REM WORKING PAPER SERIES

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REM Working Paper 0375-2025

April 2025

REM – Research in Economics and Mathematics
Rua Miguel Lúpi 20,
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ISSN 2184-108X

REM – Research in Economics and Mathematics

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Shaken Balances: Climate Risks and the Dynamics of Fiscal and External Sustainability *

António Afonso† José Alves‡ João Jalles§ Sofia Monteiro**

April 2025

Abstract

This paper examines the impact of natural disasters on fiscal and external sustainability across 134 economies from 1980 to 2023. We adopt a two-step approach: first, we estimate country-specific, time-varying sustainability coefficients; second, we assess their determinants using Weighted Least Squares panel regressions with fixed effects. To complement the long-run analysis, we employ local projections to capture the short-term dynamics following disaster-related mortality, vulnerability, and resilience shocks. Results show that natural disasters weaken fiscal sustainability, particularly in emerging and vulnerable economies. Vulnerability exacerbates fiscal and external fragility, while resilience mitigates adverse effects on public accounts. Local projections reveal that fiscal sustainability deteriorates significantly in the medium term after disaster shocks, whereas external sustainability responses are more muted and heterogeneous. Together, these findings highlight the importance of combining long- and short-run approaches to understand how climate shocks propagate through macroeconomic channels and to inform adaptive, risk-sensitive fiscal policy frameworks.

JEL: E62, F32, H63, O23, Q54, C33
Keywords: Fiscal Sustainability, External Sustainability, Climate Risk, Natural Disasters, Local Projections, Weighted Least Squares

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* This work was supported by the FCT (Fundação para a Ciência e a Tecnologia) [grant number UIDB/05069/2020]. The opinions expressed herein are those of the authors and do not necessarily reflect those of the authors' employers. Any remaining errors are the authors' sole responsibility.
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1. Introduction

Natural disasters have become an increasingly pressing economic and social challenge worldwide, with both their frequency and intensity rising substantially in recent decades. Between 2010 and 2020, the number of recorded disasters rose by more than 40% compared to the previous decade, inflicting annual economic losses exceeding $300 billion (World Bank, 2021). While the human and material devastation of these events is immediately visible, their macroeconomic repercussions often extend well beyond the short term. Disasters can disrupt production, reduce revenue mobilization, raise government spending needs, weaken external trade flows, and strain access to external financing – placing fiscal and external sustainability under considerable pressure.

Despite growing awareness of these risks, the long- and short-run effects of climate-related disasters on macroeconomic sustainability remain insufficiently understood. Fiscal sustainability refers to a government's ability to maintain current fiscal policies without risking insolvency or explosive debt dynamics (Blanchard et al., 1990), while external sustainability denotes a country's capacity to meet its external obligations without persistent current account deficits or depletion of reserves (Obstfeld and Rogoff, 1996). Natural disasters can compromise both through direct damage to economic structures and indirect effects on investor confidence, trade flows, and fiscal space – particularly in economies with limited institutional resilience.

In response to disasters, governments often increase public spending on relief, reconstruction, and social protection, while simultaneously experiencing tax revenue losses due to economic contraction. This dual impact drives fiscal deficits upward and contributes to rising debt burdens. On the external side, disasters may disrupt exports, increase import needs, and trigger capital outflows – undermining the current account and reducing external buffers. These dynamics are especially acute in developing and emerging economies, where weak institutional capacity, limited policy space and fragile financial stability compound the effects of climate shocks.

Empirical evidence from past disasters underscores these mechanisms. The 2004 Indian Ocean tsunami significantly affected trade and fiscal accounts in Indonesia and Thailand, while the 2010 Haiti earthquake led to a near collapse in revenue collection and external balances (Cavallo and Noy, 2011; Noy, 2009). Yet, despite such cases, the academic literature has often relied on static models that fail to capture the evolving nature of disaster impacts. Moreover, most studies examine fiscal and external sustainability in isolation, overlooking their interdependence and the role of structural features such as vulnerability and resilience in shaping macroeconomic outcomes.

This paper addresses these gaps by combining a dynamic measurement of sustainability with a global panel dataset of disaster events and contributes to the literature by addressing systematically such climate-related macroeconomic vulnerability. First, we estimate country-specific, time-varying fiscal and external sustainability coefficients that reflect how macroeconomic responses evolve over time. Second, we examine the long-run effects of disaster-related mortality, climate vulnerability, and resilience on these sustainability metrics using Weighted Least Squares (WLS) panel regressions with fixed effects. Finally, we assess the short-run dynamics using local projections (Jordà, 2005), which allow us to trace the year-by-year impact of shocks while accounting for dynamic adjustment and heterogeneity.

Our results show that natural disasters significantly weaken fiscal sustainability, particularly in emerging and vulnerable economies. Increases in structural vulnerability further erode sustainability, while higher resilience helps mitigate adverse effects – though erosion of resilience over time poses growing fiscal risks. External sustainability is also affected, albeit less consistently in the short term. Vulnerability shocks have a positive and significant impact on external sustainability, likely reflecting adaptive adjustments, while the effects of mortality and resilience shocks are less pronounced. The short-run analysis confirms that fiscal sustainability deteriorates persistently in the aftermath of disaster mortality shocks, while external accounts exhibit more muted and heterogeneous responses.

Together, these findings underscore the value of integrating long- and short-run perspectives in assessing climate-related macroeconomic risk. The combination of fixed-effects panel regressions and local projections offers a comprehensive framework to analyze both structural vulnerabilities and temporal dynamics. The evidence highlights the need for adaptive fiscal frameworks, targeted resilience-building, and regionally tailored strategies to preserve macroeconomic stability in the face of intensifying climate shocks.

The remainder of the paper is structured as follows. Section 2 reviews the relevant theoretical and empirical literature. Section 3 presents the data and empirical strategy, including the construction of sustainability coefficients and the estimation methodology. Section 4 reports the main results, including both long-run panel regressions and short-run local projections. Section 5 concludes with policy implications and avenues for future research.

2. Literature Review

The relationship between natural disasters, climate risks, and economic sustainability has garnered increasing scholarly attention in recent years, particularly in light of the accelerating frequency and severity of such events (Fratzscher et al., 2020; Klomp, 2020; McKibbin et al., 2021; De Winne and Peersman, 2021; Kabundi et al., 2022; IPCC, 2022; Cantelmo et al., 2024). Natural disasters are unique in their ability to disrupt both fiscal and external balances simultaneously, presenting multidimensional challenges for policymakers. In addition to their toll on human lives and physical infrastructure (Raddatz, 2009), these shocks threaten macroeconomic stability, constrain growth, and deepen inequalities, particularly in vulnerable economies with limited resilience (Botzen et al., 2019; Klomp and Valckx, 2014; Benali et al., 2019). This section reviews the literature on fiscal and external sustainability in the context of natural disasters. Although these dimensions are typically analyzed separately, they are deeply interconnected and jointly determine macroeconomic resilience. We first examine the fiscal dimension before turning to external sustainability, and then highlight their interplay.

Fiscal sustainability refers to the government's ability to maintain a stable debt path over time without undermining its solvency or macroeconomic stability (Blanchard et al., 1990). Natural disasters compromise this equilibrium by exerting pressure on both sides of the public budget. On the expenditure side, emergency responses, reconstruction, and welfare needs drive significant fiscal outlays (Melecky and Raddatz, 2011; Benali et al., 2019; European Commission, 2022). On the revenue side, disasters reduce economic activity, which in turn diminishes the tax base and other revenue streams (ECB, 2023; OECD, 2013).

Numerous empirical studies document these effects. For instance, Borensztein et al. (2009) show that disaster-induced infrastructure damage in Belize led to a surge in public spending. Melecky and Raddatz (2011) find that disaster impacts are especially severe in low-income regions, while Benali et al. (2019) identify a unidirectional causal relationship between disasters and increased government expenditure in middle- and high-income economies. IMF (2003) case studies similarly underscore the fiscal deterioration following catastrophic events in Sub-Saharan Africa.

Governments often finance these imbalances through borrowing, which exacerbates debt accumulation and affects credit quality (Zenios, 2022). Gagliardi et al. (2022), using simulations for EU countries, predict sharp increases in debt-to-GDP ratios under different global warming scenarios. This highlights how climate risks can translate into long-term fiscal fragility.

Additionally, climate shocks influence fiscal outcomes via indirect mechanisms such as commodity price fluctuations – particularly in fossil fuel and food markets – and through the fiscal implications of subsidies and inflation (Agarwala et al., 2021). These effects are more pronounced in economies highly exposed to climate-sensitive sectors or with limited fiscal space.

Institutional quality plays a key moderating role. As Noy (2009) and Klomp and Valckx (2014) argue, stronger institutions improve governments' capacity to deliver timely and effective disaster responses, enhancing fiscal resilience. Conversely, weak governance, corruption, and limited administrative capacity amplify fiscal vulnerabilities (European Commission, 2022).

Another emerging strand of literature emphasizes the importance of insurance as a fiscal risk management tool. The European Central Bank (2023) stresses that catastrophe insurance can provide rapid post-disaster funding, reduce reconstruction delays, and mitigate adverse macroeconomic effects. However, coverage remains limited: only 25% of climate-related losses in the EU are insured, and this gap is expected to widen, particularly in more disaster-prone countries (Boitan, 2023). Cantelmo et al. (2024) argue that insurance and adaptation are essential complements to traditional fiscal tools in the face of mounting climate volatility.

Furthermore, fiscal space – the government's capacity to raise resources or reallocate spending without compromising solvency – conditions the impact of disasters. Countries with ample fiscal space can absorb shocks more effectively, while others may be forced into difficult trade-offs (Bohn, 1998). The literature also emphasizes the dynamic nature of fiscal sustainability: it evolves over time in response to both shocks and structural conditions. Yet many existing studies adopt static approaches that fail to account for this temporal dimension (Raddatz, 2007).

Our paper contributes to this debate by introducing time-varying fiscal sustainability coefficients, enabling a more nuanced analysis of how fiscal responses evolve in the wake of disasters and how institutional and economic contexts shape these dynamics.

External sustainability refers to a country's ability to meet its international financial obligations without resorting to unsustainable borrowing or depleting foreign reserves (Obstfeld and Rogoff, 1996). Natural disasters threaten external sustainability through a variety of channels: export losses, surges in import demand, disruptions to capital flows, and financial market instability.

The empirical evidence is substantial. Rasmussen (2004) finds that the Caribbean's current account balances worsened significantly in disaster years between 1970 and 2002. Similarly, Borensztein et al. (2009) observe deteriorations in the current account following disasters, driven by declining export capacity and increased import needs. Chang and Zhang (2020) show that different types of disasters have heterogeneous effects on current accounts and foreign debt, reflecting their sectoral and geographical impact.

Natural disasters can also trigger capital outflows, exchange rate depreciation, and increased sovereign risk premia. Cantelmo et al. (2023) argue that disaster-induced external borrowing raises default risk and undermines investor confidence, particularly in countries with weak credit histories or low institutional credibility. Kolerus (2021) documents short-term current account weakening across OECD countries following major natural disasters from 1870 to 2016.

