiscal capacity, by contrast, captures a government's ability to absorb the fiscal ramifications, such as through access to credit at low interest rates and the ability to sustain spending as revenues fall. Richer countries can borrow to smooth the shock and respond counter-cyclically, whereas countries with limited fiscal space are forced to reduce spending and potentially accumulate debt on unfavourable terms. The two channels are distinct: while exposure determines the extent to which local temperatures react to global shocks, fiscal capacity determines how costly a shock is for public finances. Our empirical strategy allows us to separate them. First, we document how exposure differs across income groups. In a second step, we hold exposure constant to isolate the role of fiscal capacity. We find that although the gradient is driven primarily by differential exposure, fiscal capacity also plays a non-negligible role.

All our results are reported for a global temperature shock that raises local temperature by 0.1°C on impact, which corresponds approximately to a one-standard-deviation shock in our sample. The estimated responses therefore reflect the effect of a typically sized temperature shock. To ensure comparability, we likewise scale local temperature shocks to raise local temperature by 0.1°C on impact.

We conduct a variety of robustness checks to verify our results: (i) we vary the construction of the temperature shocks; (ii) we experiment with the main specification; (iii) we adjust the sample; and (iv) we adopt a different benchmark year for the income classification. Our results are robust to these changes.

Related literature. We contribute to several strands of the literature. First, there is a broad literature that studies the economic damage caused by climate change. Within this strand of literature, several papers empirically study the impact of local temperature variation on economic outcomes (Dell et al., 2012, 2014; Burke et al., 2015; Newell et al., 2021; Kahn et al., 2021; Nath, 2025). Local temperature variations refer to variations within countries or small regional units. These studies find medium-term reductions in GDP ranging between 0.5% and 2%, on average, as a response to a 1°C increase in local temperature. In a recent contribution, Bilal & Känzig (2024) estimate the economic damages of global temperature shocks, finding that the costs of a 1°C increase in global temperature are substantial, as they reduce world GDP by 12%. The authors show that, in contrast to local temperature, global temperature is highly correlated with extreme weather events, which explains the magnitude of the effect. Although global temperature shocks of 1°C have not yet been observed in practice, the study highlights the detrimental effects of global

warming. Dell et al. (2012) show that local temperature shocks affect both the level of output and economic growth, and that the effects are concentrated in poorer countries. While the effects on GDP are well established, we offer a complementary analysis of the public finance response to temperature shocks.

Second, we relate to a strand of literature that studies the public finance aspects of climate change, as surveyed in Barrage (2025). She presents five stylised facts on the nexus of climate change and public finances that arise from both model-based and empirical assessments thereof: climate-related shocks cause increases in public expenditures, declining public revenues, and increased borrowing costs. At the same time, fiscal action can mitigate economic costs and shape both the magnitude and the distribution of the effects. A recent contribution by Akyapı et al. (2025) examines a broad range of weather variables and finds a counter-cyclical fiscal response. Pintus et al. (2024) examine the effects of temperature increases in an econometric framework similar to the one used in this study. In a panel of developed economies between 2002 and 2022, they show that climate shocks are contractionary and increase public debt and deficits over a business-cycle horizon. They find that the main transmission mechanisms are lower tax revenues combined with an increase in government spending on public subsidies for the sample under consideration. In their heterogeneity analysis, they show that the effects are strongest among warmer, climate-vulnerable, and highly indebted countries. While their study benefits from the quarterly availability of their data, we extend their analysis along various dimensions. Our annual dataset allows us to study the effects more broadly in terms of time and country coverage, extending the time back to 1960 and covering 175 countries worldwide. This allows us to explore heterogeneity across different time horizons and, in particular, across different country groupings. We expect public finance effects to vary substantially across different regions according to their exposure to climate change but also their economic development.

Lastly, we contribute to the understanding of the distribution of the fiscal burden of climate change across countries with different income levels. Lis & Nickel (2010), Noy & Nualsri (2011), Melecky & Raddatz (2011), and Melecky & Raddatz (2015) study the effects of extreme weather events on a range of fiscal variables. The studies find that higher-income and more developed countries respond counter-cyclically by increasing spending, with falling revenues and increasing debt, while developing countries react more pro-cyclically. Overall, poorer countries are more affected by extreme weather than richer countries due to their lower ability to adapt (Fankhauser & McDermott, 2014). Others focus on temperature changes in particular: annual temperature increases worsen the fiscal balance as a percentage of GDP in African countries (Kunawotor et al., 2022) as well as in Middle Eastern and North African (MENA) countries (Giovanis & Ozdamar, 2022). Debt-to-GDP increases in MENA countries. The quality of institutions and countries' adaptive capacities are important factors in explaining heterogeneity in response to temperature changes (Giovanis & Ozdamar, 2022).

Roadmap. The remainder of the paper is structured as follows. Section 2 describes the data. Section 3 discusses our empirical approach. In Section 4, we present our results on the average effects of local and global temperature on public finances. Section 5 then discusses how the results vary across countries with different income levels and proposes two complementary mechanisms. Section 6 performs some robustness checks, and Section 7 concludes.

2 Data

This section describes the data used in our analysis. We combine climate variables constructed from the ERA5 monthly reanalysis dataset with public finance data from the Global Macro Database (GMD). Section 2.1 describes the temperature data and the construction of temperature shocks. Section 2.2 describes the public finance and macroeconomic data.

2.1 Temperature data

Our temperature data are obtained from the monthly ERA5 reanalysis dataset provided by Copernicus, the EU's Earth observation programme (Hersbach et al., 2023). ERA5 provides globally consistent estimates of atmospheric, oceanic, and land-surface variables. We use monthly two-metre air temperature for the 1960-2025 period. The monthly reanalysis fields are first aggregated to annual frequency by averaging monthly observations within each grid cell, yielding annual grid-level temperature values.

From the annual two-metre air temperature fields, we construct two measures: a local (country-level) temperature and a global (world-level) temperature. The *local* temperature measure is computed as a population-weighted average of grid-cell temperatures, reflecting the temperature experienced by the population rather than by land area. Population weights are obtained from the CIESIN Gridded Population of the World, Version 4 (GPWv4), Revision 11, using the population distribution for the year 2000 (CIESIN, 2018). We hold population weights fixed at the year-2000 distribution so that variation in the local temperature measure reflects changes in temperature rather than underlying population changes. The population data are aggregated from their native 30 arc-second (approximately 1 km) resolution to the 0.25° (approximately 28 km) ERA5 grid. Country-level temperatures are computed by intersecting the ERA5 grid with country boundaries and averaging the temperatures of all grid cells within each country's borders using the aggregated population weights. The *global* temperature measure is computed as an area-weighted average of annual two-metre air temperatures across all ERA5 grid cells worldwide, covering both land and sea surfaces. Area weighting accounts for the fact that the surface area represented by ERA5 grid cells decreases with latitude.[1]

To construct local and global temperature *shocks*, we first derive temperature anomalies as deviations from a reference temperature, defined as the average temperature over the 1960-1980 period (Bilal & Känzig, 2024). We use the anomalies in a setup proposed by Hamilton (2018) – and subsequently applied by Bilal & Känzig (2024), Nath et al. (2024), and Pintus et al. (2024) – which allows us to capture exogenous movements in temperature. Therefore, we regress mean (global or local, respectively) temperature anomalies on their lags dated $t-h$ and construct the temperature shock as the resulting regression innovation. Formally, the temperature shock is defined as the residual from regressing temperature on its lags:

$$T_t^{\text{shock}} = T_t - \left(\hat{\alpha} + \hat{\beta}_1 T_{t-h} + \cdots + \hat{\beta}_p T_{t-h-p+1}\right), \tag{1}$$

[1] Because ERA5 is defined on a regular latitude-longitude grid, grid cells cover progressively smaller physical areas towards the poles. We therefore weight grid cell values by their surface area when aggregating them, preventing higher latitude cells from receiving disproportionate weight.

where $\hat{\beta}_i$ denotes the estimated coefficient on the i-th lag of temperature, corresponding to lag $j = h - i + 1$, and $\hat{\alpha}$ is the estimated intercept.

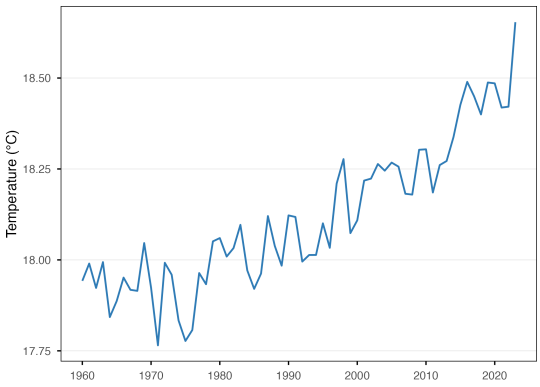
For robustness, we vary the underlying temperature measure and the construction of climate anomalies. We use sea surface temperature (SST) as an alternative temperature measure. We construct a global SST measure by computing the area-weighted average of annual sea surface temperatures across all ocean grid cells. Unlike the global air temperature measure, the SST measure excludes land areas and is therefore based exclusively on ocean grid cells. To account for adaptation, recent studies argue that anomalies should be constructed using moving averages rather than historical references (Kahn et al., 2021). Therefore, as a robustness exercise, we compute climate anomalies using a moving average over the preceding 30 years.

Figure B.1 in the Appendix presents the autocorrelation functions of the global temperature shocks used in the analysis. The shocks are largely serially uncorrelated, consistent with their construction as forecast-error innovations. Some residual autocorrelation remains at low lags but is limited in magnitude and confined to the first one or two lags. Because local projections include shock lags among the controls, this low-order autocorrelation is absorbed in the estimation, and our results are robust to increasing the number of shock lags (Section 6).

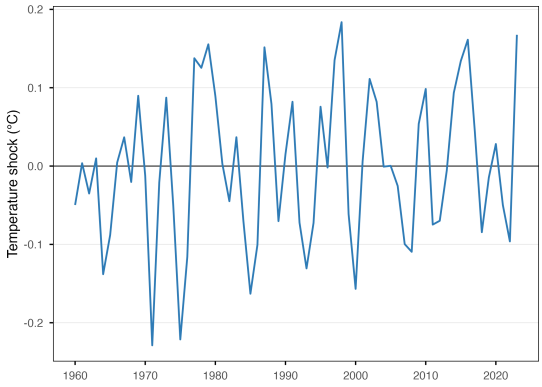
Figure 1a displays global average temperature between 1960 and 2025. While temperatures remain stable between 1960 and 1980, they start trending upwards after 1980. Figure 1b shows the global temperature shock series between 1960 and 2025. The shocks fluctuate around zero, lying mostly between -0.2 and 0.2. The largest shocks in our sample are -0.25 and 0.22, respectively.

