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Fiscal Impacts of Climate Disasters in Emerging Markets and Developing Economies

Habtamu Fuje, Jiaxiong Yao, Seung Mo Choi, and Hamza Mighri

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Fiscal Impacts of Climate Disasters in Emerging Markets and Developing Economies
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ABSTRACT: Climate-induced disasters are causing increasingly frequent and intense economic damages, disproportionally affecting emerging markets and developing economies (EMDEs) relative to advanced economies (AEs). However, the impact of various types of climate shocks on output growth and fiscal positions of EMDEs is not fully understood. This research analyzes the macro-fiscal implications of three common climate disasters (droughts, storms, and floods) using a combination of macroeconomic data and comprehensive ground and satellite disaster indicators spanning the past three decades across 164 countries. Across EMDEs, where agriculture tends to be the principal sector, a drought reduces output growth by 1.4 percentage points and government revenue by 0.7 percent of GDP as it erodes the tax bases of affected countries. Meanwhile, likely reflecting limited fiscal space to respond to a disaster, fiscal expenditure does not increase following a drought. A storm drags output growth in EMDEs, albeit with negligible impact on fiscal revenue, but government expenditure increases due to reconstruction and clean-up efforts. We find only limited impact of localized floods on growth and fiscal positions. In contrast, AEs tend to experience negligible growth and fiscal consequences from climate-induced shocks. As these shocks have much more detrimental effects in EMDEs, international support for disaster preparedness and climate change adaptation play a crucial role for these countries to confront climate change.

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WORKING PAPERS

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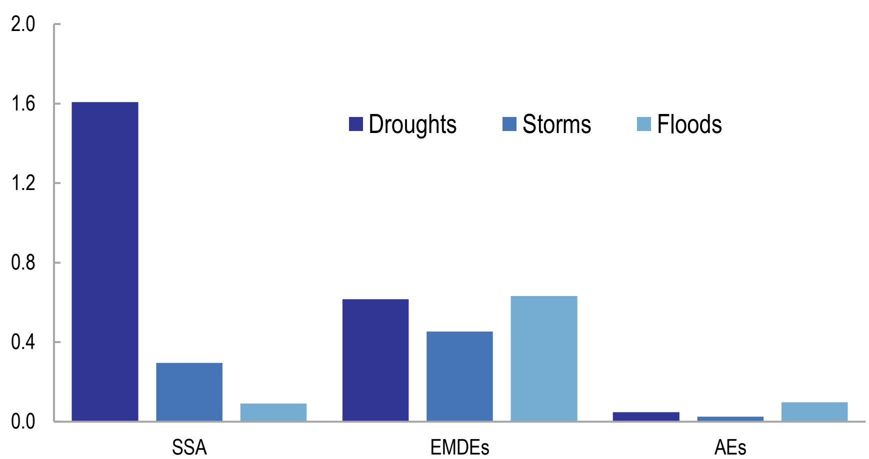
Contents

1. Economic Effects of Natural Disasters

Residents of emerging markets and developing economies (EMDEs) face recurrent natural disasters. For example, droughts affect, on average, 1.6 percent of the population annually in sub-Saharan Africa (SSA) since 1990 (Figure 1), especially the Horn of Africa and the Sahel. This level of exposure is thirty-three times higher than in advanced economies (AEs). Storms and floods impact around 0.5 percent of the population annually in EMDEs, again several times higher than in AEs. Notably, island countries in the Northern Pacific and the Caribbeans are particularly vulnerable to storms while certain regions in Southeastern Africa such as Madagascar and Mozambique are frequently hit by cyclones. For example, Cyclone Idai ravaged Mozambique, Malawi, and Zimbabwe in 2019, causing catastrophic damage to millions of people in its path. Globally, the frequency and intensity of these disasters are expected to increase as temperature continues to rise (IPCC 2023). Although this study covers all EMDEs, a special emphasis is accorded to SSA as it has a higher exposure of natural disasters.