However, some studies report ambiguous results. Raddatz (2009) finds no consistent relationship between initial debt levels and the macroeconomic impact of climatic disasters. Heger et al. (2008) suggest that post-disaster aid flows and debt relief can actually improve external balances in the medium term, particularly in small island economies. These mixed findings highlight the importance of context – especially aid availability, external financing conditions, and trade structure – in shaping the external effects of disasters.

Despite these contributions, most studies analyze external sustainability using static frameworks that fail to capture adjustment dynamics over time. Our paper addresses this limitation by constructing time-varying external sustainability measures, allowing for a more comprehensive assessment of how countries manage and adapt to external shocks.

Although fiscal and external sustainability are frequently studied in isolation, their interdependence is crucial in understanding the macroeconomic effects of natural disasters. Fiscal shocks often spill over into external accounts through increased foreign borrowing, higher import needs, and currency depreciation. Hence, fiscal shocks could drive the current account in the same direction and a government budget deficit would imply a current account deficit. Naturally, this argument holds when the government budget is not fully financed by domestic private saving and needs to be financed by foreign capital inflows.

In turn, external imbalances can raise the cost of debt servicing and restrict access to international capital, aggravating fiscal pressures (Bohn, 1998; Obstfeld and Rogoff, 1996). Few studies model the joint dynamics of these sustainability dimensions in the context of natural disasters. This paper fills that gap by developing a unified framework that integrates time-varying fiscal and external sustainability metrics. This approach offers a dynamic and context-sensitive view of how natural disasters affect macroeconomic resilience and helps identify the institutional and structural factors that mediate these effects.

3. Methodology and Data

3.1. Empirical Approach

This paper employs a two-stage analytical framework to investigate the impacts of natural disasters on fiscal and external sustainability. First, we follow a backward-looking measure approach based on Bohn (1998) to estimate fiscal response coefficients. This methodology allows us to evaluate the relationship between a given country primary balance and debt is stationary, estimating the following regression (Afonso et al., 2019):

$$PB_{i,t} = \zeta_{0,i,t} + \phi_{i,t}.Debt_{i,t-1} + \mu_{i,t} \quad (1)$$

where $PB_{i,t}$ denotes the Primary balance-to-GDP ratio of country *i* for period *t*, $Debt_{i,t-1}$ is the Government Debt-to-GDP ratio for country *i* for period *t-1* and $\mu_{i,t}$ represents the standard i.i.d. disturbance term satisfying the usual assumptions.

Similarly, we estimate a regression for the analysis of sustainability on external accounts:

$$X_{i,t} = \gamma_{0,i,t} + \vartheta_{i,t}.M_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

where $X_{i,t}$ denotes the Exports over GDP of country *i* for period *t*, $M_{i,t-1}$ is the Imports over GDP for country *i* for period *t-1* and $\varepsilon_{i,t}$ represents the standard i.i.d. disturbance term satisfying the usual assumptions.

Equations 1 and 2 are estimated based on Schlicht's (2021) time-varying methodology, which relies on the assumption that $\sigma_{i,t}$ changes "slowly and unsystematically over time":

$$\sigma_{i,t} = \sigma_{i,t-1} + v_{i,t} \quad (3)$$

where $v_{i,t} \sim N(0; s^2)$. According with Schlicht (2021), equations (1) or (2) and (3) should be estimated jointly. This approach extends the linear model by allowing the independent variables to gradually change over time, contrary to the linear model's assumption of static variables. The expected value of the fiscal (external) response coefficient at time *t* is equal at time *t – 1*, as it is assumed to follow a random walk process. The variation in the coefficients, denoted by $v_{i,t}$ is assumed to be normally distributed with a mean of zero and variance s^2. These variances s^2 are estimated using a method of moments estimator, which aligns with the maximum-likelihood estimator for large samples but is more efficient and easier to interpret in small samples. Consequently, the standard regression model is a special case when s^2 approaches zero, resulting in $\sigma_{i,t} = \sigma_{i,t-1}$. By allowing s^2 to be small but non-zero, we enable the coefficients to evolve slowly over time, starting from the previous

Subsequently, we apply a Weighted Least Squares panel regression model with fixed effects to assess the long-run relationships between natural disasters and sustainability outcomes. This step highlights the cumulative, persistent effects that unfold over years, reflecting the broader economic and policy adjustments. The long-run relationship is modelled as:

$$\rho_{i,t} = \alpha_i + \gamma_t + \delta_1 Disaster_{i,t-1} + \delta_2 C_{i,t-1} + \epsilon_{i,t} \quad (4)$$

where $\rho_{i,t}$ was estimated in Equation (1) and (2), so either $\phi_{i,t}$, or $\vartheta_{i,t}$, $Disaster_{i,t-1}$ denotes the *k* Disaster metric utilized to assess a climate or ecological event occurring in a country *i* in the period before (*t-1*), $C_{i,t-1}$ is a vector containing a set of control variables, α_i are the country fixed effects to account for unobservable, time-invariant factors, γ_t are the time fixed effects to control for global shocks.

We tested the stationarity characteristics of government debt, primary balance, exports and imports by implementing three different types of panel unit root tests. (a) first-generation tests, namely the Im-Pesaran-Shin unit-root test, Im et al. (2003); (b) the Fisher-type unit-root test, based on augmented Dickey-Fuller and based on Phillips-Perron; and (c) the so-called 'second-generation tests', such as the Pesaran (2007) panel unit root test. Results are presented in the appendix. To further validate the stationarity results of the series used in our paper, we adopt the Carrion-i-Silvestre et al. (2001) method, which is based on Hadri (2000)'s panel data unit root test. This serves as an additional exercise and a robustness check for our findings.

While our core empirical strategy focuses on estimating the long-run effects of climate-related disasters on fiscal and external sustainability using a two-step panel framework with Weighted Least Squares (WLS) and fixed effects, this approach primarily captures persistent relationships that unfold gradually over time. However, natural disasters – especially those involving high mortality – often trigger sharp short-run disruptions to macroeconomic stability that may not be fully captured by long-horizon averages. To complement our long-run estimates, we implement a local projections (LPs) framework à la Jordà (2005) to analyze the short-run dynamic responses of fiscal and external sustainability to disaster-related mortality shocks. The LP methodology allows us to trace the impulse response functions (IRFs) of our key sustainability metrics following climate shocks, while avoiding the rigid parametric assumptions typical of distributed lag models or vector autoregressions. This is particularly important in the context of climate-related disaster shocks, where adjustment dynamics are likely to be nonlinear, heterogeneous, and sensitive to institutional or structural features. By combining the structural rigor of our long-run panel regressions with the temporal flexibility of LPs, we offer a more holistic view of how climate shocks propagate through fiscal and external channels over both the short and long term. The LP approach has been widely adopted as a flexible tool for dynamic analysis in macroeconomics (Auerbach and Gorodnichenko, 2012; Romer and Romer, 2019). It is particularly well-suited to panel settings and does not impose restrictions on the shape of IRFs, thus enabling the identification of differentiated effects across countries and income groups (Auerbach and Gorodnichenko, 2016; Ramey and Zubairy, 2018; Jordà, 2023; Jordà and Taylor, 2025). In our case, this framework enables us to assess whether countries experience changes in macroeconomic (fiscal and external) sustainability following disaster-related mortality shocks. The unconditional local projection model is estimated as:

$$sust_{i,t+h} - sust_{i,t} = \alpha_{i,h} + \delta_{t,h} + \sum_{j=0}^{2} \beta_{1jh} dclimate_{i,t-j} + \sum_{l=0}^{1} \beta_{2lh} \left(sust_{i,t-l} - sust_{i,t-1-l} \right) + \sum_{c=0}^{2} \beta'_{4ch} X_{i,t-c} + u_{i,t+h} \quad (5)$$

where $h = 1, \ldots, 8$ is the forecast horizon; $sust_{i,t}$ is the Bohn or external time-varying sustainability coefficients; α_i denotes country fixed-effects to capture unobserved heterogeneity across countries, such as time-invariant institutional and geographical variables, while δ_t are time fixed-effects to control for global shocks such as the great recession; $dclimate_{i,t}$ denotes the deaths or climate vulnerability or resilience shocks defined in terms of the first difference of the respective continuous variable. Therefore, β_{1jh} measures the conditional mean of shocks to sustainability for each forecast horizon h on $sust_{i,t+h} - sust_{i,t}$, and is used to construct the IRFs and their associated confidence intervals. When we forecast one year ahead, we have 1988 observations in the estimation sample. For each additional year-ahead forecast, we lose observations equal to the number of cross-sectional units, i, in the sample, namely 134. Given that shocks are defined in terms of first differences in disaster-related mortality or Notre Dame Global Adaptation Initiative Country Index (ND-GAIN) indices, the magnitude of these shocks can vary substantially across countries and over time. To facilitate interpretation and enable cross-country comparability, we scale the estimated impulse response functions by the cross-sectional standard deviation of the corresponding shock. This standardization transforms the responses into the effect of a one-standard-deviation increase in disaster-related mortality (or climate change vulnerability or resilience indices), allowing us to compare the dynamic impacts across countries with different levels of disaster exposure, population size, and reporting standards. This approach also helps mitigate issues related to extreme values and the skewed distribution of disaster deaths, ensuring that the estimated responses are not driven by outliers or country-specific measurement idiosyncrasies. Moreover, standardizing the shock makes the interpretation of impulse responses more transparent and policy-relevant, as it anchors the analysis around a representative, empirically grounded measure of variation in disaster intensity across the global sample.

Treatment lags are included to capture the effect that previous shocks may have on the outcome variable. We use the Akaike information criterion (AIC) to determine the lag length which tells us to use 2 lags of the treatment variable. We also include yearly lags of $\Delta \log sust_{i,t}$ to control for serial correlation in the error term, $u_{i,t+h}$. The number of lags (1) is also determined by the AIC. The data is stationary as $\left|\sum_{l=0}^{2} \beta_{l,h}\right| < 1$ in all our specifications. In fact, $\sum_{l=0}^{2} \beta_{l,h}$ is between small for all h, which means that the persistence in the estimated models is low. Therefore, the estimated IRFs from the LPs are unlikely to be severely affected by the bias that can result from a relatively short time dimension, t=44 for most of our cross-sectional units, if combined with a situation of high persistence, as shown by Herbst and Johanssen (2024). The term $\sum_{h=1}^{h} \beta_h dclimate_{i,t+h}$ captures the Teulings and Zubanov (2014) correction. Leads of the shocks are included to avoid the bias that results from overlapping forecast horizons. The leads of the shocks are statistically significant for most combinations of $sust_{i,t}$ and h, signifying the need to control for overlapping forecast horizons. $X_{i,t}$ is a vector of additional control variable containing contemporaneous and first lags of the variables identified below in the data section. In all our LPs, we use Spatial Correlation Consistent (SCC) standard errors as proposed by Driscoll and Kraay (1998). We test whether spatial dependence is present in the disturbances between the cross-sectional units when using standard errors clustered at the country level as often applied in the LP literature. For this purpose, we use the Pesaran (2015) test, which is standard normally distributed. A value of the test statistic outside the [-1.96, 1.96] interval rejects the null hypothesis of weak cross-sectional dependence in favor of cross-sectional dependence. The test is often significant.