Figure 1: Global temperature and global temperature shocks, 1960-2025

(a) Global average temperature



(b) Global temperature shocks

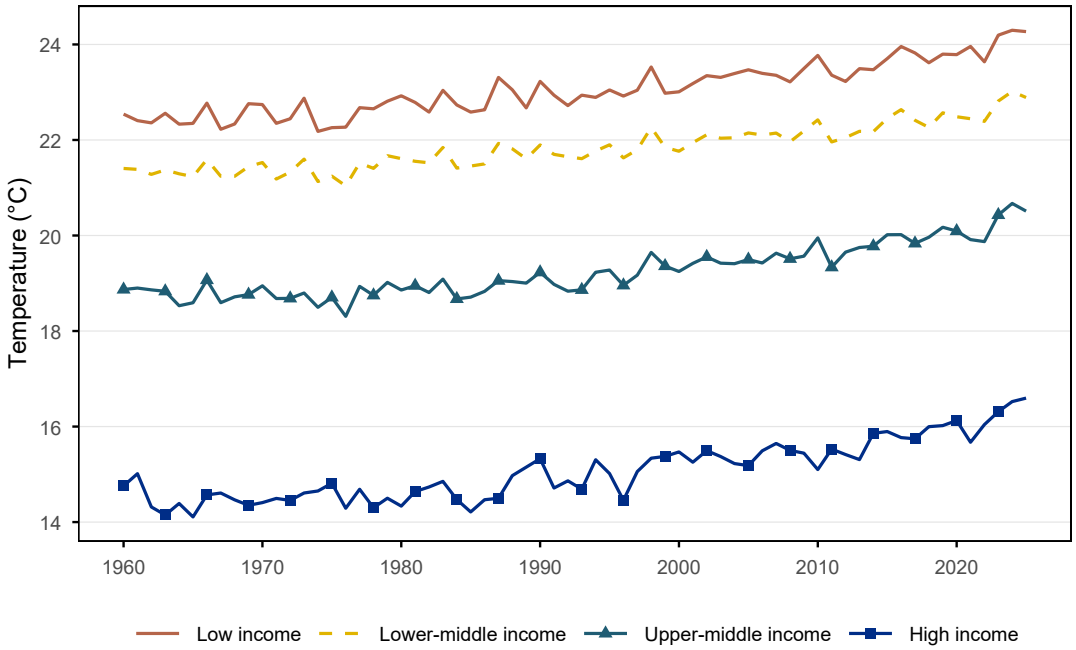


Notes: Authors' illustration. Panel a shows annual global temperature computed from two-metre air temperature (area-weighted). Panel b displays the shock series constructed from the respective global temperature anomalies.
Source: ERA5 monthly reanalysis, Hersbach et al. (2023).

Figure 2 plots average temperature by income group. All countries display an increasing trend over the sample period. Low-income countries experience the highest temperature on average, followed by lower-middle-, upper-middle-, and high-income countries. While average temperature in low-income countries has been above 22°C throughout, average temperature in high-income countries has only recently risen above 16°C. There is a substantial gap in average temperature between

high-income countries and other income groups.

Figure 2: Temperature by income group



Notes: Authors' illustration. The plot shows average local temperature (population-weighted average) by income group between 1960 and 2025. Classification into income groups follows the World Bank classification for 2019. Source: ERA5 monthly reanalysis.

Table 1 provides descriptive statistics for the temperature and temperature shock variables used in the analysis. Local temperature averages 19.75°C across the panel, with a standard deviation of 7.18°C and a wide range (from -1.42°C to 29.44°C), reflecting the cross-country heterogeneity in a global sample. The global temperature shock has a mean of zero by construction and a standard deviation of 0.10, with realised values ranging from -0.23 to 0.18. Following Bilal & Känzig (2024), we do not observe large shocks in the historical sample: the shocks observed in practice are comparatively modest, consistent with their documented range. The local temperature shock, derived directly from local temperature deviations, has a mean of 0.06 and a substantially larger standard deviation of 0.47, with a wider range (-2.56 to 2.37), reflecting the greater volatility of local relative to global temperatures. The small positive mean of the local shock is attributable to the unbalanced structure of the panel.

Responses are normalised to a shock that raises local temperature by 0.1°C on impact, close to the local warming produced by a one-standard-deviation shock (approximately 0.12°C). This allows us to compare the responses across specifications. Normalisation of the global shock is implemented in the regression rather than applied to the raw shock series reported here.

Table 1: Temperature and temperature shocks

	Mean	SD	Min	Max
Local temperature	19.75	7.18	-1.42	29.44
Global temperature shock	0	0.10	-0.23	0.18
Local temperature shock	0.06	0.47	-2.56	2.37

Notes: Authors' calculations.

2.2 Public finance and macroeconomic data

Data on our main variables of interest come from the Global Macro Database (GMD; Müller et al., 2025). The GMD achieves broader coverage than other datasets by combining and harmonising data from numerous international and historical sources into consistent country-level time series. The dataset contains 46 macroeconomic and public finance variables across 243 countries, some extending back to the nineteenth century. We focus on the government finances database between 1960 and 2025. Government expenditure comprises public spending on compensation of government employees, purchases of goods and services, transfers, interest payments, and other expenditures. Government revenue covers taxes, social contributions, grants, and other revenue. Government tax revenue includes taxes on income, profits, goods and services, and international trade. The government deficit is the difference between expenditure and revenue. Government debt consists of the total liabilities (loans, debt securities, and other borrowing) of the government.

To ensure comparability of estimates across variables, we restrict the sample to a common set of observations for which the main variables of interest (real GDP, population, the government debt-to-GDP ratio, the government expenditure-to-GDP ratio, the government revenue-to-GDP ratio, the government deficit-to-GDP ratio, and their level counterparts) are simultaneously non-missing. This common-sample restriction ensures that differences in estimated coefficients across variables are not driven by differences in sample composition but instead reflect genuine differences in the underlying relationships. In the GMD database, government expenditure, revenues, and debt are derived by multiplying the respective ratio with GDP, ensuring consistency across variables. We do not apply this restriction to tax revenue and the tax-revenue-to-GDP ratio, as this would imply losing a substantial number of observations. We also apply the restriction to the tax-revenue variables as a robustness exercise in Section 6. In addition, we visually inspect the time series of each variable for every country to identify outliers and drop the affected countries or observations accordingly.[2] Our remaining sample consists of 175 countries and 7,671 country-year observations. The government finance variables are available in local currency. Following the GMD manual, we deflate the government finance variables and convert them to US dollars. More details as well as descriptives of the GMD government finance variables can be found in Appendix A.

Our control variables follow Bilal & Känzig (2024), who combine data from various sources. Specifically, we use their measures of world real GDP (Penn World Tables; Feenstra et al., 2015), oil

[2]We manually exclude Belarus, Bulgaria, the Central African Republic, Croatia, Cyprus, the Democratic Republic of the Congo, Ecuador, Hong Kong SAR, the Kyrgyz Republic, Lesotho, Namibia, Portugal, Romania, San Marino, St. Vincent and the Grenadines, and Switzerland from the sample. In addition, we drop observations for Italy before 2000, Nicaragua before 1992, Tunisia after 2015, and Lebanon after 2020.

prices, and the Treasury yield. We thank the authors for making these data available.

3 Empirical approach

We estimate the effect of temperature on public finance variables within a local projection framework (Jordà, 2005). The approach allows us to estimate the response of the macro-fiscal variables of interest over horizon $h > 0$ to temperature shocks, as these responses may take time to build. An advantage of local projections is that each impulse response coefficient is estimated directly with a different regression, which makes it less sensitive to misspecification than VAR approaches (e.g. Jordà & Taylor, 2025). We follow Bilal & Känzig (2024) by comparing the effects of global to local temperatures. Our baseline specification reads as follows:

$$\Delta_h y_{i,t-1} = \alpha_i^h + \beta^h T_t^{\text{shock}} + \sum_{p=1}^{P} \theta_p^h \Delta y_{i,t-p} + \sum_{p=0}^{P} \mathbf{X}_{i,t-p} \mathbf{\Gamma}_p^h + \epsilon_{i,t+h}. \tag{2}$$

On the left-hand side of Equation 2, $\Delta_h y_{i,t-1}$ denotes the long difference in our public finance variable of interest from the base year $t-1$ up to year $t+h$ with $h = 0, 1, ..., H$. Our dependent variables fall into two groups. The first captures the level of economic activity and the size of public finances in logs: real GDP per capita, government debt, expenditure, revenue, and tax revenue (all in USD). The second expresses the fiscal variables as ratios to GDP: debt, expenditure, revenue, tax revenue, and the fiscal deficit. We examine each variable both in (log) levels and as a share of GDP to separate movements in the fiscal aggregates themselves from movements driven by the GDP denominator.

β_h captures the dynamic average effects of global temperature shocks T_t^{shock} on the variable of interest at horizon h. α_i^h are country fixed effects. We add lags of the dependent variable, $\Delta y_{i,t-p}$, and additional country-level controls, $\mathbf{X}_{i,t-p}$. $\epsilon_{i,t+h}$ is the error term. To account for the serial correlation in our dependent variables and the temperature shocks, we include lags of the dependent variable and the global temperature shock (Bilal & Känzig, 2024; Nath et al., 2024). Since the shock varies only with time, we cannot include time fixed effects when estimating the effects of a global temperature shock. Therefore, to control for global business-cycle dynamics, we include dummies for global recession periods and global controls (e.g. oil prices and the federal funds rate). Following standard practice in the local projections literature (Jordà, 2005), we include two lags of the dependent variable and controls to account for pre-existing dynamics and residual serial correlation. Results are robust to using one or four lags (Section 6). We further include region-specific linear trends. To obtain inference robust to serial correlation and cross-sectional dependence, we compute Driscoll & Kraay (1998) standard errors.

While Equation 2 estimates the effects of global temperature shocks, we are further interested in the effects of local temperature shocks, estimated by Equation 3:

$$\Delta_h y_{i,t-1} = \alpha_i^h + \gamma_t^h + \beta^h T_{i,t}^{Shock} + \sum_{p=1}^{P} \theta_p^h \Delta y_{i,t-p} + \sum_{p=0}^{P} \mathbf{X}_{i,t-p} \mathbf{\Gamma}_p^h + \epsilon_{i,t+h}, \tag{3}$$

where β^h captures the effects of local temperature shocks, $T_{i,t}^{Shock}$. As the local temperature shocks vary by country and time, we can include time fixed effects. Therefore, we no longer include controls for global business-cycle dynamics. The remaining structure is the same. To compare the responses to local and global temperature shocks, we normalise the shocks to an increase in local temperature by 0.1°C.

4 Global vs. local temperature: the importance of global warming for public finances

Figure 3 displays the responses of public finance variables to a global temperature shock (normalised to increase local temperature by 0.1°C, corresponding to approximately one standard deviation), according to Equation 2. The global temperature shock has persistent effects on local temperature. To benchmark our results and to relate to the literature, we first estimate the response of real GDP to a global temperature shock. The latter leads to a gradual decline in real GDP per capita that peaks at 1.6% after six years and is significant at the 5% level in years 4-9. Our results are broadly in line with Bilal & Känzig (2024), who study global temperature shocks normalised to raise local temperature by 1°C. Although we scale our shock differently, the responses coincide in magnitude once expressed under a common normalisation in addition to being similar in timing. The main difference is that their GDP point estimates turn upward towards the end of the horizon and become clearly insignificant at later horizons, whereas our GDP response shows somewhat more persistence, though also imprecisely estimated at long horizons.