Figure 1. Exposure to Extreme Disasters since 1990
(Average percentage of population affected in a year)



Sources: EM-DAT, the International Disaster Database; and IMF staff calculations.

Note: A disaster is considered extreme if the total number of deaths plus 30 percent of the total affected population make up at least 1 percent of the entire population of the country.

SSA = Sub-Saharan Africa; EMDEs= Emerging Market and Developing Economies, excluding SSA; AEs = Advanced Economies.

However, the macroeconomic implications of these disasters have not been fully documented, particularly in terms of their fiscal effects. Droughts undermine agricultural production, especially in low-income countries (LICs) which rely heavily on rainfed farming, as was seen in the “four-season drought” in the Horn of Africa during 2020-22 that left millions severely food insecure.[1] Tropical and subtropical storms also cause massive damages to infrastructure and lead to major displacement of residents, with EMDEs being more vulnerable than AEs due to less resilient infrastructure. While the magnitude of these negative impacts on

[1] Throughout this paper, we use the following regional groupings: the world is divided into AEs and EMDEs, which is further divided either into LICs and emerging markets (EMs) or SSA and other-EMDEs, referring to EMDEs outside SSA.

economic activity in EMDEs have been estimated by some researchers (as reviewed below), fewer studies assess the resulting impacts on fiscal positions, particularly in SSA and LICs in general. Climate change-induced disasters are expected to affect fiscal positions in two ways. First, as economic activity slows down, the tax base is likely to erode, leading to a decline in revenue. Second, disaster responses, including provision of social protection and reconstruction, could lead to elevated fiscal expenditure. However, their actual impact can differ across countries significantly. For example, destruction of public infrastructure following disasters could impair revenue mobilization capacity of the state, leading to a further decline in fiscal revenue (while the tax base is already affected). Fiscal expenditure, despite the need to respond to disasters, might not increase in countries with limited fiscal space.

This study empirically assesses the extent to which climate change-induced disasters affect economic activity and fiscal positions in EMDEs. While some studies consider the impact of disasters on fiscal positions within a region (as is reviewed below), this study analyzes a global sample of 164 countries over three decades, comparing AEs against EMDEs as well as, within EMDEs, LICs against EMs to understand potential differences between groupings. Also, more granular estimates are provided according to the type of disasters—droughts, storms, and floods—to understand the heterogenous impacts of these disasters. We also analyze the impacts of disasters based on access to development assistance, levels of trade openness, and the quality of governance.

The results illustrate that climate change-induced disasters drag economic growth and add to fiscal pressures in EMDEs, but there is no statistically significant impact on fiscal expenditure, likely reflecting the limited fiscal space in these countries. Specifically,

- **Real GDP growth** is lowered by more than one percentage point in EMDEs in the year of a drought or a severe storm. The impact of storms appears to arise mostly in LICs. However, droughts and storms did not have significant impact in AEs. Also, we do not find significant growth impact of floods in EMDEs.
- **Fiscal revenue** as a share of GDP tends to diminish in the year of drought in EMDEs. The total real revenue declined by 4.5 percentage points—leading to a 0.5 percent decline in government revenue as a share of GDP—in a drought year. But we do not find a statistically significant association between fiscal revenue and storms or floods.
- **Public expenditure** does not change meaningfully in response to disasters in EMDEs. Likely owing to the limited fiscal space, contrary to the conjecture that disaster responses would raise expenditure, absolute level of expenditure declined slightly during a disaster year, leading to only a slight increase in expenditure as a share of GDP. LICs, which experience larger growth declines, tend to have higher spending as a share of GDP in the aftermath of storms.[2]
- As a result, **primary balance** tends to worsen during drought and storm years, raising public debt in EMDEs. In AEs, these disasters have no significant impact on the primary balance or public debt.