3.2. Data and Stylized Facts

This paper relies on a panel dataset comprising annual observations from both developed and developing economies for the period 1980 to 2023, based on data availability. The empirical strategy unfolds in two stages. In the first, we compute country-specific, time-varying fiscal and external sustainability coefficients. This step uses data on government primary balances, public debt, exports, and imports, all expressed as percentages of GDP and sourced from the IMF's World Economic Outlook (WEO) database. These macroeconomic indicators provide the foundation for assessing fiscal pressures and external imbalances over time.

In the second stage, we estimate the impact of natural disasters on these sustainability coefficients using mortality as the main independent variable. Mortality data are obtained from the Emergency Events Database (EM-DAT), compiled by the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain. EM-DAT offers standardized information on more than 22,000 major disaster events worldwide from 1900 onward, covering a broad spectrum of climate-related hazards including droughts, floods, storms, and extreme temperatures. To be recorded in the database, an event must meet at least one of the following criteria: cause ten or more fatalities, affect at least one hundred people, result in a state of emergency declaration, or trigger a call for international assistance (Tselios and Tompkins, 2021). We employ the total number of disaster-related deaths – including both confirmed fatalities and missing persons – as our preferred metric of disaster severity and human impact.

To complement the disaster data and contextualize countries' structural exposure to climate risks, we incorporate indicators of vulnerability and resilience from the Notre Dame Global Adaptation Initiative (ND-GAIN). The vulnerability index captures a country's sensitivity to climate-related disruptions across six critical sectors: ecosystems, food, water, health, infrastructure, and habitat. In contrast, the resilience index reflects the degree to which a country is institutionally and economically equipped to adapt to these shocks. This measure includes components related to governance quality, social capital, and the ability to leverage investments in adaptation. Higher vulnerability indicates a greater need for adaptation efforts, while higher resilience signals stronger institutional readiness and policy capacity to respond to climate stress.

In order to isolate the effect of disaster-related mortality on sustainability outcomes, we control for several macroeconomic and institutional variables. For fiscal sustainability, we include GDP growth, the debt-to-GDP ratio, inflation, government effectiveness, and official development assistance (ODA). The GDP growth rate, drawn from the World Bank, serves as a proxy for a country's capacity to generate revenue and reduce debt burdens, with higher growth generally associated with stronger fiscal positions (Barro, 1991). The debt-to-GDP ratio, sourced from the IMF WEO, captures fiscal space and vulnerability to financing shocks. As argued by Reinhart and Rogoff (2010), high initial debt levels increase the risk of fiscal crises, especially in the wake of external shocks. Inflation, collected from the World Bank, is another key macroeconomic control, as it can erode the real value of tax revenues and heighten the cost of debt servicing, particularly where indexation mechanisms are in place. High inflation also signals broader macroeconomic instability, which can amplify the fiscal consequences of disasters (Cottarelli and Jaramillo, 2012). Governance quality, proxied by the Government Effectiveness index from the WEO, reflects a country's institutional capacity to implement fiscal policy and respond effectively to emergencies. External aid data – specifically net official development assistance (ODA) received, in current USD – come from the World Bank. These transfers often increase in the aftermath of disasters, providing temporary relief and fiscal space for affected countries, particularly in low-income contexts (Gupta et al., 2003).

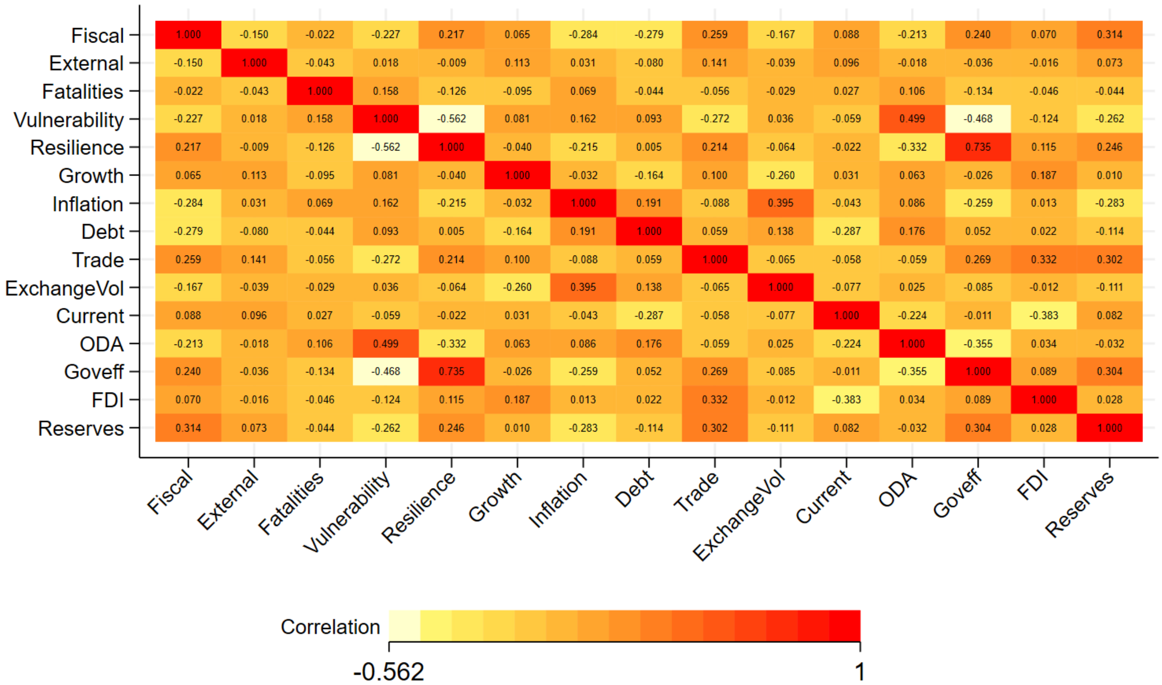
For external sustainability, we include trade openness, exchange rate volatility, the current account balance, foreign exchange reserves, and FDI inflows. Trade openness, defined as the sum of exports and imports as a share of GDP (World Bank), captures a country's exposure to global trade disruptions as well as its potential for recovery through international markets. Exchange rate volatility, which measures fluctuations in nominal exchange rates, is important for understanding the vulnerability of external accounts to financial instability. High volatility can deter foreign investment, reduce trade competitiveness, and complicate external debt service. The current account balance, as a percentage of GDP, sourced from the IMF WEO, reflects the sustainability of external financing. Countries with large pre-existing deficits may find it more difficult to absorb shocks, while those with surpluses have more external buffers (Milesi-Ferretti and Razin, 1996). Foreign exchange reserves – official holdings of international currencies by central banks – are another critical buffer, helping maintain exchange rate stability and providing liquidity during times of distress. Finally, FDI inflows, also collected from the WEO, represent external financing that can support growth, infrastructure recovery, and technology transfer in the aftermath of disasters, though they may also respond negatively to heightened risk perceptions.

The use of these controls allows us to estimate the net effect of disaster-related mortality on fiscal and external sustainability, accounting for heterogeneity in macroeconomic fundamentals, governance quality, and structural resilience. Although some variables appear in both sets of regressions, fiscal and external sustainability are governed by distinct mechanisms, requiring tailored specifications to fully capture their respective dynamics.

Table A1 presents descriptive statistics for all variables employed in the analysis. The fiscal and external sustainability coefficients used in the second-stage regressions exhibit broadly similar average values, though the external coefficient tends to be marginally higher on average and displays less dispersion, as indicated by a lower standard deviation. Among the key explanatory variables, normalized disaster-related deaths (per population) have the highest number of observations (8,526), but a low mean value of approximately 0.1, reflecting the relative infrequency of large-scale mortality events in most countries and years. Regarding structural vulnerability and resilience, the average normalized Vulnerability index slightly exceeds that of Resilience, suggesting that, on average, countries in the sample are more exposed to climate risks than they are institutionally or economically prepared to respond to them. However, the standard deviation of Vulnerability is smaller, implying less cross-country variability relative to Resilience, which exhibits greater heterogeneity across countries. The control variables show summary statistics consistent with prior literature. One notable outlier is observed in the inflation data: the maximum value corresponds to an extreme inflation episode in the Democratic Republic of the Congo in 1994. This value stands out significantly in the distribution and underscores the importance of accounting for extreme macroeconomic volatility in the estimation framework.

Figure 1 displays the correlation matrix of key variables using a heatmap representation. The strongest positive correlation is found between Governmental Efficiency and Resilience (0.735), underscoring the close association between institutional quality and a country's adaptive capacity. The second most notable correlation is a negative one between Resilience and Vulnerability (-0.562), reflecting the conceptual and empirical tension between a country's exposure to climate risks and its readiness to address them – higher resilience tends to accompany lower vulnerability. The sustainability coefficients – both fiscal and external – are negatively correlated with the normalized number of disaster-related deaths, although the magnitudes of these correlations are modest. This pattern suggests that higher disaster mortality is associated with a weakening of macroeconomic sustainability, but the strength of the relationship is relatively limited in the unconditional correlations, justifying the need for more nuanced multivariate analysis.

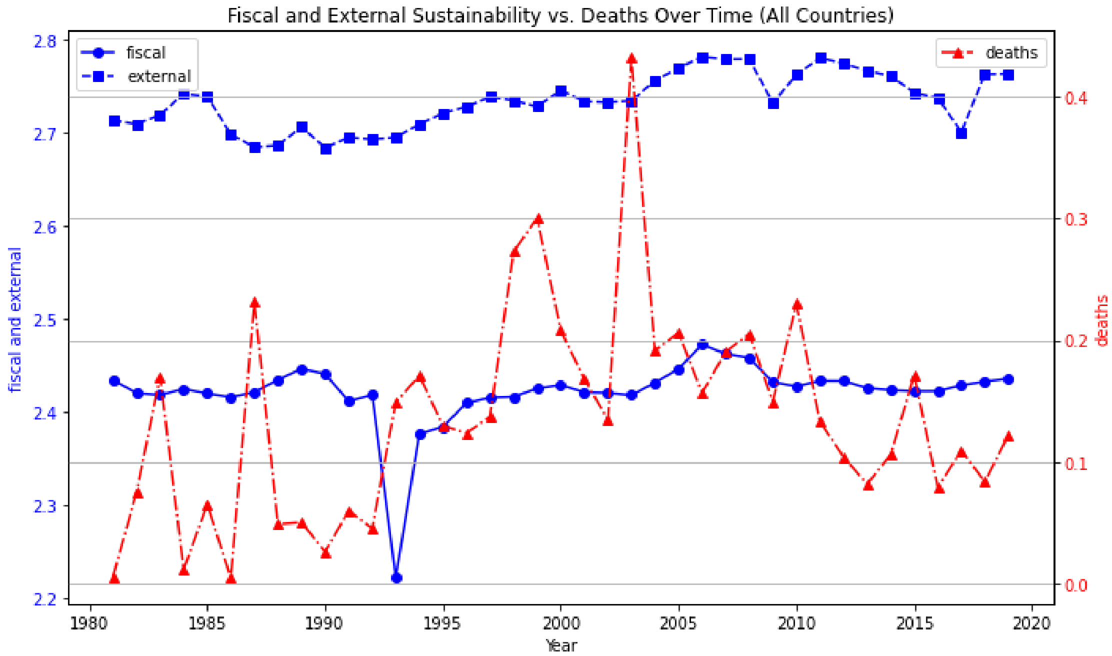
Figure 1: Correlation Map



Notes: Heatmap of Correlations (all sample) Notes: This figure reports the correlation coefficients between the variables used in this paper. A warmer colour means a correlation that is closer to 1 (red) and a lighter one is closer to 1 (light yellow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Source: Authors' own computations.