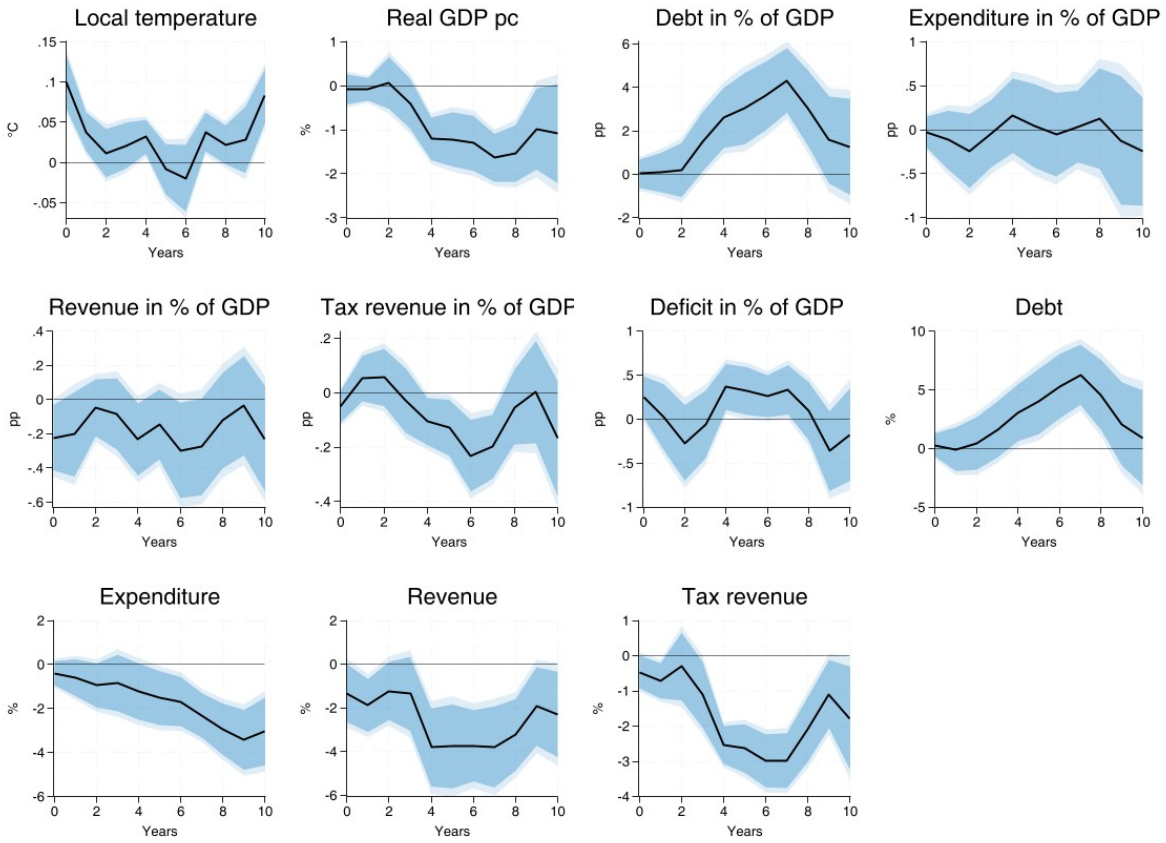
In response to the shock to global temperature, government expenditure declines: at its peak, expenditure is 3.4% lower than before the shock. Responses are significant at horizons 5-10, indicating persistence of the effect, similarly to the GDP response. As a share of GDP, however, expenditure does not show any significant response, indicating that it falls roughly proportionally to output. Government revenue also declines gradually and with a shape similar to the GDP response, though imprecisely estimated at later horizons. In USD terms, the declines are again substantial: tax revenue falls 2.9% and total revenue 3.8% below pre-shock levels at their peaks. While revenue as a percentage of GDP is imprecisely estimated throughout the horizons, the response of tax revenue as a percentage of GDP is clearly significantly different from zero at horizons 5-7. Unlike expenditure, revenue does fall relative to output: as a share of GDP, it declines by around 0.3 percentage points (pp), meaning that revenue contracts somewhat faster than GDP. The level responses are therefore driven largely by the decline in real GDP, with an additional contraction on the revenue side.

The government deficit rises accordingly, with a peak response of -0.3 pp of GDP.[3] The response is significant at horizons 4-7. Government debt follows a hump-shaped path, rising steadily before reversing after around seven years and becoming insignificant after nine. In USD terms, the debt level rises by up to 6.3% at its peak, and the debt-to-GDP ratio mirrors this hump-shaped behavior. The debt-to-GDP response is consistent with the GDP response, as the cumulative effects take time to build over the medium run. Debt and debt-to-GDP responses are significant at horizons

[3] The government deficit here refers to net borrowing/lending, meaning the difference between government expenditure and revenue. A positive impulse response therefore corresponds to an increase in the deficit.

4-8.

Figure 3: The effects of global temperature shocks on public finances



Notes: Impulse responses to a global temperature shock, normalised to increase local temperature by 0.1°C. Shaded light (dark) areas represent 95% (90%) confidence bands.

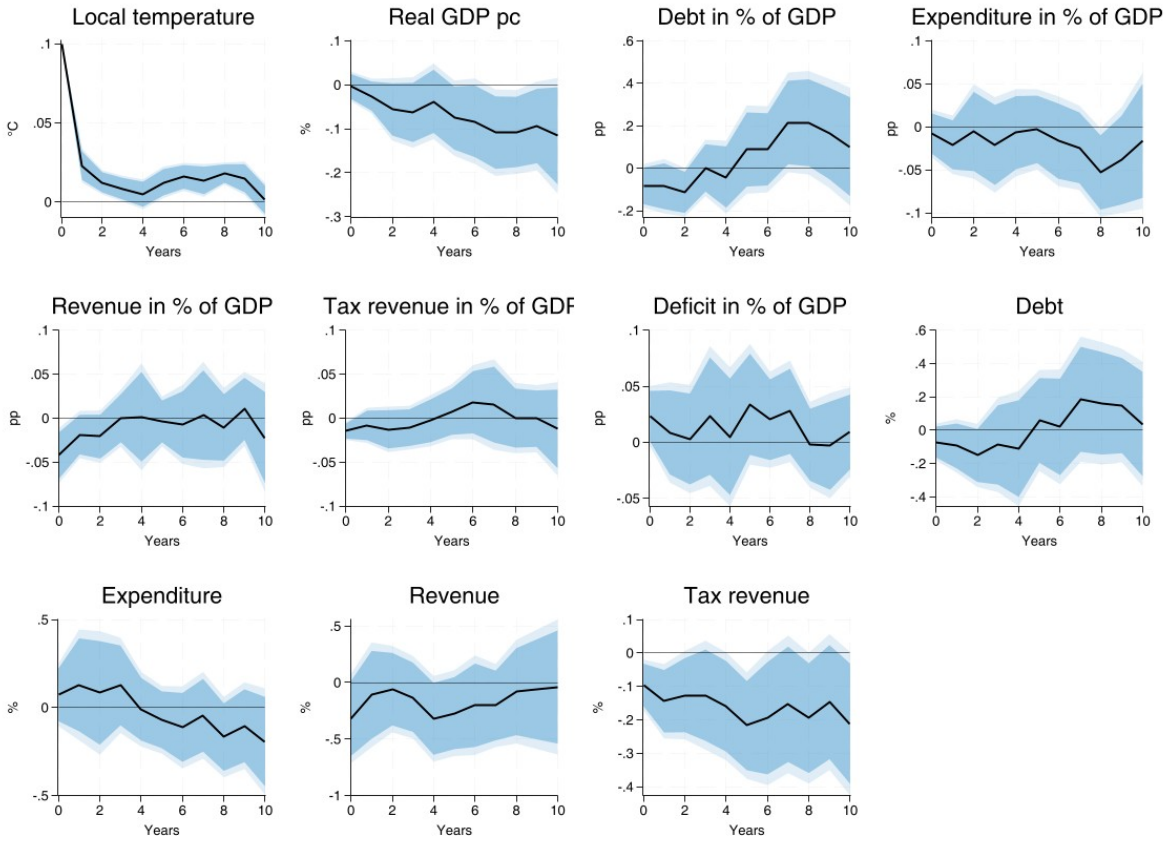
Figure 4 shows the estimated impulse responses to a local temperature shock, normalised to raise local temperature by 0.1°C on impact, following Equation 3. The temperature increase is quite persistent. Real GDP per capita falls persistently, reaching a cumulative peak of 0.1% after 10 years, although the response is not significant at the 5% level. Rescaled to a 1°C local temperature increase, this corresponds to a peak response of real GDP per capita of about 1%, consistent with previous estimates in the literature (Nath et al., 2024; Bilal & Känzig, 2024).

The effect of a local temperature shock is markedly smaller than that of a global shock of comparable size. Bilal & Känzig (2024) attribute this divergence to the fact that global temperature shocks are more closely linked with extreme weather events (e.g. droughts, storms, and heatwaves). A global shock captures the common, systemic component of warming that coincides with these extreme events and propagates through global channels (e.g. trade, commodity prices, and supply chains). In contrast, a local shock captures primarily the direct impact of a country's own temperature.

Turning to the public finance variables, the medium-term point estimates for government expenditure are negative in both USD and as a share of GDP, but the effects are statistically indistinguishable from zero. As before, the impulse responses are estimated with considerable uncertainty.

Government tax revenue in USD declines steadily, with a peak response of about 0.2%. Total government revenue in USD, however, does not decline significantly, suggesting that other revenue sources offset the fall in tax revenue. As a share of GDP, neither total nor tax revenue declines significantly. There is no significant effect on the government deficit; government debt increases after four years, both in USD and as a share of GDP, but these responses are also insignificant.

Figure 4: The effects of local temperature shocks on public finances



Notes: Impulse responses to a local temperature shock, normalised to increase local temperature by 0.1°C. Shaded light (dark) areas represent 95% (90%) confidence bands.

5 Who bears the fiscal costs of global warming: exposure and fiscal capacity

In Section 4, we established that temperature shocks impact public finances in a global sample. The existing literature points out that the negative effects of temperature on GDP have been largest in low-income countries (Dell et al., 2012). We estimate the effects of a global temperature shock on public finances by income group to examine whether poorer countries' fiscal response mirrors the negative GDP response (i.e. whether poorer countries suffer more with respect to their public finances in the face of climate change). We follow the classification of the World Bank, which distinguishes between low-income, lower-middle-income, upper-middle-income, and high-income countries. Importantly, the World Bank groupings change every year as countries become richer or poorer. We choose 2019 as a baseline for classification, as it captures recent income dynamics

(before the COVID-19 crisis). The classification is displayed in Figure A.1. The results are robust to assigning income groups based on 1987 and 2000 income-group classifications (Section 6).

The responses in Figure 5 capture the fiscal consequences of global warming by income group. Output falls substantially in all but the highest-income countries (Figure 5a): real GDP per capita declines gradually for high-income countries, with a peak response of -0.8% after six years, but the response is not significant at the 5% level for most of the horizon. The three lower-income groups all experience large and statistically significant contractions: real GDP per capita decreases gradually, with a peak response of 2.5% in upper-middle income countries and of 2.3% in lower-middle income countries seven years after the shock. In low-income countries, real GDP per capita declines more sharply, with a peak response of 1.8% after four years. The results indicate that poorer economies are hit not only hard but also early compared to richer economies.

In high-income countries, expenditure falls slightly in USD terms (significant at the 10% level) but rises as a share of GDP: the ratio increases not because governments spend more, but because output contracts more than spending. Spending in high-income countries does not react significantly within the first seven years following the shock. The middle-income groups show modest declines in the level of expenditure; the expenditure-to-GDP ratio is unchanged for upper-middle-income countries, while it declines slightly for lower-middle countries. Low-income countries do not display any significant expenditure responses. Taken together, expenditure adjusts little in any group: spending does not fall in proportion to the output loss.

Revenue responds more strongly than expenditure to the global temperature shock. In USD terms, tax revenue falls across all income groups, with larger declines for poorer countries, which is consistent with their larger output losses. The more interesting result is in the ratio: tax-revenue-to-GDP is essentially unchanged for high- and upper-middle-income countries, declines modestly for lower-middle-income countries, and falls substantially for low-income countries. The ratio remains unchanged in richer countries, as their revenue simply tracks the (smaller) output loss. The pronounced decline in the tax-revenue-to-GDP ratio for low-income countries shows that the tax base contracts faster than output: revenue collapses more than proportionally as the economy shrinks. This indicates that GDP losses reduce tax revenue by shrinking the tax base, with the effect being particularly pronounced in low-income countries. Total government revenue shows a similar pattern: it declines in USD for all groups except low-income countries, and the revenue-to-GDP ratio moves significantly only for the middle-income groups. Notably, total revenue in low-income countries does not show any significant response despite the decline in tax revenue, implying that the fall in tax revenue is offset by other revenue sources. Examples are external grants and aid, which tend to rise following adverse shocks and constitute a substantial share of revenue in these economies.

Next, we turn to the government deficit as a percentage of GDP. High-income countries experience a small improvement in the fiscal balance (i.e. the deficit reduces) at horizon 9 and 10, and upper-middle-income countries see a short window of improvement at horizons 2 and 3. Lower-middle- and low-income countries, on the other hand, see a decline in their fiscal position within the first eight years. Afterwards, the response turns insignificant.