Literature

There is a vast literature on the impact of natural disasters on economic production. For example, Hsiang (2010), Acevedo (2016), and Bakkensen and Barrage (2018) study the impact of cyclones and hurricanes on economic growth. Desbureaux and Rodella (2019) quantify the impact of droughts on labor market outcomes in

[2] Integrating disaster response in the budget process and building fiscal resilience could help countries better respond to climate change-induced disasters. For details of how to manage fiscal costs of disaster, build fiscal buffer, and utilize it effectively, please see the 2018 IMF note entitled “How to Manage the Fiscal Costs of Natural Disasters.”

large Latin American urban areas. Kotz et al. (2022) analyze the economic impact of rainfall changes. Aside from distinguishing diverse types of disasters, the literature has also focused on the impact on specific sectors, such as agriculture (for example, Mendelsohn (2009), De Winne and Peersman (2021)), or on country groups, such as low-income countries (Acevedo and others, 2019). Bergeijk and Lazzaroni (2015) and Botzen et al. (2019) provide meta-analysis of the economic impact of natural disasters.

To the extent that economic output serves as the tax base, the impact of natural disasters on economic output is a useful benchmark for understanding whether there is a sizable impact of natural disasters on fiscal outcomes. A growing literature has focused on estimating the impact of climate change-induced shocks on public finances performance in AEs and EMs, with most studies finding decreased revenue, increased expenditure, and higher debt as fiscal outcomes following weather or natural disaster shocks.[3] For example, using data for high and middle-income countries, Melecky and Raddatz (2011) estimate that climate disasters raise government expenditure by about 15 percent and lowered revenue by about 10 percent over the five years following a disaster. This led to an increase in public debt and higher borrowing costs, thereby putting an additional burden on public finance and further dampening long-term growth. However, this impact appears lower for countries with already high initial public debt. Akyapi et al. (2022) study the impacts of extreme weather events on government revenue, expenditure, debt, and GDP per capita using weather variables constructed from billions of geospatial weather observations. They found that high maximum daily temperatures have a pro-cyclical and negative impact on government revenue, while government spending and debt increased in response to droughts and flood-like conditions. Using the data from the Middle East and Central Africa, Duenwald et al. (2022) document that climate disasters trigger an immediate decline in output by 1–2 percentage points which can be at times even permanent. Public debt increases by 2.5 percent of GDP in disaster years, reflecting lower growth, lower tax revenue, and higher spending. The impact of disasters on revenue and expenditure has been also documented for Indonesia (Wiyanti and Halimatussadiah 2021) and Pacific Island countries (Nishizawa et al. 2019). A small, growing literature also focuses on the local fiscal impact. For example, Sanoh (2015) finds that rainfall shocks affect revenue collection of local governments through agricultural incomes. Jerch et al. (2023) analyze local public finance dynamics following hurricane shocks in the U.S.

This paper distinguishes from previous studies by examining natural disasters of diverse types using the same methodology, with a focus on the heterogenous fiscal outcomes of various country groups. In doing so, we resort to the Emergency Events Database (EM-DAT) that records a comprehensive set of natural disasters. Problems associated with EM-DAT such as recording inaccuracy and under-reporting of older events are well noted in the literature (see, for example, Acevedo (2016)). To alleviate such concerns, we focus on the post-1990 sample and include country and time fixed effects. We also restrict our analysis to severe disasters, following the literature that distinguishes the intensity of natural disasters (Becker and Mauro 2006; Fomby et al. 2013). As it is well known that droughts are slow-moving disasters whose impact is hard to quantify, we use the Palmer Drought Severity Index (PDSI) as the main measure of droughts. It is also worth noting that natural disasters are different from extreme weather events. By the definition of the EM-DAT,[4] natural disasters have a focus on human cost. As such the fiscal response may not necessarily be the same as that to extreme weather events. This paper focuses on natural disasters rather than extreme weather events.

[3] Gerling (2017) finds that key fiscal variables remain surprisingly stable following weather-related disasters in a panel of 19 countries between 1970-2015.

[4] EM-DAT includes all disasters that conform to at least one of the following criteria:10 or more people dead;100 or more people affected; the declaration of a state of emergency; or a call for international assistance.