Fiscal and external sustainability are particularly susceptible to the adverse effects of natural disasters, often leading to pronounced imbalances in public finances and external accounts. Figure 2 illustrates the temporal evolution of the computed fiscal and external sustainability coefficients alongside the incidence of natural disaster-related fatalities. A discernible pattern emerges, particularly during the mid-1980s and mid-1990s, when spikes in fatalities coincide with notable declines in the fiscal sustainability coefficient. This trend likely reflects the fiscal pressures induced by disasters – stemming from increased public spending on relief and reconstruction, coupled with revenue losses due to economic disruption. Although this relationship becomes less prominent in more recent years, the early 2000s still reveal a marked deterioration in fiscal sustainability following a surge in disaster-related mortality. In contrast, the external sustainability coefficient follows a smoother trajectory over time, though it remains responsive to periods of intensified disaster activity. Notable deviations are observed during episodes of elevated fatalities, particularly prior to the mid-2000s. These patterns suggest that external sustainability is also adversely affected by disasters, albeit potentially buffered by factors such as international financial assistance, shifts in trade balances, or exchange rate adjustments.

Figure 2: Fiscal and External Sustainability vs Fatalities, over time

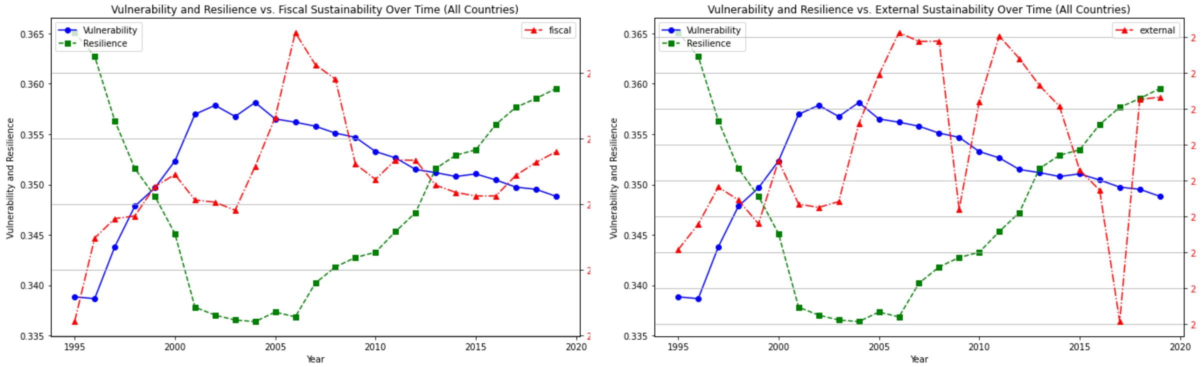


Notes: This figure display the Fiscal (blue) and External (blue) Sustainability average per year measured on the left y-axis and the fatalities (red) measured in the right y-axis. Each line represents one of these variables. Source: Authors' own computations.

To shed further light on these dynamics, Figure 3 presents two panels that plot sustainability coefficients alongside measures of climate vulnerability and resilience. In both panels, an inverse relationship between vulnerability and resilience is evident: as one increases, the other tends to decline. Resilience experienced a marked decline until the mid-2000s, after which it began to recover, while vulnerability trended upward during the same period before gradually falling through 2020. When these patterns are compared with the sustainability coefficients, a nuanced picture emerges. Public account sustainability (Panel A) showed moderate growth with intermittent fluctuations until the mid-2000s, followed by a sharp decline during the 2008 financial crisis and a prolonged period of stagnation throughout the 2010s. In contrast, external account sustainability (Panel B) exhibited greater volatility: it peaked in the mid-2000s, dropped sharply during the global crisis, rebounded to previous highs, and then fell significantly again in the late 2010s, before recovering in more recent years. These patterns highlight the complex interplay between fiscal and external sustainability and broader macroeconomic shocks.

Figure 3: Fiscal and External Sustainability vs Vulnerability and Resilience, over time

Panel A: Fiscal Sustainability ***Panel B: External Sustainability***



Notes: This figure display the Vulnerability (blue), and Resilience (green) measured in the left y-axis and the Fiscal (Panel A) and External (panel B) Sustainability average per year measured on the right y-axis. Each line represents one of these variables.

Source: Authors' own computations.

Figure 4: Fiscal and External Sustainability vs External Support, over time

Panel A: Fiscal Sustainability ***Panel B: External Sustainability***

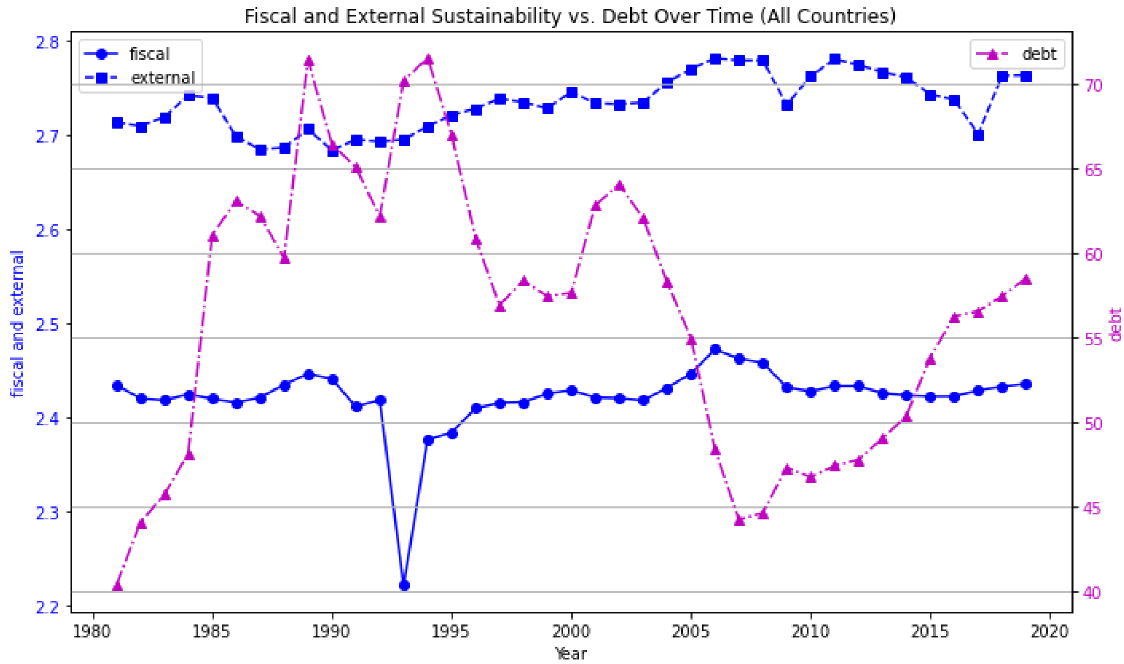
Notes: This figure display in Panel A the fiscal sustainability coefficient (in orange) and the ODA (in green), while in Panel B, we display External Sustainability (light blue) and FDI (Purple) average per year. Each line represents one of these variables.

Source: Authors' own computations.

In the aftermath of severe disasters, countries frequently turn to external support to stabilize their economies. Figure 4 depicts the evolution of Official Development Assistance (ODA) in Panel A and Foreign Direct Investment (FDI) in Panel B, each considered in relation to fiscal and external sustainability, respectively. Strikingly, both forms of external support display trajectories that closely align with those of the sustainability indicators. This alignment suggests that external financial inflows play a pivotal role in cushioning the economic fallout from natural disasters and facilitating the recovery of fiscal and external balances. The observed synchronicity between external support and sustainability underscores the critical role of international cooperation and financial instruments in bolstering economic resilience in the face of climate-related shocks.

The 2008 collapse of the U.S. housing market and the bankruptcy of Lehman Brothers on September 15 triggered a global financial crisis (GFC), plunging economies into recession and straining sovereign debt levels. As demand contracted and credit markets froze, fiscal and external sustainability came under significant pressure. Figure 5 tracks the evolution of the debt-to-GDP ratio alongside public and external sustainability indicators. Debt levels rose sharply during key stress periods – the mid-1980s, mid-1990s, early 2000s, and notably during the 2008 GFC – driven by fiscal stimulus, financial instability, and crisis-related government spending.

Figure 5: Sustainability and Governmental Debt, over time

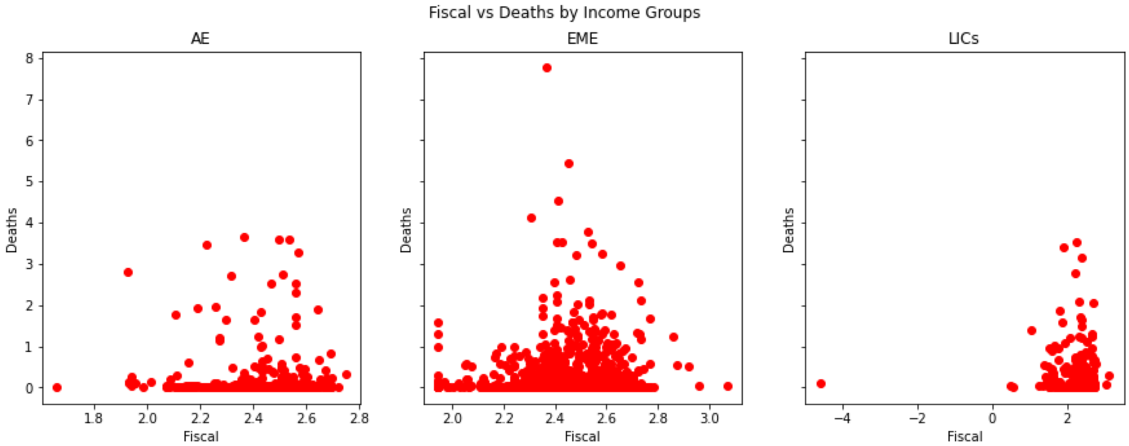


Notes: This figure display the Fiscal (blue) and External (blue) Sustainability average per year measured on the left y-axis and the debt over GDP ratio (purple) measured in the right y-axis. Each line represents one of these variables.
Source: Authors' own computations.