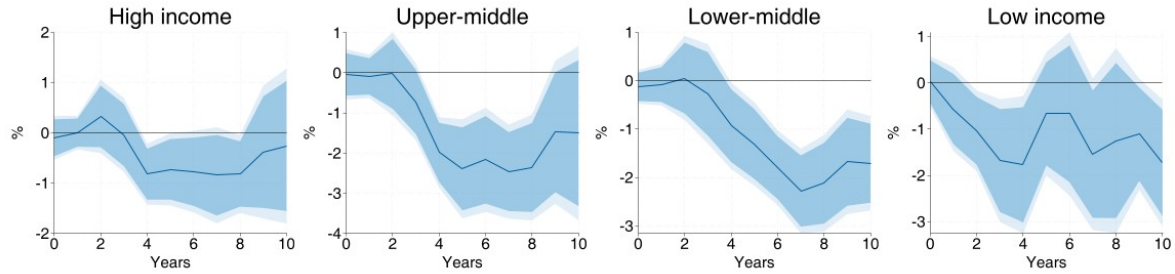
Finally, we inspect the response of government debt. Debt increases for all income groups, following

a similar hump-shaped path: it rises steadily, begins to fall after approximately seven years, and becomes insignificant by the end of the horizon. Measured in levels, government debt rises modestly for high-income countries but increases sharply for low-income countries, where the debt level shows a peak response of 13.6%. The debt-to-GDP ratio mirrors this pattern, rising by 10 pp for low-income countries, which is roughly twice the increase observed for the middle-income groups.

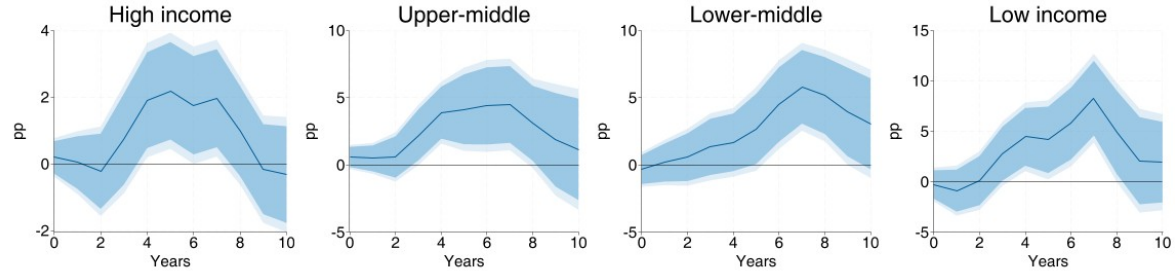
To summarise, low-income countries experience large output losses and large increases in government-debt-to-GDP ratios in response to a global temperature shock; their tax revenue declines, and their budget deficit rises substantially. At the same time, expenditure and expenditure as a percentage of GDP do not display any significant effect. As the economy shrinks and the tax base decreases, low-income countries do not or cannot cut spending and are forced to run larger deficits and take on more debt, as they do not have the fiscal capacity to react to the global temperature shock. High-income countries experience small (insignificant) output effects and no effect on revenue as a percentage of GDP. Their expenditure as a percentage of GDP rises, and their deficit falls. High-income countries, therefore, have the fiscal capacity to absorb the shock and even manage to eventually improve their budget balance. Lower-middle- and upper-middle-income countries lie in between. The effects are in line with the literature such as Noy & Nualsri (2011) and Melecky & Raddatz (2011, 2015), who find that higher-income countries respond counter-cyclically, while lower-income countries exhibit a more pro-cyclical response. Global warming imposes a fiscal burden that is regressive. Next, we decompose the role of exposure and fiscal capacity for the differential response across income groups.

Figure 5: The effects of a global temperature shock (0.1°C) on public finances by income group

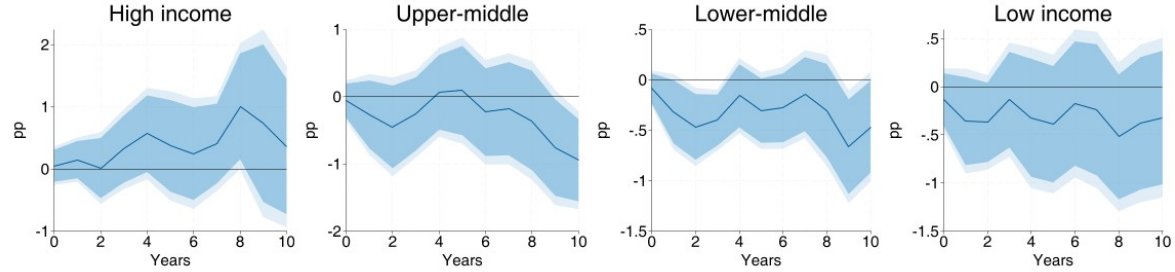
(a) Real GDP pc



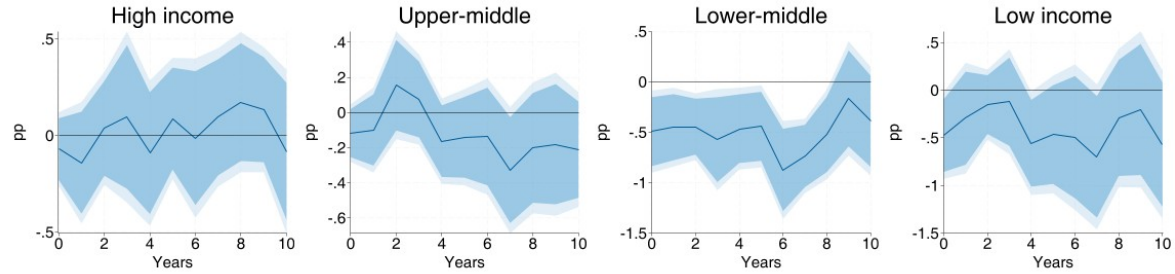
(b) Government debt in % of GDP



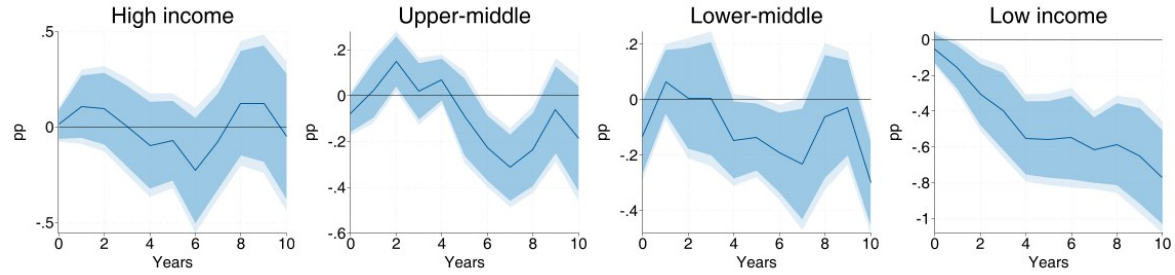
(c) Government expenditure in % of GDP



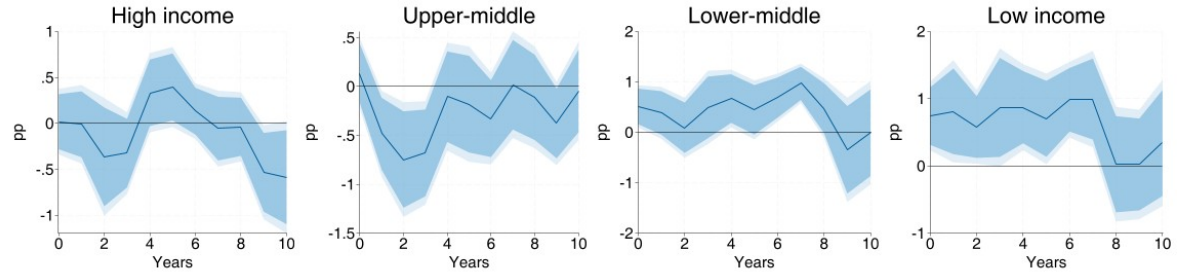
(d) Government revenue in % of GDP



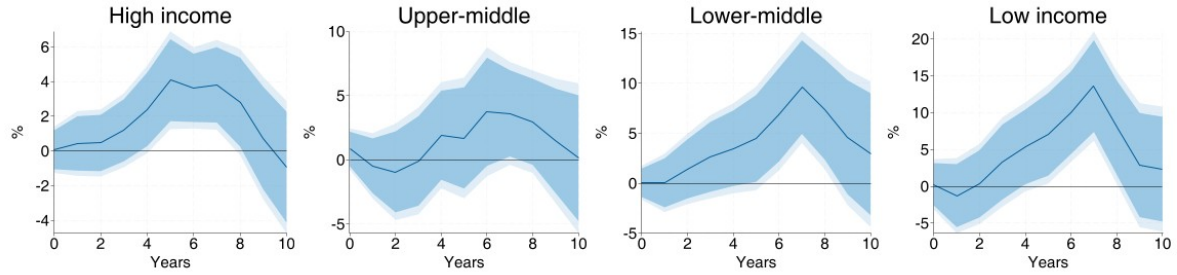
(e) Government tax revenue in % of GDP



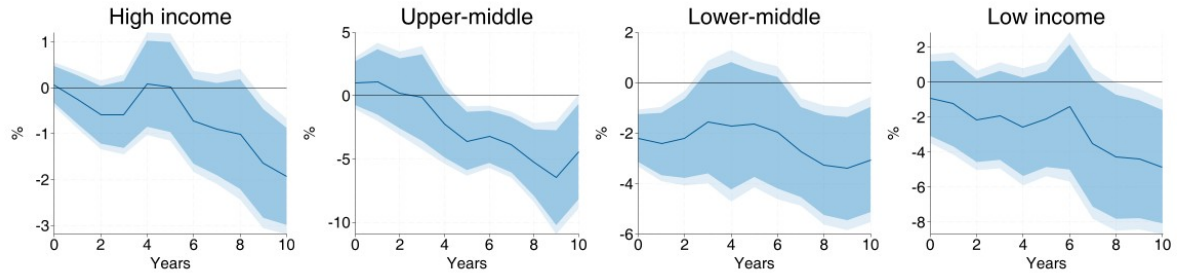
(f) Government deficit in % of GDP



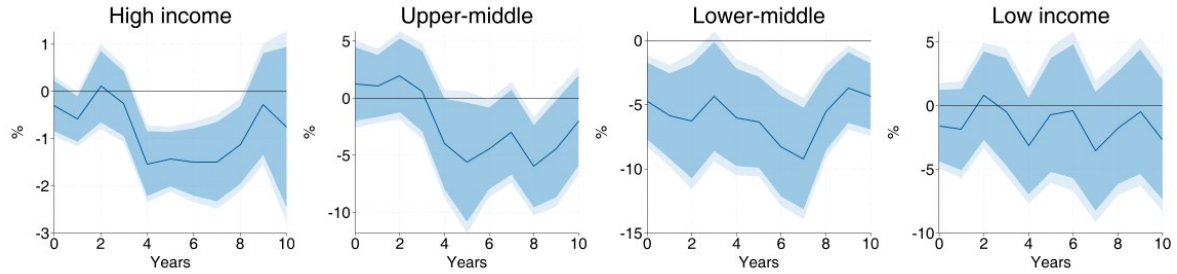
(g) Government debt



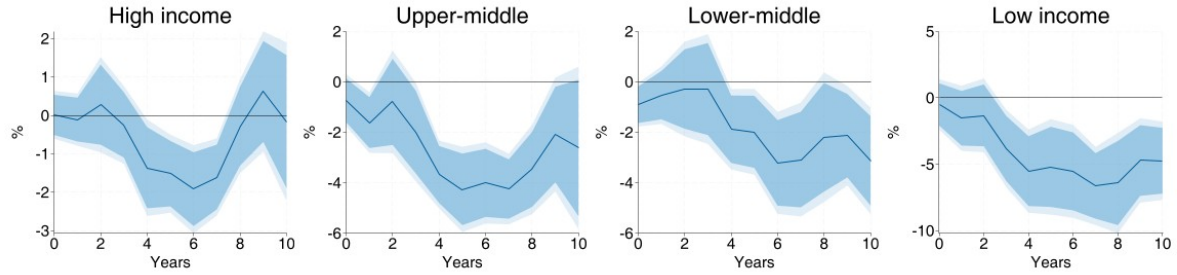
(h) Government expenditure



(i) Government revenue



(j) Government tax revenue



Notes: Impulse responses to a global temperature shock, normalised to increase local temperature by 0.1°C on average. Shaded (dark) blue areas represent 95% (90%) confidence bands.