The heterogeneity in fiscal responses to natural disasters can be important, as LICs might not have the fiscal space to respond even if increasing public spending is anticipated and advisable. Akin to our study is the work by Noy and Nualsri (2011), who employed EM-DAT to estimate the fiscal consequences of natural disasters using quarterly fiscal data for a large panel of countries. They found pro-cyclical spending in AEs and counter-cyclical spending in EMDEs following natural disasters. Compared to this study, we greatly expand country coverage, differentiate several types of disasters, and employ the local projections method (Jordà 2005) which has several advantages and helps assess persistence of fiscal impacts (Jordà and Salyer 2003; Plagborg-Møller and Wolf 2021). Relatedly, a study of Latin American and Caribbean economies found that the occurrence of an extreme weather event causes, on average, an increase in the fiscal deficit of about 0.9 percent of GDP for lower middle-income countries and low-income countries, due to a fall in fiscal revenue (IDB 2021). While the contemporaneous average effect on public expenditure is limited and, in the case of low-income countries, it can include a fall in spending. This is likely to occur from bank credit restrictions and low budget execution capabilities in the public sector. For high-income and higher middle-income countries, this impact is not significant, possibly due to their greater preparedness and response capability following natural disasters.

As to the policy response to natural disasters, IMF (2016, 2019) emphasize the importance of building fiscal buffers and providing self-insurance. This paper underscores this point by showing that fiscal expenditure does not change significantly in response to disasters in EMDEs.

2. Data and Descriptive Statistics

2.1. Definitions and Data

Two data sources are utilized for measuring climate change-induced disasters: the PDSI to detect droughts and EM-DAT to identify extreme storms and floods.

The PDSI is a physical measure that uses precipitation and temperature data to evaluate the level of dryness. The index ranges from -10 (dries) to +10 (wettest) and is concentrated around [-4, +4] range. The PDSI raw data are recorded at a high resolution of 0.5° × 0.5°, i.e., roughly on 55 kilometers by 55 kilometers land area. These data are aggregated at the first administrative (i.e., province/region) level and then aggregated at country level weighted by the contribution of first administrative divisions to the country's economic activity—proxied by nightlight data.[5] When the aggregated index is below –2 during crop growing seasons[6], the country is considered as facing drought.[7]

[5] Nightlight data are obtained from the Earth Observations Group at the Colorado School of Mines. See, for example, Hu and Yao (2022) regarding the use of nightlight data as a proxy for economic activity.

[6] Crop growing seasons are identified by the uptake in the Normalized Difference Vegetation Index (NDVI). The NDVI quantifies the level of vegetation by measuring the difference between near-infrared (generated by vegetation) and red light (absorbed by vegetation). Three consecutive months with the highest increase in NDVI mark the beginning of crop growing season. Therefore, droughts that occur in these months are likely to have large adverse effects on agriculture.

[7] That is, D_{it} is a dummy variable indicating a drought in country i in year t, as defined in below:

$$D_{it} = I\left\{\left[\sum_{p} \mathrm{NTL}_p \times \left(\frac{1}{3}\sum_{m=1}^{3} PDSI_{i,p,t,m}\right)\right] < -2\right\},$$

where I is an indicator function, NTL_p is the weight of province p in the national total nightlight per capita, and $PDSI_{i,p,t,m}$ is the PDSI for the three crop growing months, $m = 1,2,3$.

The EM-DAT provides ground-based disaster indicators, including for meteorological and hydrological disasters, with information on the number of affected people, death, and economic damages. We focus on floods and storms from this database. To account for the severity these disasters, we consider the death toll as well as the number of people affected. Following standard methods in the literature (Becker and Mauro, 2006), an extreme flood or storm occurs if the number of deaths plus 30 percent of the affected population makes up at least 1 percent of the total population. That is, D_{it}, a dummy variable indicating an extreme flood or an extreme storm in country i in year t, is defined as