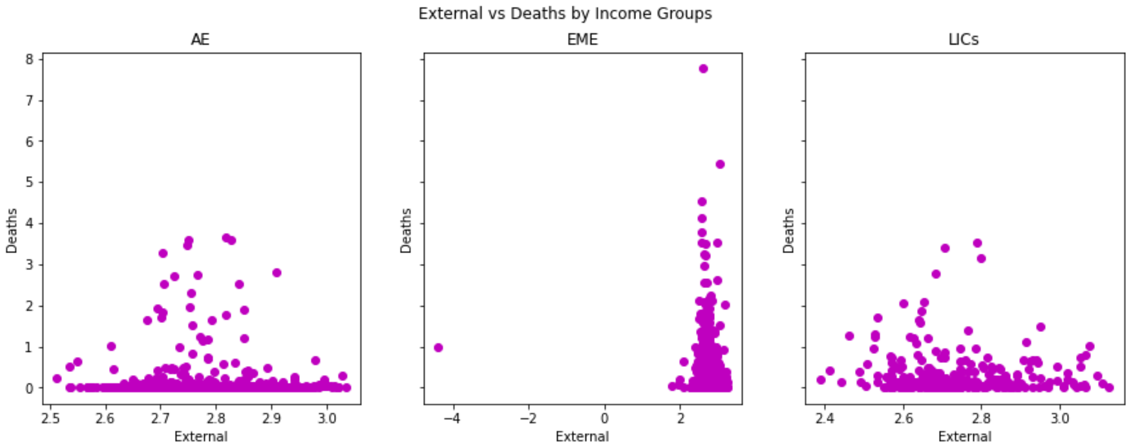
Fiscal sustainability generally declined during these periods of rising debt, reflecting the difficulty of maintaining balanced budgets under growing fiscal pressure. External sustainability, meanwhile, was more volatile, especially during the 1980s and 1990s, amid currency instability and shifting trade balances. Beyond financial crises, natural disasters also contributed to fiscal strain. The rising costs of disaster-related damages and fatalities increased public spending needs, pushing many countries to seek external assistance – from institutions like the IMF and the World Bank – to restore fiscal and external balances.

Figure 6: Sustainability and Fatalities, over Income Groups

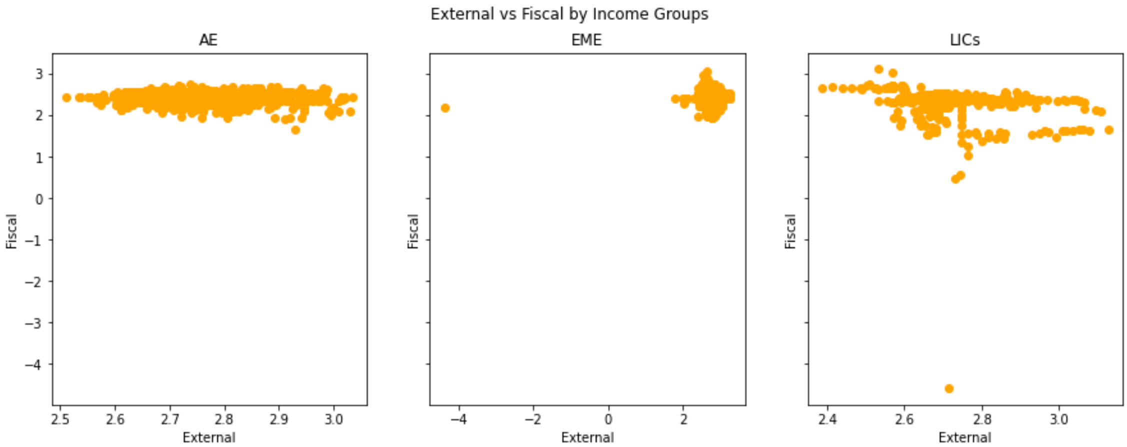
Panel A: Fiscal Sustainability and Fatalities



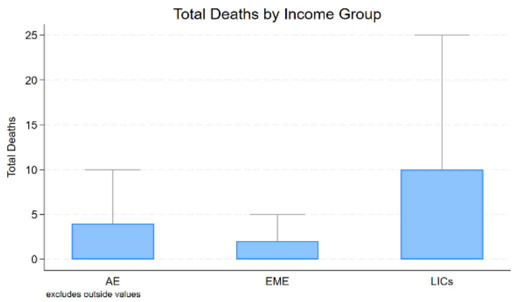
Panel B: External Sustainability and Fatalities



Panel C: Fiscal vs External Sustainability



Panel D: Fatalities



Notes: This figure display the Fiscal (Panel A) and External (Panel B) Sustainability average per year against Fatalities, in Panel C we report a scatter plot with both sustainability coefficients and Panel D presents a box plot of the total fatalities, all graphs subdivided by income groups (AE – Advance Economies, EME – Emerging markets, and LIC's – Low-income countries. Each point represents a country average value.
Source: Authors' own computations.

The dynamics of fiscal and external sustainability vary notably across countries, influenced by income levels and vulnerability to natural disasters. Figure 6 presents a breakdown by income group: Advanced Economies (AEs), Emerging Markets (EMEs), and Low-Income Countries (LICs). Panel A shows that most AEs and EMEs exhibit fiscal sustainability coefficients (log scale) between 2 and 3, though EMEs display a wide dispersion in disaster-related fatalities, including several extreme cases. In contrast, LICs cluster around a sustainability value of 2, with fatalities generally concentrated between 0 and 4. Panel B focuses on external sustainability, revealing that while AEs and LICs show broader variation, EMEs have more concentrated coefficients between 2 and 3. However, EMEs also face a high incidence of extreme fatality events, underscoring their vulnerability despite relatively stable external positions. Panel C examines the relationship between fiscal and external sustainability, broadly supporting the twin deficits hypothesis – higher fiscal sustainability tends to coincide with higher external sustainability. AEs report the highest and most consistent values, EMEs follow similar patterns with some volatility, and LICs show greater variability in fiscal sustainability but more stable external metrics. Finally, Panel D underscores the disproportionate human toll in LICs, where fatalities from natural disasters are highest. The box plot reveals wide dispersions and numerous outliers, highlighting the urgent need for resilience-enhancing policies and international support to mitigate the fiscal and external consequences of such events.

4. Empirical Analysis

In terms of our empirical analysis, we start by presenting the baseline WLS-FE model for Fiscal and External Sustainability. Secondly, we analyse how an occurrence could impact the sustainability of both accounts by levels of Income and Regions. Further, on Subsection 4.2, we assess how sustainability reacts in the short term when a natural disaster occurs.

4.1. Long-run Results

Table 1 presents the results of a series of weighted least squares (WLS) regressions examining the impact of natural disaster mortality and structural vulnerability on fiscal sustainability. All models apply weights equal to the inverse of the squared standard error of the estimated fiscal sustainability coefficient, thereby giving greater influence to observations with more precise estimates. We incorporate time and country fixed effects in our regressions to control for unobserved heterogeneity and ensure the robustness of our results.

The first set of regressions (columns 1–4) presents WLS models without fixed effects, while the second set (columns 5–8) introduces both country and time fixed effects, allowing for a cleaner identification of within-country, over-time effects of the explanatory variables on fiscal sustainability. Across both sets of models, the coefficient on disaster mortality is consistently negative. In the non-fixed effects regressions, the estimates are negative but statistically insignificant, suggesting that in a pooled cross-country setting, higher disaster-related mortality is weakly associated with lower fiscal sustainability. However, once country and time fixed effects are included (columns 5–8), the estimates remain negative and become statistically significant at the 10% and 1% level in the most complete specifications (columns 7 and 8). This shift in significance and robustness indicates that controlling for time-invariant country characteristics and common global shocks reveals a clearer link between disaster intensity and fiscal stress – likely due to the fiscal costs of reconstruction, social support, and disrupted revenues in the wake of disasters. Structural vulnerability also shows a stark contrast between specifications. In the regressions without fixed effects (columns 1–4), the coefficient is negative and statistically significant, consistent with the notion that countries structurally exposed to natural hazards tend to experience weaker fiscal sustainability. However, in the fixed effects models (columns 5–8), the coefficient turns positive and significant. This reversal likely reflects the role of persistent country-level differences – such as institutional capacity, governance, or development status – that correlate with both vulnerability and fiscal behavior. Once these fixed effects are included, the estimates suggest that within-country increases in vulnerability over time may be associated with stronger fiscal responses, possibly driven by policy responses and adaptation, external conditionality, or increased awareness of fiscal risks.

Other covariates behave largely as expected. Economic growth shows positive and sometimes significant effects in the models without fixed effects but loses significance under fixed effects. Debt remains consistently negative and significant in both sets of regressions, reaffirming its role as a drag on fiscal sustainability. ODA received is strongly negative and statistically significant in both model sets, suggesting that higher aid dependence may weaken a country's fiscal responsiveness, possibly due to substitution effects or softened adjustment incentives. Government effectiveness is significant in the full specifications.

Taken together, the comparison between pooled and fixed-effects WLS regressions demonstrates the importance of accounting for unobserved country-specific and time-specific heterogeneity. The fixed effects models provide stronger support for the interpretation that natural disaster intensity weakens fiscal sustainability, while the role of vulnerability appears more complex and context dependent. These findings highlight the fiscal risks associated with climate-related shocks and the importance of institutional and policy adaptation to build long-term resilience.

Table 1.a Fiscal Sustainability and Disasters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deaths	-0.0168	-0.0151	-0.0256	-0.0131	-0.0014	-0.0052	-0.0043*	-0.0085***
	(0.021)	(0.022)	(0.022)	(0.023)	(0.003)	(0.003)	(0.003)	(0.003)
Vulnerability	-10.8078***	-9.4096***	-11.2677***	-7.4707***	2.3335***	3.8697***	2.5925***	4.3724***
	(0.309)	(0.499)	(0.577)	(0.662)	(0.556)	(0.700)	(0.538)	(0.656)
Growth	0.2416***	0.3038***	0.1771***	0.3031***	-0.0045	0.0031	-0.0047	-0.0001
	(0.061)	(0.062)	(0.065)	(0.064)	(0.009)	(0.011)	(0.008)	(0.009)
Inflation	0.0066***	0.0008	0.0066***	0.0020	-0.0008***	-0.0006**	-0.0005***	-0.0004*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Debt	-0.0026***	-0.0022***	-0.0026***	-0.0021***	-0.0002***	-0.0001***	-0.0001***	-0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ODA		-0.0311***		-0.0296***		-0.0021***		-0.0023***
		(0.001)		(0.001)		(0.000)		(0.000)
GovEff			0.0158	0.3652***			0.0123	0.0402***
			(0.044)	(0.053)			(0.012)	(0.014)
Obs.	2,765	1,947	2,429	1,729	2,765	1,947	2,429	1,729
R-squared	0.4424	0.5790	0.4609	0.5967	0.9931	0.9933	0.9950	0.9953
Country effects	No	No	No	No	Yes	Yes	Yes	Yes
Time Effects	No	No	No	No	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the fiscal sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the vulnerability index, the logarithm of the GDP growth rate, the inflation rate, the debt over GDP rate, the logarithm of the external grants and aid inflow, and the government effectiveness index.

Building on the prior analysis, Table 1b presents the same WLS regressions but substitutes the ND-GAIN Vulnerability Index with the Resilience Index, capturing a country's capacity to anticipate, absorb, and adapt to climate-related shocks. This change shifts the interpretation from structural exposure to adaptive capacity, offering a complementary perspective on how climate-related risk factors influence fiscal sustainability.