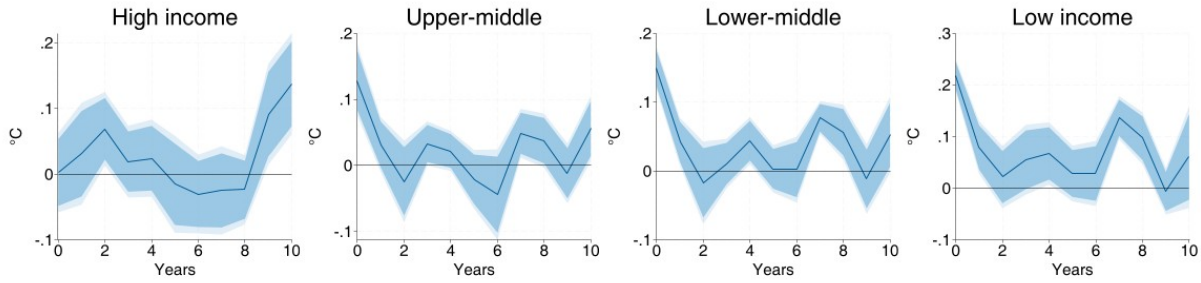
Physical exposure

We start by estimating how strongly a global temperature shock translates into local warming across income groups. To do so, we estimate Equation 2 for each income group with local temperature

as the dependent variable. Figure 6 displays the pass-through of the global temperature shock on local temperature across income groups. On average, a global temperature shock does not increase temperatures in high-income countries. The impact is, however, quite substantial for other income groups: upper-middle-income countries experience a temperature increase of about 0.12°C, lower-middle-income countries of about 0.15°C, and low-income countries of 0.2°C. Additionally, the effect of the global shock on local temperatures is most persistent in low-income countries, followed by lower-middle income countries.

Poor countries are disproportionately in areas where a global shock translates into more local warming. It follows that heterogeneity in the response across income groups is partly due to physical exposure to global warming. Poorer countries experience a higher pass-through of global temperature shocks. This can be explained by their geographical location and temperature level. Figure A.1 displays a map of countries according to their income level. The low-income and lower-middle-income groups are composed of countries located in geographical areas that experience very hot temperatures (e.g. the Sahel region for low-income countries). Figure 2 shows average temperatures for each income group between 1960 and 2025. While temperature increases are larger in areas further from the equator, where most high-income countries are located, lower-income countries experience increases on top of their already high temperatures. Low-income countries are exposed to greater risks, especially owing to their location in geographically sensitive areas, and they have been hit hardest in the past by natural disasters, whose frequency and severity are expected to increase (Farid et al., 2016). High-income countries, on the other hand, are concentrated in geographically cold areas. Countries in hot areas have been shown to experience the strongest negative effects of temperature shocks on GDP (Bilal & Känzig, 2024).

Figure 6: Transmission of global temperature shock



Notes: Impulse responses of average local temperature to a global temperature shock, normalised to increase local temperature by 0.1°C. Light (dark) shaded areas represent 95% (90%) confidence bands.

Fiscal capacity

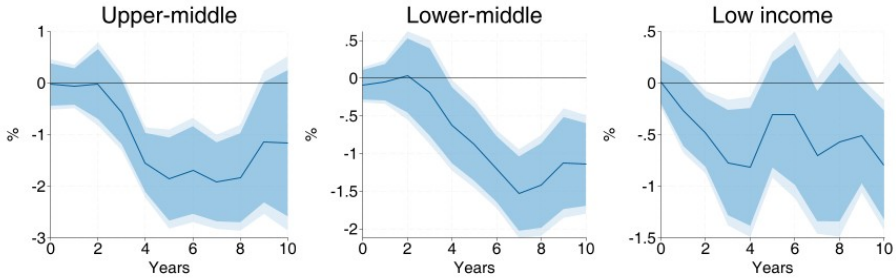
Next, we want to isolate the fiscal sensitivity to global warming, holding the exposure constant. To do so, we re-estimate Equation 2 with local temperature as the dependent variable for each income group. This time, however, we normalise the shock such that the global shock translates into local warming of 0.1°C for each income group. The same normalisation is then applied when re-estimating Equation 2 with our main variables of interest as dependent variables. In this way, we can infer whether the fiscal response varies given that income groups experience the same local warming (e.g. whether exposure is held constant across countries). Figure 7 displays

the responses of public finance variables once exposure is held constant for upper-middle-, lower-middle-, and low-income countries. We do not show the responses for high-income countries, as temperatures in high-income countries do not react significantly to a global temperature shock on impact (see Figure 6). For this reason, we cannot normalise the shock to increase by 0.1°C in high-income countries. The responses of upper-middle-, lower-middle-, and low-income countries converge, indicating that the fiscal costs operate primarily through differential exposure rather than differential fiscal sensitivity. The stronger response of low-income countries, however, persists even if attenuated when accounting for exposure.

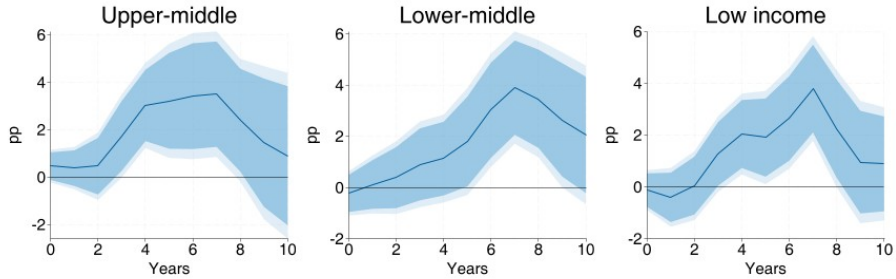
Real GDP per capita shows a peak response of -2.5%, -2.3%, and -1.8% in upper-middle-, lower-middle-, and low-income countries, respectively (see Figure 5). When we account for exposure, the peak impacts decrease to -2%, -1.5%, and -0.8%, respectively. Another notable finding is the response of government debt: while the debt-to-GDP ratio increased by almost twice as much (5 pp difference) in low-income compared to lower-middle- and upper-middle-income countries in Figure 5, the difference declines to 1 pp when exposure is held constant (Figure 7). Furthermore, the response of government expenditure and revenue becomes much more similar in size when controlling for exposure, which is then also reflected in the response of the government deficit as a percentage of GDP. The reduction in the size of the effect is highly notable also for government tax-to-GDP in low-income countries. While the magnitude of the response does not decline much for upper-middle- and lower-middle-income countries, we see that exposure plays a larger role in terms of tax revenue for low-income countries. The fiscal burden of global warming is, therefore, driven primarily by differences in exposure, with a non-negligible role for differential fiscal capacity.

Figure 7: The effects of a global temperature shock (0.1°C temperature increase) on public finances by income group

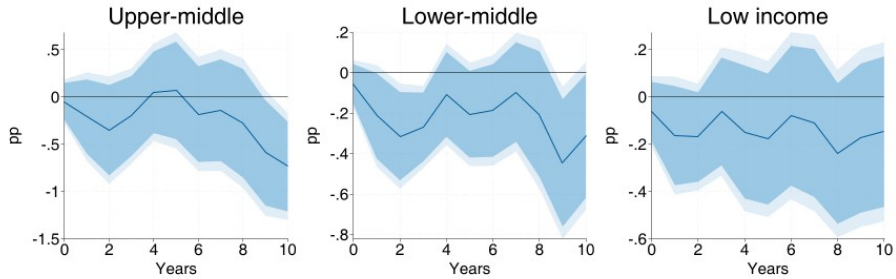
(a) Real GDP pc



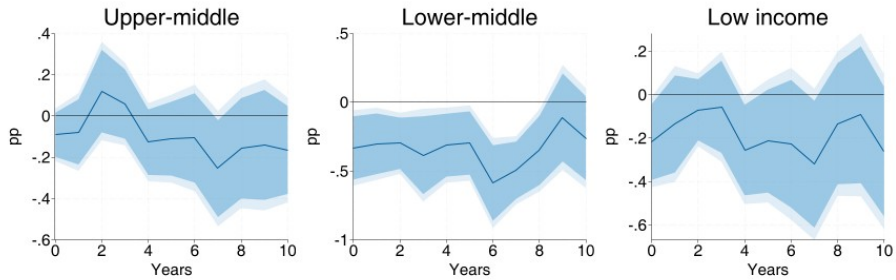
(b) Government debt in % of GDP



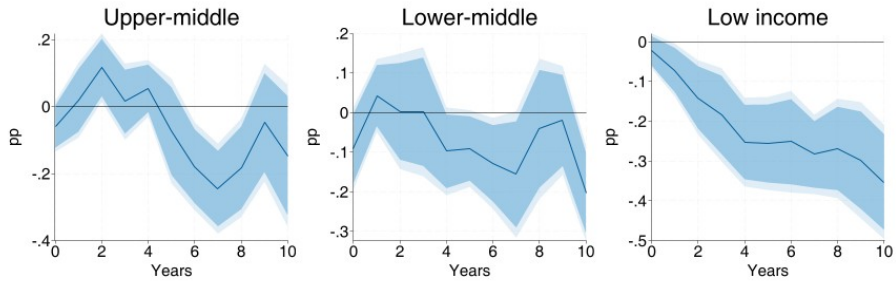
(c) Government expenditure in % of GDP



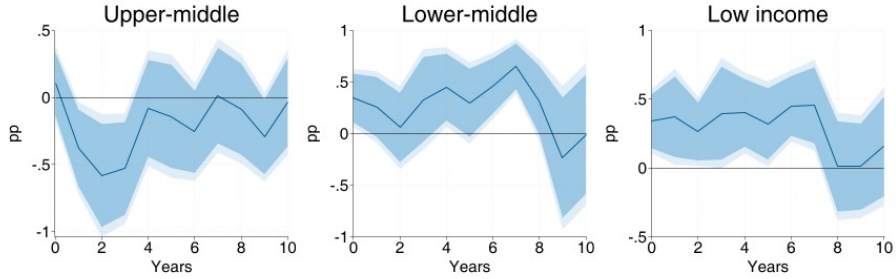
(d) Government revenue in % of GDP



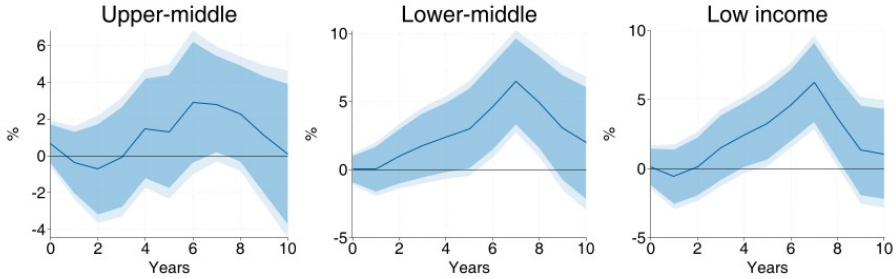
(e) Government tax revenue in % of GDP



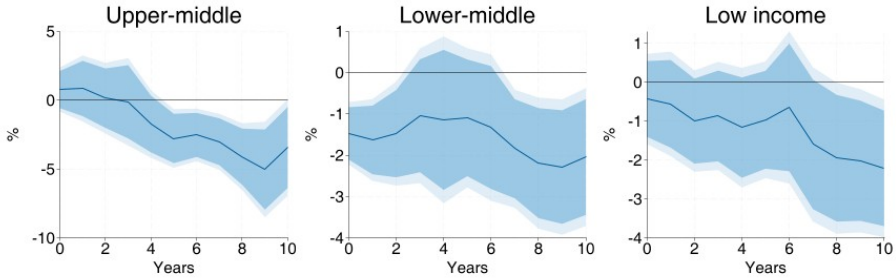
(f) Government deficit in % of GDP



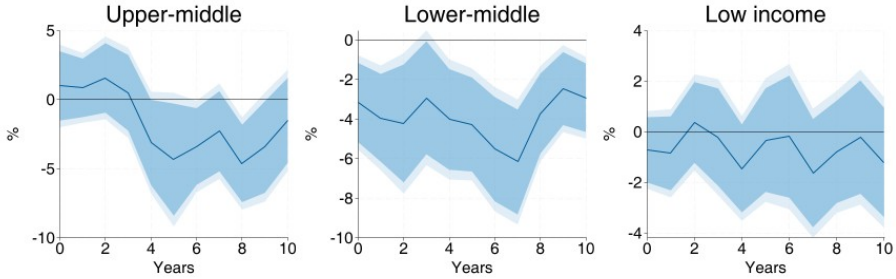
(g) Government debt



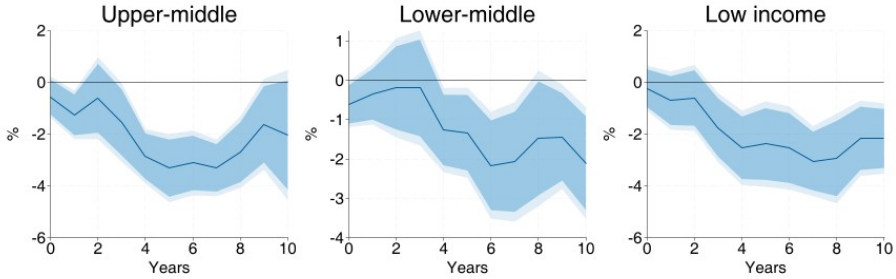
(h) Government expenditure



(i) Government revenue



(j) Government tax revenue



Notes: Impulse responses to a global temperature shock, normalised to increase local temperature by 0.1°C for each income group. Shaded (dark) blue areas represent 95% (90%) confidence bands.