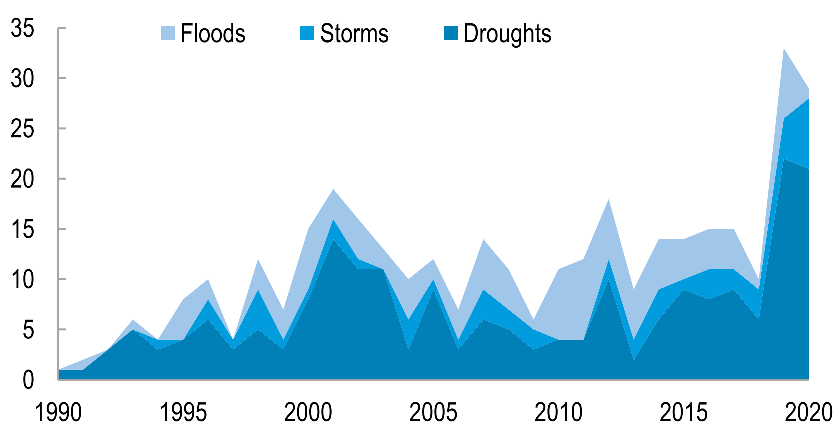
$$D_{it} = I\left\{\left[\frac{(Death\ toll)_{it} + 0.3\ (Affected\ Population)_{it}}{Population_{it}}\right] > 0.01\right\} \quad (1)$$

Data on GDP, revenue, expenditure, debt, and current account are from the IMF World Economic Outlook (WEO) database. Data on terms of trade (TOT), agricultural value added, and population are from the World Bank's World Development Indicators (WDI). Governance index, ranging from 0 (lowest rank) to 100 (highest rank), is from the Worldwide Governance Indicators (WGI) project that compiles various indicators.[8]

2.2. Descriptive Statistics

In this section, we briefly preview descriptive figures on disasters and macroeconomic indicators.
Across the globe, extreme disasters are recorded every year. Droughts are more common than extreme storms and floods. The number of droughts has increased in recent years, topping the high drought incidence observed in the early 2000s (Figure 2).

Figure 2: Frequency of Extreme Natural Disasters
(Global, Number of per year)



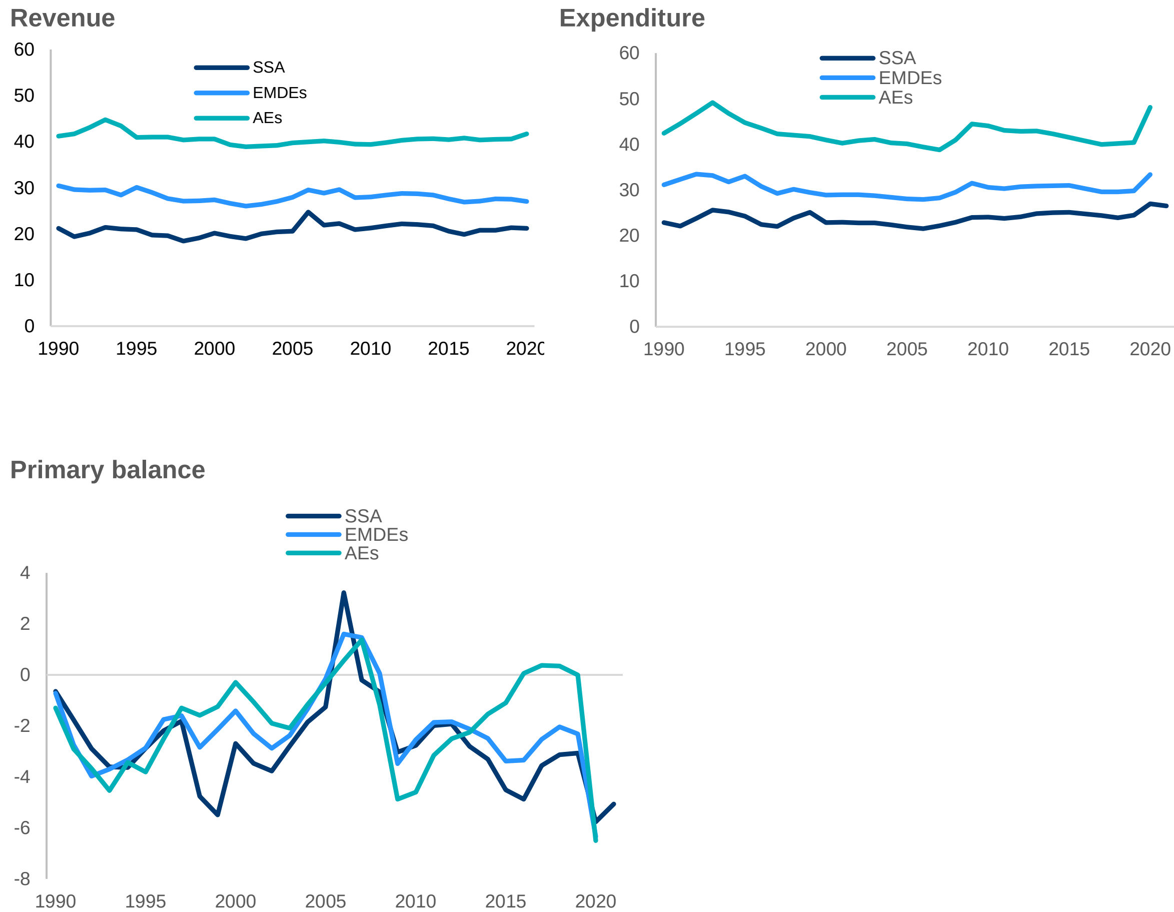
Sources: EM-DAT, the International Disaster Database; PDSI, National Oceanic and Atmospheric Administration (NOAA); and IMF staff calculations.