Several key differences emerge. First, while the direction of the disaster mortality effect remains negative across specifications – consistent with earlier findings – its magnitude is larger and more precisely estimated in the simpler models (e.g., columns 1 and 2), though again only statistically significant in the most saturated fixed effects specification (column 8). This consistency reinforces the idea that natural disasters systematically weaken fiscal sustainability, particularly when adaptive responses are constrained. Second, replacing vulnerability with resilience reverses the sign of the structural variable. Whereas vulnerability was negatively associated with fiscal sustainability in the pooled models, resilience exhibits a positive for the first two regressions without fixed effects, and a negative statistically significant for the other specifications. This flip is intuitive: higher resilience levels are associated with stronger fiscal outcomes across countries, but within-country declines in resilience over time – such as through institutional erosion or infrastructure degradation – appear to weaken fiscal sustainability. In essence, resilience acts as a buffer, and its erosion makes countries more fiscally fragile in the face of shocks. This contrast highlights an important economic distinction: vulnerability captures static exposure, while resilience reflects dynamic capacity. The fixed effects estimates suggest that it is not only being vulnerable that matters — it is the inability to respond that poses fiscal risk. These findings point to the importance of investing in long-run institutional and adaptive capacity as a means of promoting fiscal sustainability under increasing climate stress.

Table 1.b Fiscal Sustainability and Disasters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deaths	-0.1005***	-0.0699***	-0.0268	-0.0024	0.0026	-0.0021	-0.0014	-0.0063*
	(0.024)	(0.023)	(0.024)	(0.023)	(0.003)	(0.004)	(0.003)	(0.003)
Resilience	5.8044***	1.5727***	-1.6302***	-3.9951***	-0.5177***	-0.4913***	-0.3818***	-0.3930***
	(0.289)	(0.520)	(0.532)	(0.602)	(0.081)	(0.097)	(0.074)	(0.087)
Growth	0.0633	0.2204***	0.1671**	0.3507***	-0.0015	0.0041	-0.0029	0.0000
	(0.068)	(0.067)	(0.069)	(0.066)	(0.009)	(0.011)	(0.008)	(0.010)
Inflation	0.0070***	0.0001	0.0068***	0.0008	-0.0007***	-0.0005**	-0.0004**	-0.0002
	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Debt	-0.0040***	-0.0029***	-0.0028***	-0.0018***	-0.0002***	-0.0002***	-0.0001***	-0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ODA		-0.0396***		-0.0371***		-0.0022***		-0.0024***
		(0.001)		(0.001)		(0.000)		(0.000)
GovEff			0.8481***	0.8880***			0.0126	0.0374***
			(0.049)	(0.051)			(0.012)	(0.014)
Obs.	2,778	1,960	2,442	1,742	2,778	1,960	2,442	1,742
R-squared	0.2974	0.5043	0.3784	0.5775	0.9931	0.9933	0.9950	0.9952
Country effects	No	No	No	No	Yes	Yes	Yes	Yes
Time Effects	No	No	No	No	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the fiscal sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the resilience index, the logarithm of the GDP growth rate, the inflation rate, the debt over GDP rate, the logarithm of the external grants and aid inflow, and the government effectiveness index.

Next, we evaluate the relationship between disaster-related mortality and the sustainability of external accounts. Tables 2a and 2b present this analysis, where we estimate the coefficients using Weighted Least Squares (WLS) regressions, both with and without fixed effects. The key distinction between Table 2a and Table 2b lies in the inclusion of vulnerability and resilience indexes in the latter.

Our findings indicate that disaster mortality adversely affects the sustainability of external accounts. This effect is particularly evident in columns (7) and (8) of Table 2a, where we employ the full specification models, incorporating fixed effects. These results emphasize the significant role of disaster-induced mortality in deteriorating external account sustainability, likely due to its negative repercussions on economic activity, investment, and trade.

Table 2.a External Sustainability and Disasters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deaths	0.0030	0.0030	0.0015	0.0012	-0.0010	-0.0007	-0.0057**	-0.0053*
	(0.006)	(0.006)	(0.006)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)
Vulnerability	-0.2779***	-0.2847***	-0.0274	-0.0328	-0.1374	0.0182	0.0261	0.1827
	(0.052)	(0.052)	(0.057)	(0.058)	(0.209)	(0.220)	(0.214)	(0.225)
Openness	0.0006***	0.0006***	0.0006***	0.0007***	0.0024***	0.0024***	0.0023***	0.0023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ExchVol	0.0177	0.0172	0.0102	0.0100	0.0073	0.0080	0.0090*	0.0097*
	(0.013)	(0.013)	(0.013)	(0.013)	(0.005)	(0.006)	(0.005)	(0.006)
Current	-0.0009***	-0.0009***	-0.0010***	-0.0010***	-0.0005***	-0.0005***	-0.0005***	-0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FDI		-0.0002		-0.0002		-0.0001		-0.0000
		(0.000)		(0.000)		(0.000)		(0.000)
Reserves			-0.0109***	-0.0111***			0.0115***	0.0111***
			(0.004)	(0.004)			(0.003)	(0.003)
Obs.	2,715	2,698	2,546	2,529	2,715	2,698	2,546	2,529
R-squared	0.1190	0.1202	0.1157	0.1162	0.8687	0.8693	0.8678	0.8686
Country effects	No	No	No	No	Yes	Yes	Yes	Yes
Time Effects	No	No	No	No	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the external sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the vulnerability index, the trade openness indicator, the current account balance as a percentage of GDP, the logarithm of the Foreign exchange reserves as percentage of GDP, and the Foreign Direct Investment inflow as a percentage of GDP.

Table 2.b External Sustainability and Disasters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Deaths	0.0052	0.0053	0.0020	0.0018	-0.0018	-0.0015	-0.0059**	-0.0057**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.002)	(0.003)	(0.003)	(0.003)
Resilience	0.0508	0.0559	0.0479	0.0515	0.2164***	0.2083***	0.1960***	0.1891***
	(0.040)	(0.041)	(0.039)	(0.039)	(0.054)	(0.054)	(0.057)	(0.058)
Openness	0.0006***	0.0006***	0.0006***	0.0006***	0.0024***	0.0024***	0.0023***	0.0023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ExchVol	0.0152	0.0146	0.0109	0.0107	0.0070	0.0078	0.0087	0.0096*
	(0.014)	(0.014)	(0.013)	(0.013)	(0.005)	(0.005)	(0.005)	(0.006)
Current	-0.0010***	-0.0010***	-0.0010***	-0.0010***	-0.0005***	-0.0005***	-0.0005***	-0.0005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FDI		-0.0000		-0.0002		-0.0001		-0.0001
		(0.000)		(0.000)		(0.000)		(0.000)
Reserves			-0.0106***	-0.0108***			0.0119***	0.0115***
			(0.004)	(0.004)			(0.003)	(0.003)
Obs.	2,752	2,724	2,546	2,529	2,752	2,724	2,546	2,529
R-squared	0.0944	0.0948	0.1161	0.1167	0.8803	0.8809	0.8685	0.8691
Country effects	No	No	No	No	Yes	Yes	Yes	Yes
Time Effects	No	No	No	No	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the external sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the resilience index, the trade openness indicator, the current account balance as a percentage of GDP, the logarithm of the Foreign exchange reserves as percentage of GDP, and the Foreign Direct Investment inflow as a percentage of GDP.

Furthermore, the vulnerability index exhibits a negative and highly statistically significant coefficient in the models without fixed effects (columns 1 and 2). This suggests that greater vulnerability to disasters exacerbates external account instability, potentially by increasing financial risk and reducing investor confidence. Additionally, exchange rate volatility enters with a positive and statistically significant coefficient in the full fixed effects models, suggesting that greater fluctuations in exchange rates are associated with improved external account sustainability. This counterintuitive result may reflect the role of exchange rate flexibility as a shock absorber: in countries with more volatile but flexible exchange rate regimes, external imbalances may adjust more efficiently through relative price movements, supporting a more sustainable trade balance over time.

Trade openness, on the other hand, is consistently positive and highly statistically significant across all models, suggesting that higher levels of trade integration contribute positively to the sustainability of external accounts. Foreign Direct Investment (FDI), although negative, does not reach statistical significance, implying that its effect may be more nuanced or context dependent. On the other hand, international reserves display a contrasting effect: they are negative in models without fixed effects but positive when fixed effects are included, highlighting potential differences in short-term versus long-term dynamics.

A similar pattern emerges in Table 2b, where disaster-related mortality negatively impacts external balances in the full fixed effects models (columns 7 and 8). Additionally, resilience is positively associated with external accounts in the fixed effects models, reinforcing the idea that greater resilience to disasters mitigates their adverse economic impact.

Overall, the results from both tables align, reinforcing the conclusion that disaster mortality undermines external account sustainability, while resilience and trade openness play stabilizing roles. These findings emphasize the importance of strengthening economic resilience and disaster preparedness to mitigate financial vulnerabilities.

To gain a clearer understanding of the impact of disaster-related mortality on sustainability, we analyze how different income groups are affected by these challenges. Tables 3a and 3b present this analysis, categorizing countries into Low-Income Countries (LICs), Emerging Markets (EME), and Advanced Economies (AE). Table 3a focuses on fiscal sustainability, while Table 3b examines external sustainability.

Table 3a. Fiscal Sustainability Impact by Income Groups

	LICs	LICs	EME	EME	AE	AE
Deaths	-0.0121	-0.0114	-0.0085***	-0.0063*	0.0000	0.0000
	(0.011)	(0.011)	(0.003)	(0.003)	(0.000)	(0.000)
Vulnerability	-0.6066		4.3714***		0.3701	
	(2.106)		(0.657)		(0.000)	
Resilience		-0.1297		-0.3929***		-0.3676
		(0.368)		(0.087)		(0.000)
Growth	-0.0137	-0.0104	-0.0001	0.0000	-0.2276	-0.1652
	(0.025)	(0.026)	(0.009)	(0.010)	(0.000)	(0.000)
Inflation	-0.0016**	-0.0016**	-0.0004*	-0.0002	-0.0607	-0.0505
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Debt	0.0000	0.0000	-0.0001***	-0.0002***	-0.0109	-0.0099
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ODA	-0.0028***	-0.0028***	-0.0023***	-0.0024***	0.6196	0.4869
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
GovEff	0.0485	0.0575	0.0402***	0.0374***	0.0238	0.0886
	(0.042)	(0.045)	(0.014)	(0.014)	(0.000)	(0.000)
Obs.	296	296	1,722	1,735	650	650
R-squared	0.9946	0.9946	0.9953	0.9952	0.8054	0.8151
Country effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the fiscal sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the vulnerability or resilience index, the logarithm of the GDP growth rate, the inflation rate, the debt over GDP rate, the logarithm of the external grants and aid inflow, and the government effectiveness index. The Income groups are: Low Income Countries (LIC's), Emerging markets (EME), and Advance Economies (AE).

In Table 3a, we observe that disaster-related mortality has a statistically significant negative impact on fiscal sustainability only in emerging economies, whereas there are no significant effects for low-income or advanced economies. This finding suggests that emerging markets, which often have weaker institutional frameworks and less fiscal flexibility, may struggle to absorb the economic shocks caused by disasters. The vulnerability index is positively associated with fiscal sustainability in emerging markets, while the resilience index has a negative coefficient. This may indicate that, although vulnerable economies require more fiscal adjustments, increased resilience does not necessarily translate into stronger fiscal positions, possibly due to the high costs associated with resilience-building measures. Interestingly, external aid exhibits a negative effect, implying that while aid inflows may provide short-term relief, they might not effectively support long-term fiscal stability.