6 Robustness

To verify the robustness of our findings, we perform several robustness checks: (i) we vary the construction of the temperature shocks; (ii) we experiment with the main specification; (iii) we adjust the sample; and (iv) we adopt a different benchmark year for the income classification. In each case, we modify only one aspect of the benchmark specification, holding all remaining components constant.

First, we test robustness regarding the construction of our temperature shock measures. As outlined in Section 2.1, we vary the underlying temperature measure and the construction of climate anomalies. We use sea surface temperature (SST) as an alternative temperature measure and compute climate anomalies using a moving average over the preceding 30 years. Figure C.1 in the Appendix displays the results of estimating Equation 2 with these two alternative shock measures, each normalised to a common 0.1°C of local warming on impact. The figure overlays the resulting point estimates on the baseline responses. Across all public finance variables, the point estimates from the alternative shocks lie within the baseline confidence bands, indicating that our findings are not driven by the particular choice of shock construction.

Second, we assess the sensitivity of our baseline results to the lag structure and to the inclusion of region-specific trends. Specifically, we re-estimate the model with one lag, with four lags, and without region-specific linear trends. Figure C.2 overlays the resulting point estimates on the baseline responses. Across all outcome variables, the alternative specifications trace the same dynamic shape as the baseline, and their point estimates remain within the baseline confidence bands throughout the horizon. The only notable difference is for government tax revenue, where the alternative specifications imply a somewhat smaller response. We conclude from this that our results are robust to these modeling choices.

Third, we experiment with the sample. In a first exercise, we winsorise the variables to account for potential outliers in our dataset. In a second exercise, we restrict the sample to a common set of observations for all variables. The main results are based on a common set for all variables except tax revenue and tax-revenue-to-GDP, as observations for these variables are missing frequently, and restricting the sample therefore implies losing a substantial number of observations for all other variables. Figure C.3 displays the results, which are largely consistent: the variables show the same dynamics as the baseline, and their point estimates remain within the baseline confidence bands throughout the horizon. The only exception is government revenue, where the point estimates are smaller for the sample restriction compared to the baseline.

Lastly, we assess sensitivity to the classification year by re-assigning income groups based on the 1987 and 2000 income-group classification of the World Bank. Given that countries change income status over time, this alters the composition of the groups. The responses are robust across classification years for the large majority of outcomes (see Figure C.4) and, importantly, for both the highest- and lowest-income groups, which anchor our central finding. Estimates depend on the classification year only for revenue for the middle-income groups, where reclassification of developing countries alters group composition. The overall pattern across income levels is preserved under all three classification years.

7 Conclusion

This paper studies the fiscal consequences of temperature shocks in a global sample of 175 countries over the 1960-2025 period. Using local projections and temperature shocks constructed from gridded weather data, we estimate the dynamic responses of government revenue, expenditure, the fiscal balance, and debt to local and global temperature shocks in addition to examining whether these responses depend on the specific income group that countries belong to.

We find that global and local temperature shocks have different fiscal implications. Global temperature shocks, which are closely linked to droughts, storms, and other extreme weather events, trigger a persistent decline in output, an increase in the budget deficit, and higher government debt. Local temperature shocks, by contrast, leave public finances largely unaffected. This distinction is in line with recent findings for the response of output; it suggests that the fiscal risks of climate change operate primarily through the global component of warming rather than through a country's own temperature fluctuations.

The fiscal burden of global warming is distributed unequally across countries. Low-income countries suffer the largest output and tax-revenue losses; as government spending does not fall, they are forced to increase deficits and debt. High-income countries, on the other hand, experience negligible output effects and little impact on their fiscal position. We show that the results reflect two distinct mechanisms. Poorer countries are more physically exposed, whereby a global shock translates into disproportionately stronger local warming. In addition, they have less fiscal capacity to absorb the shock. Decomposing the two, we find that differential exposure accounts for most of the differential response, while fiscal capacity also plays a non-negligible role.

Taken together, our results show that climate change imposes a fiscal burden that falls disproportionately on the countries least responsible for causing global warming and least able to finance an effective response. This burden adds to already large financing needs in poorer countries (Matzner & Steininger, 2025) and is likely to deepen their adaptation deficit, which reflects, in part, tight budget constraints (e.g. Fankhauser & McDermott, 2014). These findings have implications for the design of climate and development policy. To the extent that the fiscal consequences of warming are concentrated among low-income countries that are highly exposed to temperature increases and have limited access to affordable finance (e.g. Cevik & Jalles, 2022a,b; Kling et al., 2025), mechanisms that expand their fiscal space may be central to managing the fiscal effects of a warming climate. This calls for stronger international coordination, with climate finance directed primarily towards adaptation in these countries.

Our analysis focuses on national fiscal outcomes, leaving open whether the fiscal effects of warming differ across levels of government or regions within countries. Subnational data could reveal whether local governments in more exposed regions bear a disproportionate share of the burden. Future work could also extend the analysis beyond temperature to other climate variables (e.g. precipitation) or to natural disasters directly, which would help identify the specific climate hazards driving the fiscal costs we document.

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Appendix A Data

Following the GMD manual, we deflate the government finance variables and convert them to US dollars. The procedure, which follows the methodology used by the World Bank,[4] ensures that the real growth rates of the economy are applied:

1. We take the deflator from the GMD. The deflator base years differ across countries. We first set the base year to 2015 for all countries.
2. The respective government finance variable for the base year is converted to USD using the end-of-period exchange rates available in the GMD. This allows us to calculate an anchor value.
3. Next, we obtain the constant local currency series by applying the adjusted deflator. We calculate annual real growth rates from the constant local currency series.
4. Last, the growth rates are applied forwards and backwards from the 2015 anchor value.

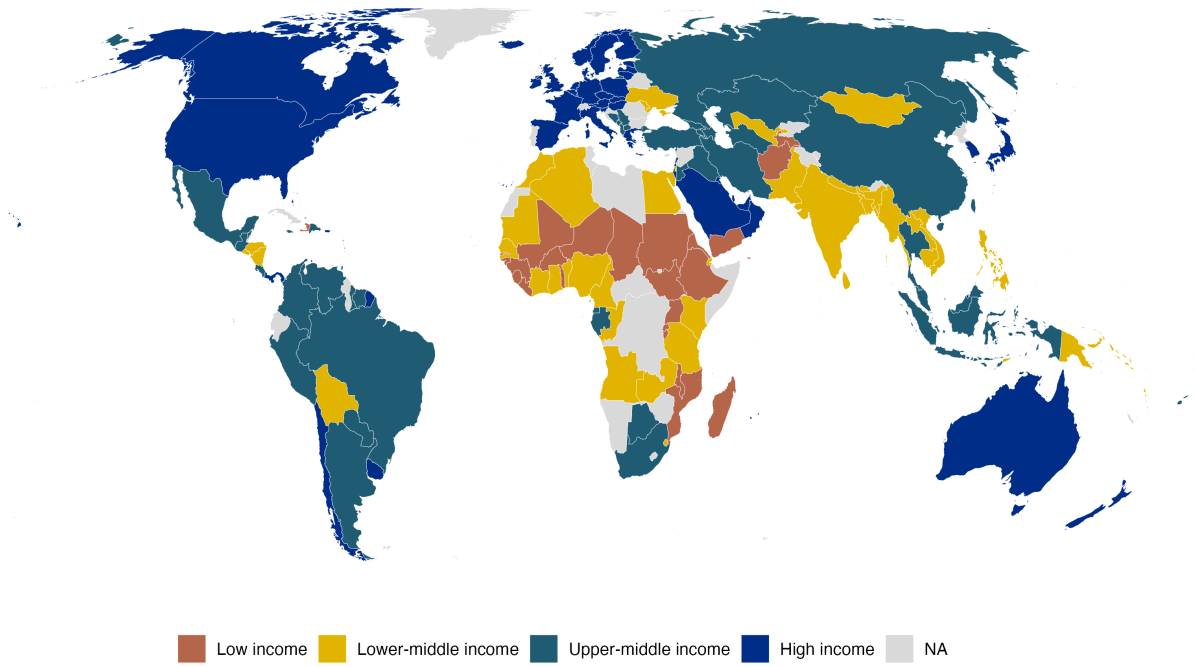
Table A.1: Descriptive statistics

	Mean	SD	Min	Max
Real GDP per capita (USD)	343,632	1,440,000	0.18	23,600,000
Population	37.91	131.9	0.01	1,438.07
Government debt (USD)	206,920	1,140,000	0	25,000,000
Government revenue (USD)	104,673	420,165	0	7,420,000
Government tax revenue (USD)	53,383	167,987	0	2,650,000
Government expenditure (USD)	119,543	518,378	0	9,330,000
Government deficit (USD)	-11,280	87,586	-2.91e+06	203,528
Government expenditure in % of GDP	25.68	14.37	0.00	248.54
Government revenue in % of GDP	25.73	14.94	0.00	337.76
Government tax revenue in % of GDP	16.91	7.99	0.09	147.64
Government deficit in % of GDP	-2.09	8.35	-208.49	129.18
Government debt in % of GDP	53.37	47.96	0.00	677.18

Notes: Authors' calculations. Population is in millions. Government debt, government revenue, government tax revenue, government expenditure, and government deficit are in million USD.