[8] We use government effectiveness, which captures, among other aspects, perceptions of the quality of public services and the quality of policy formulation and implementation, both of which are critical for responding to disasters. In this paper, countries are grouped into "High Governance" and "Low Governance" using the indicator's median value of 50 as a threshold.

Three key fiscal indicators (revenue, expenditure, and primary balance) extensively analyzed in this paper are presented in Figure 3. On average, revenue as a share of GDP is lower in SSA compared to other-EMDEs and more so when we compare it with AEs. Consequently, public expenditure as a share of GDP is smaller.

Figure 3: Macroeconomic Indicators

(Percent of GDP, regional averages)



Sources: World Economic Outlook database and IMF staff calculations.

3. Empirical Approach

3.1. Panel Regression

A set of panel regressions are used to analyze the instantaneous impacts of disasters on growth and fiscal indicators. To establish a baseline association, each (Y_{it}) of real GDP growth, revenue, expenditure, and primary fiscal balance is regressed on disaster indicator along with control variables (X) using the global sample:[9]

$$Y_{it} = \gamma_i + \pi Y_{it-1} + \alpha D_{it} + X_{it}'\beta + e_{it}, \quad (2)$$

where D_{it} is a dummy indicator of a natural disaster—three dummies for drought, extreme flood, or extreme storm that are analyzed separately—for country i in year t, X_{it} is a vector of controls that potentially influence growth and fiscal outcomes, including year-on-year inflation, level of terms of trade (TOT), current account deficit, value added of agriculture as a share of GDP, debt to GDP ratio, total population, GDP per capita (US$), and official development assistance (ODA) in US$ per capita. e_{it} is an error term. The coefficient of interest, α, indicates the extent to which macroeconomic indicators respond to natural disasters. Since natural disasters are exogenous, α can be interpreted in a causal sense.

Building on this baseline regression, we analyze the differential impacts of disasters across regions—comparing AEs and EMDEs—by introducing an interaction variable between country grouping dummy and disaster dummy as follows:

$$Y_{it} = \gamma_i + \pi Y_{it-1} + \alpha_{AEs}\, D_{it} * AE_i + \alpha_{EMDEs}\, D_{it} * EMDE_i + X_{it}'\beta + e_{it} \quad (3)$$

where AE_i and $EMDE_i$ are dummies that would be one if country i is in the corresponding grouping. The coefficients of interest (α_{AE} and α_{EMDE}) measure the magnitude of disaster impacts in AEs and EMDEs.[10] Next, we analyze the heterogeneity of disaster impacts across country groupings based on their access to ODA, trade openness, and governance quality by interacting these variables (C_{it}) with disaster dummy:

$$Y_{it} = \gamma_i + + \pi Y_{it-1} + \alpha_1 D_{it} \times C_{it} + \alpha_2 D_{it} \times (1 - C_{it}) + X_{it}'\beta + e_{it} \quad (4)$$