Table 3b presents similar results for external account sustainability. Disaster-related mortality negatively affects external balances in emerging markets, as observed previously, but also in low-income countries. This suggests that both income groups experience heightened financial instability following disasters, likely due to increased borrowing needs, reduced exports, or capital flight. Additionally, the vulnerability coefficient is negative when statistically significant, reinforcing the notion that more vulnerable economies struggle to maintain external sustainability. Conversely, the resilience index is positively associated with external accounts in these two income groups, indicating that higher resilience may help mitigate the adverse effects of disasters on financial stability.

Table 3b. External Sustainability Impact by Income Groups

	LICs	LICs	EME	EME	AE	AE
Deaths	-0.0178*	-0.0051	-0.0065*	-0.0066**	-0.0021	-0.0022
	(0.010)	(0.010)	(0.003)	(0.003)	(0.004)	(0.004)
Vulnerability	-3.4851***		-0.2944		0.4574	
	(0.734)		(0.270)		(0.348)	
Resilience		0.6844*		0.1707**		0.0451
		(0.352)		(0.069)		(0.106)
Openness	0.0018***	0.0024***	0.0025***	0.0025***	0.0016***	0.0016***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
ExchVol	0.0862**	0.0823*	0.0282**	0.0283**	0.0026	0.0027
	(0.040)	(0.043)	(0.012)	(0.012)	(0.003)	(0.003)
Current	0.0007	0.0020**	-0.0005***	-0.0005***	0.0052***	0.0051***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
FDI	0.0005	0.0012	-0.0023***	-0.0023***	-0.0000	-0.0000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Reserves	0.0479***	0.0404***	0.0151***	0.0150***	0.0161***	0.0162***
	(0.008)	(0.009)	(0.004)	(0.004)	(0.003)	(0.003)
Observations	161	161	1,869	1,869	660	660
R-squared	0.9131	0.9001	0.8739	0.8742	0.8854	0.8851
Country effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the external sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the vulnerability or resilience index, the trade openness indicator, the current account balance as a percentage of GDP, the logarithm of the Foreign exchange reserves as percentage of GDP, and the Foreign Direct Investment inflow as a percentage of GDP. The Income groups are: Low Income Countries (LIC's), Emerging markets (EME), and Advance Economies (AE).

A notable finding is that Foreign Direct Investment (FDI) is negatively associated with external sustainability in emerging markets. This could reflect investor concerns regarding post-disaster economic recovery, leading to reduced capital inflows. Overall, these results highlight the disproportionate impact of disaster mortality on emerging and low-income economies and emphasize the need for targeted policy responses to enhance resilience and financial stability.

Lastly, we examine the regional heterogeneity in how disaster-related mortality affects fiscal and external accounts. Table 4a presents results for fiscal outcomes, while Table 4b focuses on external balances. In Table 4a, the Europe and Central Asia (ECA) region exhibits a negative response in public accounts to disaster-related mortality, indicating fiscal stress likely driven by increased recovery spending. By contrast, Latin America and the Caribbean (LAC) show a positive fiscal response, possibly reflecting the role of external inflows – such as remittances or international aid – that cushion budgetary pressures. Vulnerability has a positive association with public accounts in South Asia (SAR), Sub-Saharan Africa (SSA), ECA, LAC, and East Asia and the Pacific (EAP), suggesting that in disaster-prone settings, governments may respond with temporary fiscal adjustments that stabilize public finances. However, resilience shows a negative relationship in LAC and EAP. This unexpected result may reflect the upfront fiscal costs of resilience-building measures, which, in the short term, can outweigh their stabilizing benefits. Turning to external accounts in Table 4b, we find that SAR, LAC, and EAP experience deterioration following disaster-related mortality – likely a result of capital flight, trade disruptions, or increased reliance on external borrowing. Vulnerability is positively associated with external sustainability in SAR, indicating compensatory mechanisms at play, but negatively associated in MENA and LAC, where greater vulnerability may intensify financial fragility. Resilience, on the other hand, is positively linked to external sustainability in SAR, SSA, ECA, and EAP, suggesting that resilient institutional and macroeconomic frameworks help mitigate post-disaster external pressures. In LAC, however, resilience is negatively associated, possibly due to the fiscal and external burden of financing adaptation and mitigation policies without corresponding gains in stability.

In sum, these findings underscore significant regional variation of natural disasters regarding the consequences for fiscal and external sustainability. They highlight the need for tailored policy strategies that consider regional institutional capacity, vulnerability profiles, and financing constraints to strengthen both short-term responsiveness and long-term sustainability.

Table 4a. Fiscal Sustainability by regions

	SAR	SAR	SSA	SSA	ECA	ECA	MNA	MNA	LAC	LAC	EAP	EAP
Deaths	0.0119	0.0041	-0.0067	-0.0052	-0.0272*	-0.0289*	-0.0044	-0.0053	0.0251***	0.0213***	0.0015	0.0008
	(0.008)	(0.009)	(0.008)	(0.008)	(0.015)	(0.016)	(0.012)	(0.012)	(0.006)	(0.006)	(0.003)	(0.003)
Vulnerability	2.9950***		2.4604*		3.7698***		-0.2170		3.0139***		3.0260***	
	(0.712)		(1.318)		(0.873)		(0.360)		(0.640)		(0.709)	
Resilience		0.0320		-0.4376*		-0.1702		0.1839		-1.0027***		-0.1707**
		(0.169)		(0.257)		(0.188)		(0.146)		(0.161)		(0.068)
Growth	0.0204	0.0147	-0.0067	-0.0033	-0.0207	-0.0241	0.0186	0.0212*	0.1610***	0.1747***	-0.0027	-0.0053
	(0.028)	(0.032)	(0.018)	(0.018)	(0.023)	(0.024)	(0.012)	(0.012)	(0.028)	(0.027)	(0.028)	(0.028)
Inflation	-0.0017	-0.0017	-0.0011***	-0.0011***	-0.0003	-0.0000	0.0000	0.0000	-0.0025***	-0.0024***	0.0004	0.0005**
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Debt	-0.0013***	-0.0013***	-0.0000	-0.0000	-0.0008***	-0.0010***	-0.0001	-0.0002*	0.0006***	0.0008***	-0.0001	-0.0002*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ODA	-0.0045***	-0.0059***	-0.0024***	-0.0024***	-0.0099***	-0.0098***	0.0007	0.0008	-0.0122***	-0.0081***	-0.0028**	-0.0011
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
GovEff	-0.0568*	-0.0274	0.0927***	0.1070***	-0.0349*	0.0013	0.0098	0.0041	-0.0345*	-0.0061	-0.0073	-0.0105
	(0.029)	(0.031)	(0.029)	(0.031)	(0.018)	(0.022)	(0.011)	(0.011)	(0.019)	(0.020)	(0.012)	(0.012)
Observations	107	107	595	595	236	236	176	176	368	368	240	253
R-squared	0.9964	0.9955	0.9945	0.9945	0.9490	0.9444	0.9577	0.9581	0.8797	0.8853	0.9969	0.9967
Country effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the fiscal sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the vulnerability or resilience index, the logarithm of the GDP growth rate, the inflation rate, the debt over GDP rate, the logarithm of the external grants and aid inflow, and the government effectiveness index. SAR stands for South Asia Region, SSA represents Sub-Saharan Africa, ECA is Europe and Central Asia, MNA denotes Middle East and North Africa, LAC means Latin America and the Caribbean, and EAP signifies East Asia and Pacific.

Table 4b. External Sustainability by regions

	SAR	*SAR*	*SSA*	*SSA*	*ECA*	*ECA*	*MNA*	*MNA*	*LAC*	*LAC*	*EAP*	*EAP*
Deaths	-0.0107	-0.0230*	0.0019	-0.0001	0.0049	-0.0016	-0.0159	-0.0225	-0.0094***	-0.0098***	-0.0154*	-0.0165**
	(0.011)	(0.014)	(0.008)	(0.007)	(0.014)	(0.014)	(0.018)	(0.020)	(0.003)	(0.003)	(0.008)	(0.008)
Vulnerability	5.5063***		0.4131		0.4945		-3.6810***		-0.9137*		0.0538	
	(0.989)		(0.601)		(0.692)		(0.625)		(0.547)		(0.555)	
Resilience		0.2755**		0.6034**		0.7643***		0.0511		-0.4952***		0.4339***
		(0.137)		(0.259)		(0.161)		(0.221)		(0.138)		(0.139)
Openness	0.0070***	0.0089***	0.0027***	0.0028***	0.0032***	0.0033***	0.0016***	0.0020***	0.0046***	0.0045***	0.0012***	0.0012***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ExchVol	0.4286**	0.2655	0.0371	0.0498	0.0491	0.0179	0.0024	0.0170	0.0081	0.0070	0.0257	0.0223
	(0.161)	(0.191)	(0.039)	(0.039)	(0.034)	(0.033)	(0.058)	(0.063)	(0.010)	(0.010)	(0.046)	(0.045)
Current	0.0029***	0.0039***	0.0021***	0.0022***	0.0057***	0.0058***	0.0027***	0.0027***	0.0091***	0.0087***	-0.0006***	-0.0005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
FDI	-0.0196***	-0.0211***	0.0013	0.0012	-0.0004	-0.0010	-0.0008	-0.0007	0.0030**	0.0027**	-0.0013*	-0.0010
	(0.006)	(0.007)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Reserves	0.0610**	0.0457	0.0041	0.0035	0.0263**	0.0191	0.0194*	0.0306***	-0.0134*	-0.0126*	0.0696***	0.0630***
	(0.024)	(0.029)	(0.005)	(0.005)	(0.013)	(0.012)	(0.010)	(0.011)	(0.007)	(0.007)	(0.011)	(0.011)
Observations	89	89	415	415	391	391	255	255	428	428	291	291
R-squared	0.9587	0.9396	0.8440	0.8461	0.8470	0.8562	0.8564	0.8328	0.9652	0.9661	0.9610	0.9625
Country effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

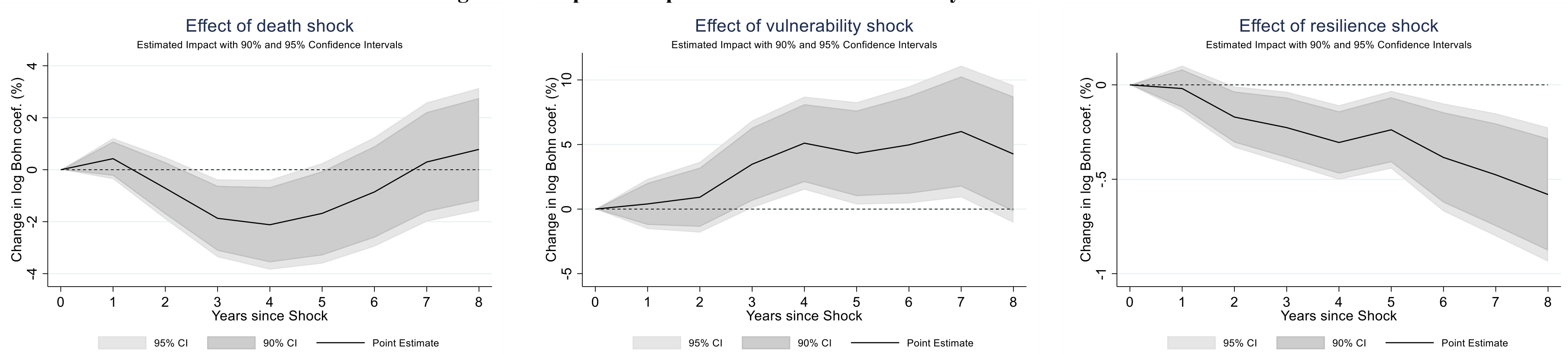
Notes: * indicates the level of significance of 10%, ** a level of 5% and *** a level of 1%. In brackets we report the robust standard errors. Obs. are the observations for each regression. The methodology employed is the WLS with and without fixed effects. The variables used are: the dependent variable is the logarithm of the external sustainability coefficient, the independent variable is the logarithm of the number of deaths disaster-related by population, the controls are the logarithm of the vulnerability or resilience index, the trade openness indicator, the current account balance as a percentage of GDP, the logarithm of the Foreign exchange reserves as percentage of GDP, and the Foreign Direct Investment inflow as a percentage of GDP. SAR stands for South Asia Region, SSA represents Sub-Saharan Africa, ECA is Europe and Central Asia, MNA denotes Middle East and North Africa, LAC means Latin America and the Caribbean, and EAP signifies East Asia and Pacific.