[4] https://datahelpdesk.worldbank.org/knowledgebase/articles/114943-how-do-you-derive-constant-price-series-in-usd

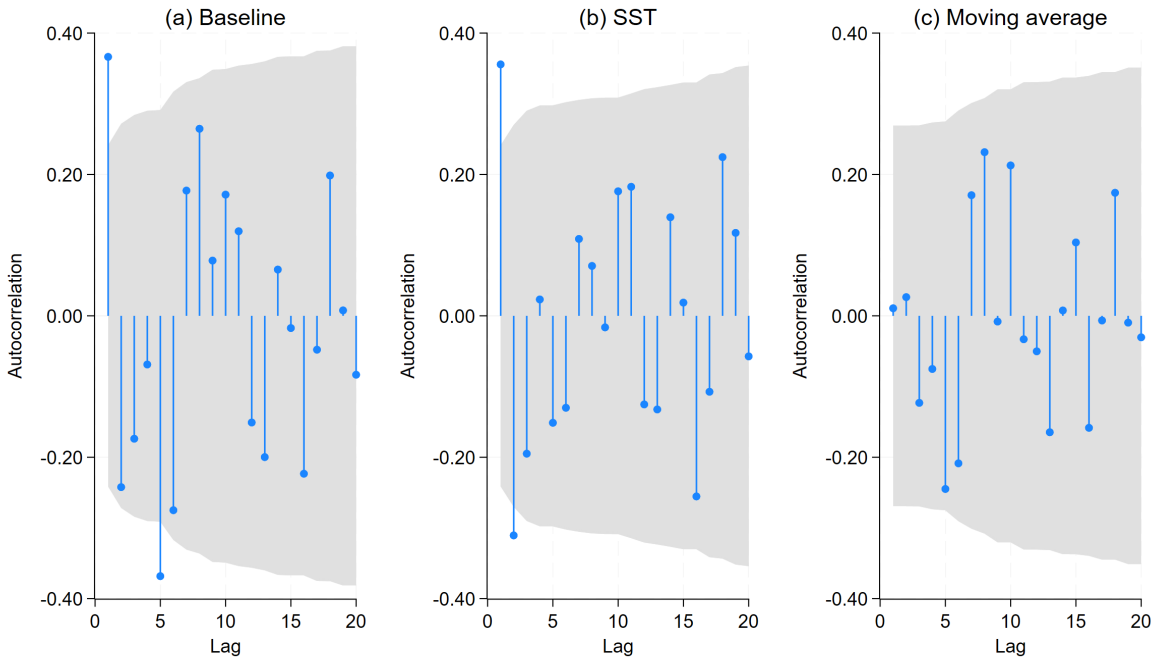
Figure A.1: Income group classification



Notes: Authors' illustration. The plot shows the countries included in our sample and the income group they belong to. Classification into income groups follows the World Bank classification for 2019. Countries with NA are those not included in our analysis.

Appendix B Diagnostics

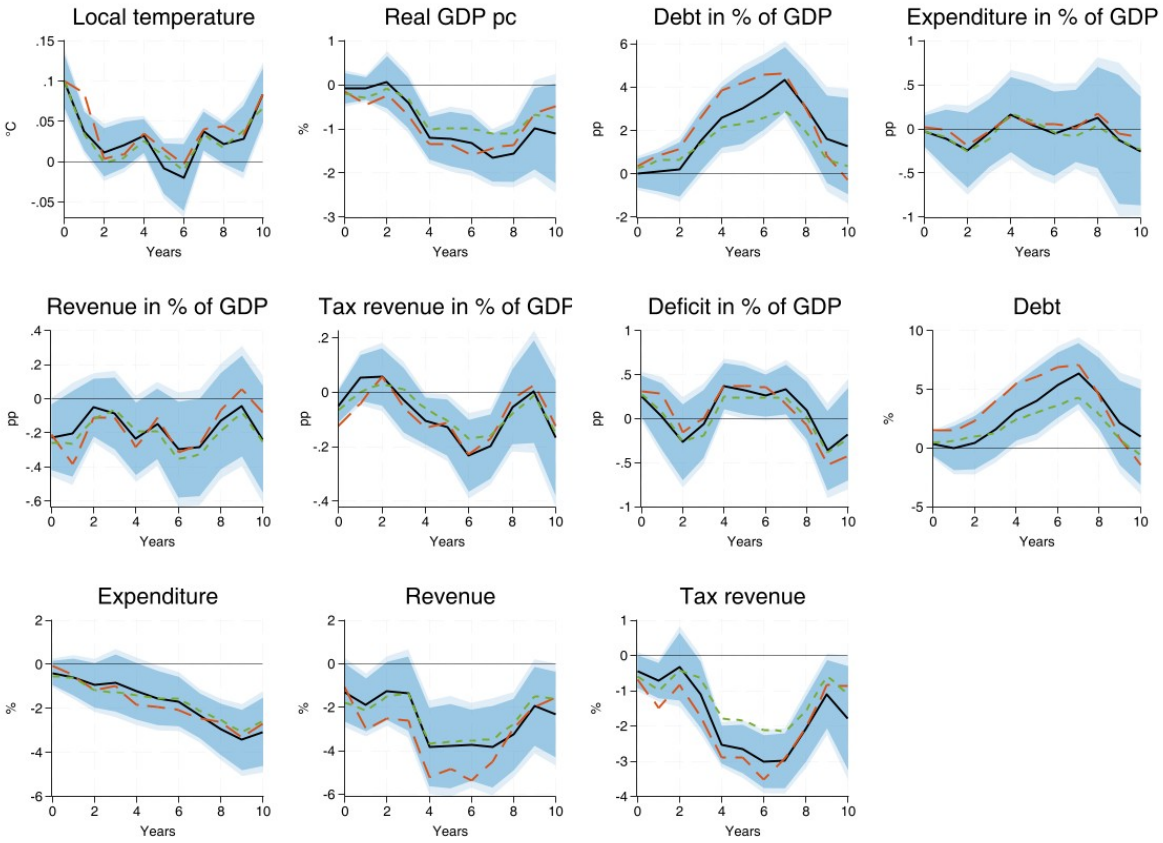
Figure B.1: Autocorrelation functions



Notes: The figure shows the autocorrelation functions (ACFs) for each of the global temperature shocks employed: Panel (a) displays the ACF of the baseline shock, panel (b) shows ACF of the shock constructed using sea surface temperature (SST), and panel (c) displays the ACF of the shock constructed using moving average for climate anomalies.

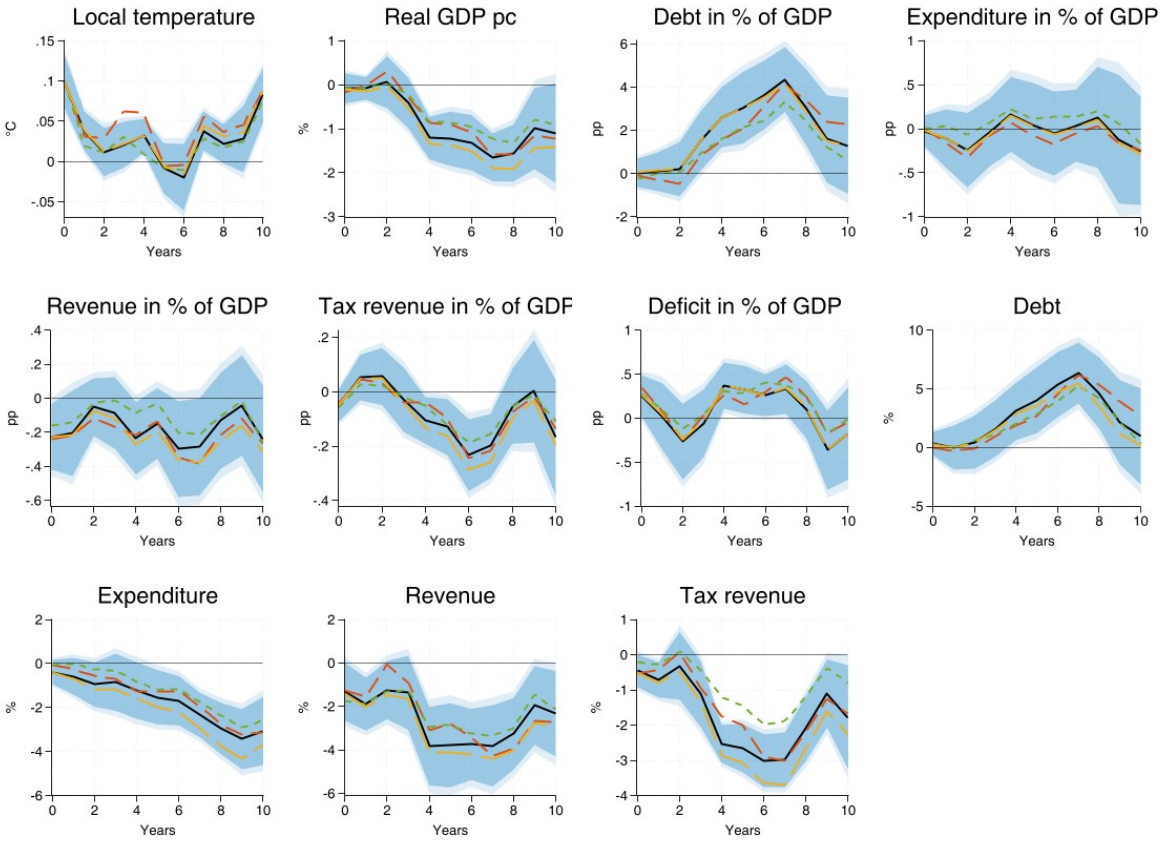
Appendix C Robustness

Figure C.1: Robustness – shock construction



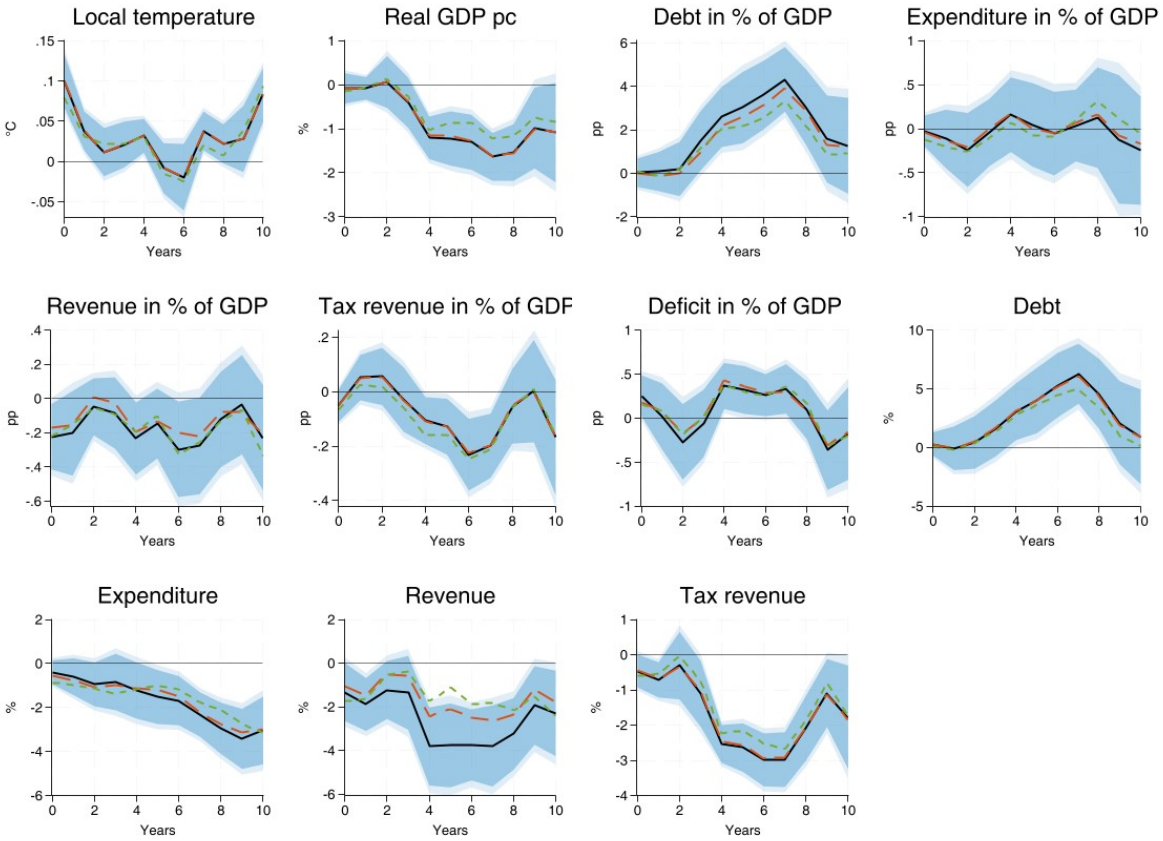
Notes: Impulse responses to global temperature shocks, each normalised to increase local temperature by 0.1°C. Solid black lines display the point estimates of the baseline results, dashed red lines display the point estimates of using sea surface temperature (SST) for shock construction, and green dashed lines display the point estimates of using moving averages to construct temperature anomalies. Light (dark) shaded areas represent 95% (90%) confidence bands of the baseline estimate.