Where C_{it} takes a value of one for countries with higher (above median) level of the access to ODA, trade openness, and governance, and zero otherwise. Hence, the coefficient of the first interaction term, α_1, reflects how these countries managed to attenuate the macroeconomic impact of natural disasters, with α_2 picking the impacts of disasters in other countries.

3.2. Local projections

Complementary to the contemporaneous impact estimated above, the dynamic macroeconomic effect of natural disasters is also analyzed using local projections method:

$$Y_{i,t+h} = \pi Y_{i,t-1} + \sum_{p=0}^{P} \alpha_p^h D_{i,t-p} + \sum_{q=0}^{Q} X'_{t-q}\beta_q^h + \gamma_{i,h} + \delta_{t,h}, \qquad h = 0,1,2,\cdots \quad (5)$$

[9] Throughout this paper, revenue, expenditure, and primary balance are defined as a percentage of GDP. Whenever we investigate the actual change in levels of these fiscal indicators, we also use year-on-year change of real revenue and expenditure without taking them as a share of GDP (e.g., results in Table A.1). This is important to disentangle the co-movement of the denominators and numerator when ratios are analyzed.

[10] Furthermore, to understand whether a disaster affects SSA countries differently than other-EMDEs, we restrict the sample to EMDEs and conduct similar analysis:

$$Y_{it} = \gamma_i + \pi Y_{it-1} + \alpha_{SSA}\, D_{it} * SSA_i + X_{it}'\beta + e_{it}$$

where SSA_i is a dummy equal to one if country i is in SSA and zero if it is a non-SSA EMDE. Whether α_{SSA} is statistically significant captures any differential impacts of disasters in SSA, compared to other EMDEs. Similar analysis is conducted to document the differential impact of disasters in low-income countries (LICs) and emerging markets (EMs).

where h is the time horizon of a natural disaster's impact. $\gamma_{i,h}$ and $\delta_{t,h}$ are country and time fixed effects, respectively, which vary at each horizon. The coefficients of interest, β_p^h, trace out the dynamic responses to the natural disaster being examined. Subscripts p and q indicate lagged values of the corresponding variables and set to a lag of one in this paper.