4.2. Short-run Results

To complement the long-run evidence from our panel analysis, we now turn to the short-run responses of fiscal and external sustainability to climate-related shocks using the LPs methodology. This approach allows us to trace the temporal dynamics of macroeconomic sustainability following one-standard-deviation shocks in disaster-related mortality, climate vulnerability, and resilience, while avoiding the rigid assumptions of parametric models. The IRFs provide additional insight into the speed, persistence, and significance of these effects over an eight-year horizon.

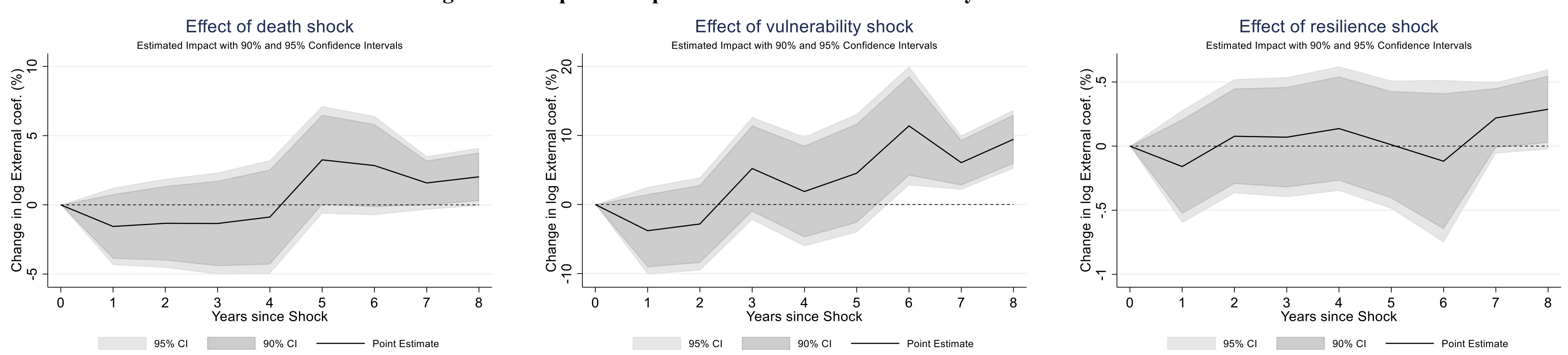
Focusing first on fiscal sustainability, the LP estimates reveal a clear and statistically significant negative response to a mortality shock. As shown in the first panel of Figure 7a, fiscal sustainability deteriorates for several years following a spike in disaster-related deaths, with the largest negative effects occurring around the third and fourth years after the shock. This medium-term decline aligns well with our fixed effects results in Table 1a and 1b, for which showed a significant negative coefficient on disaster mortality once unobserved heterogeneity was accounted for. The LP findings suggest that the fiscal impact of disaster shocks is not only negative, but also delayed, likely reflecting the cumulative costs of reconstruction and prolonged revenue disruptions. In contrast, a shock to climate vulnerability leads to a positive and statistically significant response in fiscal sustainability from years two to seven. While somewhat counterintuitive, this result is consistent with the panel regression findings (Table 1a), where increases in vulnerability over time were associated with stronger fiscal sustainability once fixed effects were included. This suggests that governments may respond to rising climate exposure with more proactive or externally constrained fiscal policy strategies, potentially driven by policy adaptation, international oversight, or preemptive consolidation efforts. Conversely, a shock to resilience generates a persistent and statistically significant negative effect on fiscal sustainability throughout the forecast horizon. This result reinforces the panel regression findings, where resilience was positively associated with fiscal health across countries, but declining resilience within countries over time correlated with weaker fiscal performance. The LP estimates thus highlight the importance of adaptive capacity in buffering the fiscal system against shocks – when resilience erodes, fiscal sustainability becomes increasingly fragile, even in the absence of direct shocks.

Figure 7a: Impulse Responses of Fiscal Sustainability to Climate Shocks



Note: The solid black lines in the figure denote the impulse responses of climate shocks on the dependent variable identified in the figure´s title. Year=1 is the first year after a shock took place at year=0. So, the position of the line at e.g., year=8 shows the change in the sustainability coefficient 8 years after the shock. The light and dark grey shaded areas display the 95 and 90% error bands.

Figure 7b: Impulse Responses of External Sustainability to Climate Shocks



Note: The solid black lines in the figure denote the impulse responses of climate shocks on the dependent variable identified in the figure´s title. Year=1 is the first year after a shock took place at year=0. So, the position of the line at e.g., year=8 shows the change in the sustainability coefficient 8 years after the shock. The light and dark grey shaded areas display the 95 and 90% error bands.

Turning to external sustainability, the short-run responses exhibit more muted and heterogeneous patterns. The IRFs show that a mortality shock generates a slight, negative response in external sustainability during the first few years, but the effects are not statistically significant at conventional levels. This is in line with the WLS-FE results, where the negative effect of disaster mortality on external accounts only emerges in the full specification. The weaker LP response suggests that external balances may be influenced by additional short-run buffers – such as aid inflows, exchange rate adjustments, or import compression – which help to offset the immediate impact of disaster shocks. The response to a vulnerability shock, by contrast, is strong and statistically significant. As shown in the fifth panel of Figure 7b, external sustainability improves markedly from year two onwards, with effects peaking around years five and six. This dynamic mirrors the panel regression result that vulnerability becomes positively associated with external sustainability once fixed effects are included, possibly reflecting adaptive trade or financing strategies among more exposed countries. In these settings, external accounts may benefit from increased external support or tighter import controls in response to heightened vulnerability. Finally, shocks to resilience produce a negative but statistically insignificant response in external sustainability. Unlike the fiscal side, external sustainability appears less sensitive to changes in resilience, at least in the short run. This muted effect is consistent with the panel analysis, where resilience was positively associated with external sustainability but not always significant. The divergence between fiscal and external responses to resilience may reflect the more direct link between institutional capacity and public finance management, as opposed to trade or capital flows, which may respond to a broader set of macro-financial conditions.

5. Conclusion and Policy Implications

This paper investigates how natural disasters contribute to shape fiscal and external sustainability in a global panel of economies from 1980 to 2023. By estimating country-specific, time-varying fiscal and external sustainability coefficients and analyzing their long-run and short-run determinants, we provide a dynamic perspective on how climate shocks propagate through macroeconomic systems. Our empirical strategy combines Weighted Least Squares (WLS) panel regressions with fixed effects and local projections to trace both persistent structural effects and short-term adjustment dynamics.

We find robust evidence that disaster-related mortality undermines fiscal sustainability, particularly in emerging and vulnerable economies. Short-term impulse responses confirm a medium-term deterioration in fiscal sustainability following mortality shocks, while external sustainability responds more moderately and heterogeneously. Vulnerability exacerbates both fiscal and external fragility, while resilience plays a mitigating role – though its erosion over time weakens public finance capacity. Distinguishing between static exposure (vulnerability) and dynamic capacity (resilience) proves essential for understanding country-specific trajectories. Government debt consistently constrains fiscal space, and external aid, while helpful in the immediate aftermath, is associated with weaker fiscal responsiveness over time. Government effectiveness enhances fiscal stability, underscoring the role of strong institutions in absorbing and managing shocks. On the external side, vulnerability is linked to deteriorating sustainability, while trade openness and foreign exchange reserves support recovery. FDI shows a negative relationship with external balances in emerging economies, pointing to investor sensitivity to climate risk.

Short-term results highlight the urgency of bolstering fiscal and external buffers before disasters strike. Fiscal policy must increasingly be designed with adaptation in mind – integrating climate risk assessments into medium-term frameworks, improving institutional preparedness, and expanding access to risk-sharing mechanisms such as insurance and contingency financing. Moreover, international support must move from reactive aid to proactive investment in resilience and macro-fiscal stability.

While our results are robust, limitations remain. Mortality, though objective, may not fully capture economic damages, especially in countries with strong infrastructure. The lack of subnational data constrains within-country analysis, and causal identification challenges persist despite the use of fixed effects. Future research should incorporate physical damage estimates, subnational variation, and identification strategies leveraging exogenous variation in disaster exposure. Overall, this paper advances the understanding of climate-related macroeconomic vulnerability by linking natural disaster mortality, vulnerability, and resilience to time-varying fiscal and external sustainability. As climate shocks grow more frequent and intense, enhancing macroeconomic resilience is not only a development priority – it is a necessity for economic stability and long-term sustainability.

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Appendix

Table A1: Summary statistics

	N	Mean	Median	SD	Min	Max
Fiscal	3316	2.402	2.438	0.322	-4.593	3.121
External	4588	2.726	2.723	0.174	-4.391	3.266
Deaths	8526	0.153	0.000	0.491	0	7.759
Vulnerability	4500	0.363	0.356	0.067	0.216	0.534
Resilience	4675	0.337	0.320	0.091	0.111	0.597
GDP Growth	7836	0.129	0.146	0.289	-4.116	4.538
Inflation	6961	26.377	4.661	361.971	-17.64	23773.131
Debt	6485	55.847	44.743	46.912	0.002	677.18
Trade Openness	6794	82.362	71.595	51.685	0.021	442.62
ExchangeVol	7682	0.041	0.004	0.307	-8.682	13.45
Current	6767	-2.811	-2.894	13.004	-240.495	311.746
ODA	5802	7.425	3.514	11.487	-8.188	260.366
Goveff	4730	-0.062	-0.198	0.979	-2.440	2.470
FDI	7624	4.150	1.872	17.756	-440.131	452.221
Reserves	6862	-2.250	-2.143	1.064	-8.666	2.806

Notes: This table presents the summary statistics of the variables under study for the period of 1980 to 2023. Specifically, we report the number of observations, mean, median, Standard deviation (SD) the maximum, and the minimum of all variables used in this paper.