Figure C.2: Robustness – specification



Notes: Impulse responses to a global temperature shock, normalised to increase local temperature by 0.1°C. Solid black lines display the point estimates of the baseline results, red and green dashed lines display the point estimates using one lag and four lags, respectively, and yellow dashed lines display the point estimates without using regional trends. Light (dark) shaded areas represent 95% (90%) confidence bands of the baseline estimate.

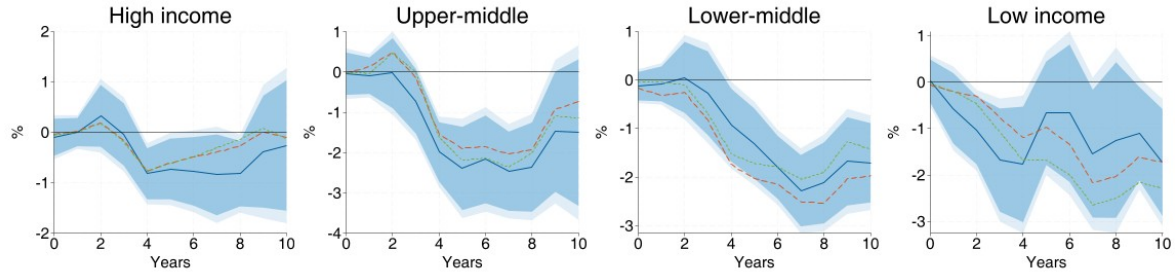
Figure C.3: Robustness – sample



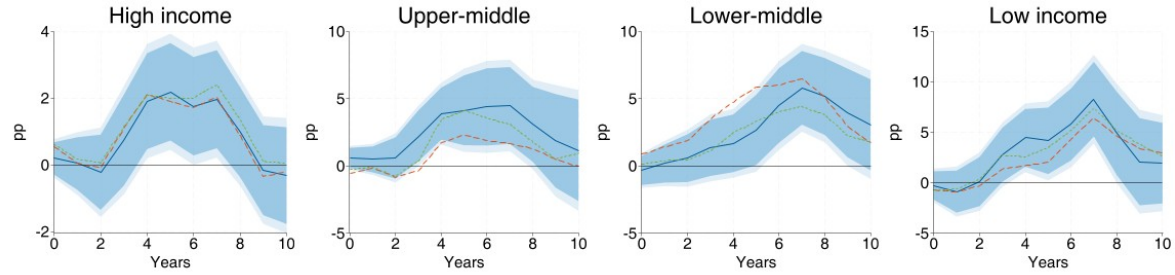
Notes: Impulse responses to global temperature shock, normalised to increase local temperature by 0.1°C. Solid black lines display the point estimates of the baseline results, while dashed red and green lines display the point estimates of adjusting the sample by winsorising and by applying a common sample, respectively. Light (dark) shaded areas represent 95% (90%) confidence bands of the baseline estimate.

Figure C.4: Robustness – income group classification

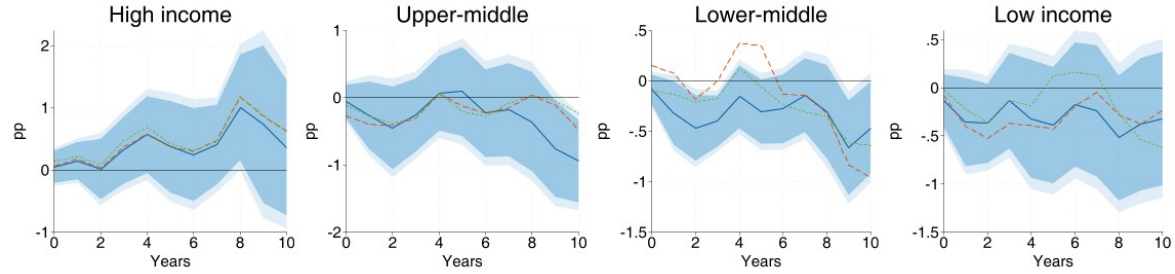
(a) Real GDP pc



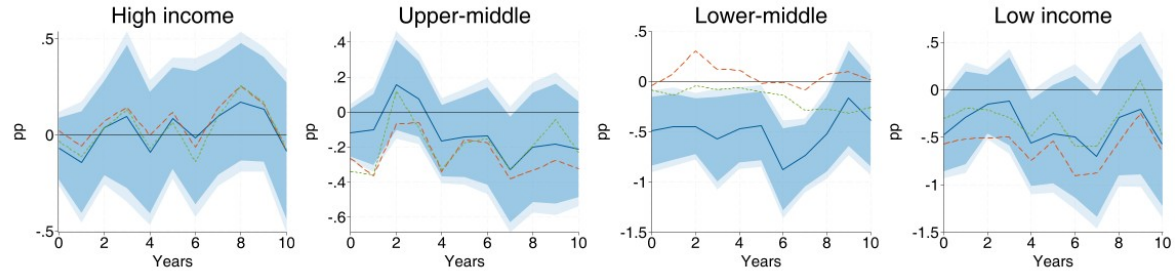
(b) Government debt in % of GDP



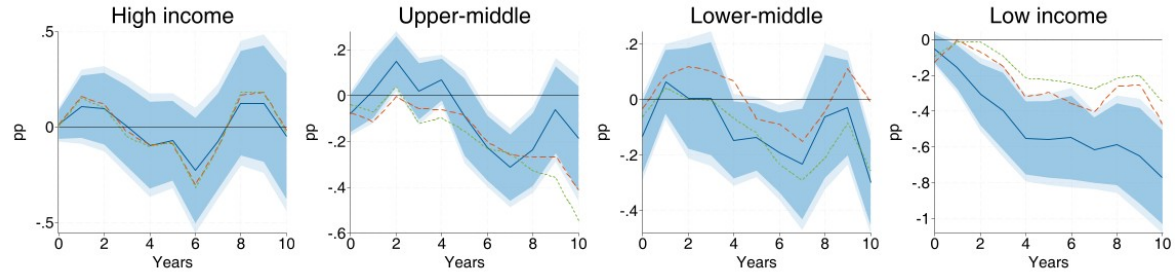
(c) Government expenditure in % of GDP



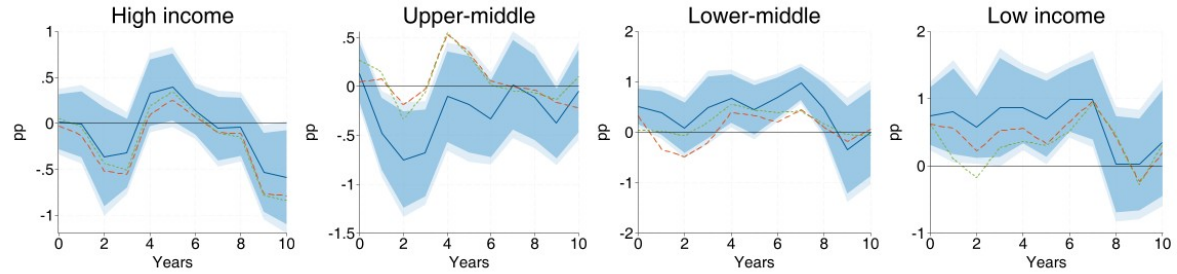
(d) Government revenue in % of GDP



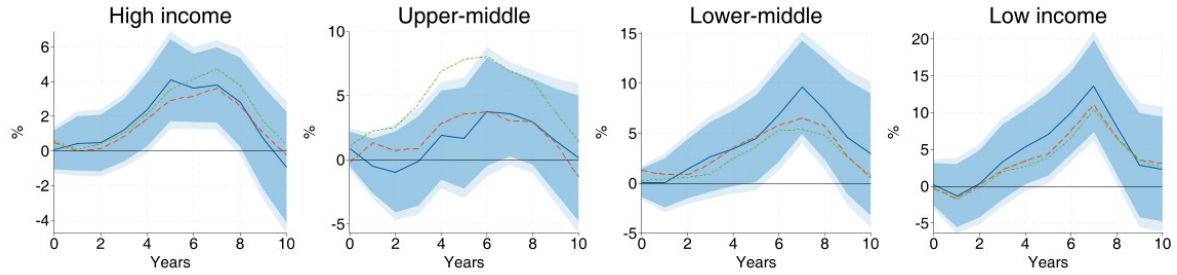
(e) Government tax revenue in % of GDP



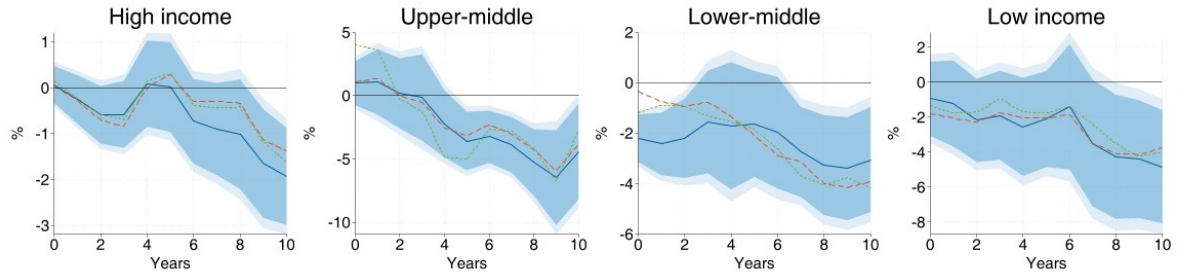
(f) Government deficit in % of GDP



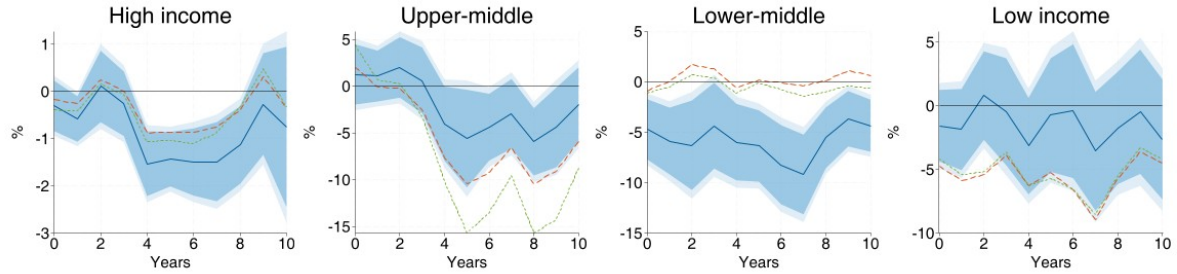
(g) Government debt



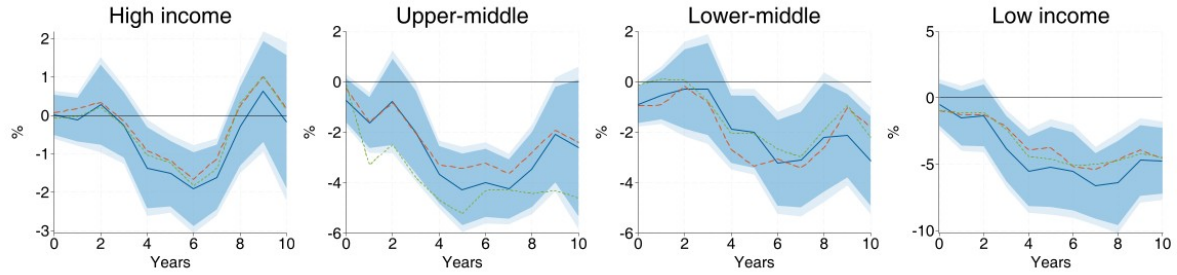
(h) Government expenditure



(i) Government revenue



(j) Government tax revenue



Notes: Impulse responses to a global temperature shock, normalised to increase local temperature by 0.1°C on average. Solid black lines display point estimates of the baseline results, while red and green dashed lines display the estimated response using 2000 and 1987 for classification of the income group, respectively. Light (dark) shaded areas represent 95% (90%) confidence bands.

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