4. Macroeconomic Impacts of Disasters

4.1. Instantaneous Growth and Fiscal Impacts

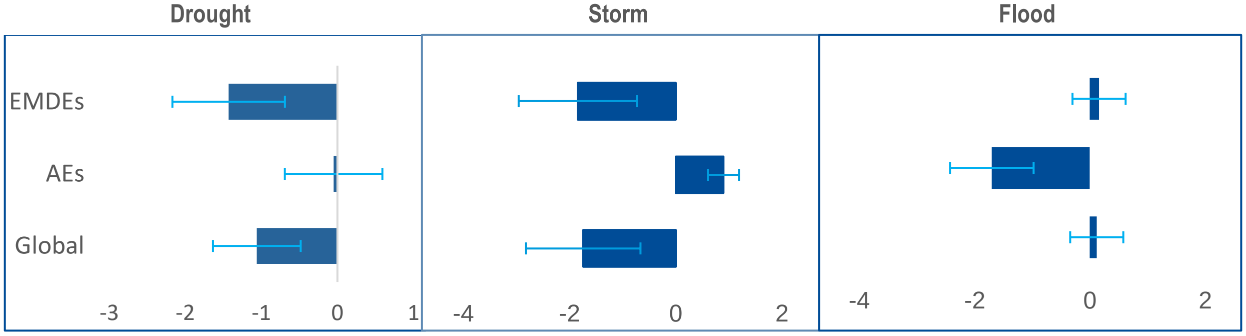
Growth impact

Globally, droughts and severe storms reduce growth, but the economic impact of floods tends to be weaker. Since droughts and severe storms erode production potential and disrupt economic activity across wider areas, their economic bearings are likely to be pronounced. Droughts, which at times wipe out an entire season of crops and consequently diminish agricultural production, reduce growth by 1 percentage point (Figure 4). This growth reduction could emanate not only from subdued agriculture production but also from drags on services and industrial activities that are strongly linked to agriculture. Similarly, high-intensity storms such as tropical cyclones, tornadoes and hailstorms that destroy infrastructure and disrupt economic activity across large parts of a country decrease growth by 1.6 percentage point. However, floods appear to have limited (and localized) impact on growth.

Furthermore, EMDEs face a larger growth damage due to droughts and storms than AEs. This differential impact is likely due to divergence in the structure of their economies and their ability to respond to disasters. As the contribution of agriculture to GDP in EMDEs is larger than in AEs, the impacts of droughts on growth tends to be larger in EMDEs (by 1.4 percentage point) than in AEs (Figure 4). Similarly, the interlinkage between agriculture and other sectors like manufacturing and services, which rely on the former for inputs and demand, tends to be much stronger in EMDEs. Storms like the tropical cyclones that frequently ravage southeastern African countries also reduce growth in EMDEs by 1.8 percentage point. For example, Cyclone Idai that ravaged several countries in March 2019 has caused a damage of US$ 1.4 billion just in Mozambique, where the reconstruction cost was estimated at US$ 2.9 billion (PDNA 2019). On the other hand, we find that the growth impact of storms like tornadoes on AEs is, surprisingly, positive, and this could be due to a significant post-disaster response that increases activity for cleanup and reconstruction. Severe floods reduce economic growth in AEs, where risks of flooding are generally high, but the impact on EMDEs appears to be insignificant. This subdued effect in EMDEs could be due to the counter effects of floods occurring prior to planting seasons by enhancing agriculture production and productivity in countries that are prone to droughts.

On the other hand, growth of SSA countries is similarly dragged by climatic shocks as elsewhere, but LICs are impacted more by storms than EMs. The gap in the growth impacts of disasters in SSA and other - EMDEs is negligible—indicating that these groups of countries are equally adversely affected by climatic shocks (Table 2). Whereas growth of LICs is affected more adversely by storms than that of EMs but droughts and floods appear to affect LICs and EMs equally.

Figure 4. Instantaneous *Growth* Impacts of Disasters: International Comparison
(Change, percentage points)



Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: AEs = Advanced Economies, EMDEs = Emerging Markets and Developing Economies.

Fiscal impact

Droughts result in the deterioration of revenue and primary balance of EMDEs by reducing the tax base and they add to debt—but public spending does not surge in response to droughts. Globally, droughts reduced revenue by 0.5 percent of GDP (Figure 5), and this is even larger in EMDEs (0.7 percent of GDP) but AEs do not experience any decrease (Table 2).[11] The absolute magnitude of revenue (real US$) decline due to droughts is about 3.4 percentage points globally and 4.5 percentage points in EMDEs (Table A.1). These absolute declines in revenue are much greater than the rate of GDP contraction (1-1.4 percentage points), indicating that the decline goes beyond a simple tax base erosion. When we look at the responsiveness to public expenditure to droughts, we find that disaster-related spendings are not sufficiently large to lead to an increase overall public expenditure. In most countries, especially in EMDEs that are exposed to frequent droughts, fiscal space is already limited and access to finance is at best unreliable. As a result, public spending, including social spending to support vulnerable groups, decreases, instead of increasing, following natural disasters like drought. While spending increases in AEs, the increase is not large enough to be statistically significant (Table A.1). With declining GDP, expenditure as percentage of GDP remains unchanged after droughts (Figure 5). The decline in revenue without a meaningful change in expenditure leads to an increase in the primary deficit by as much as 1.5 percent of GDP in EMDEs. This adds to public debt, which increases 1.4 percent of GDP.

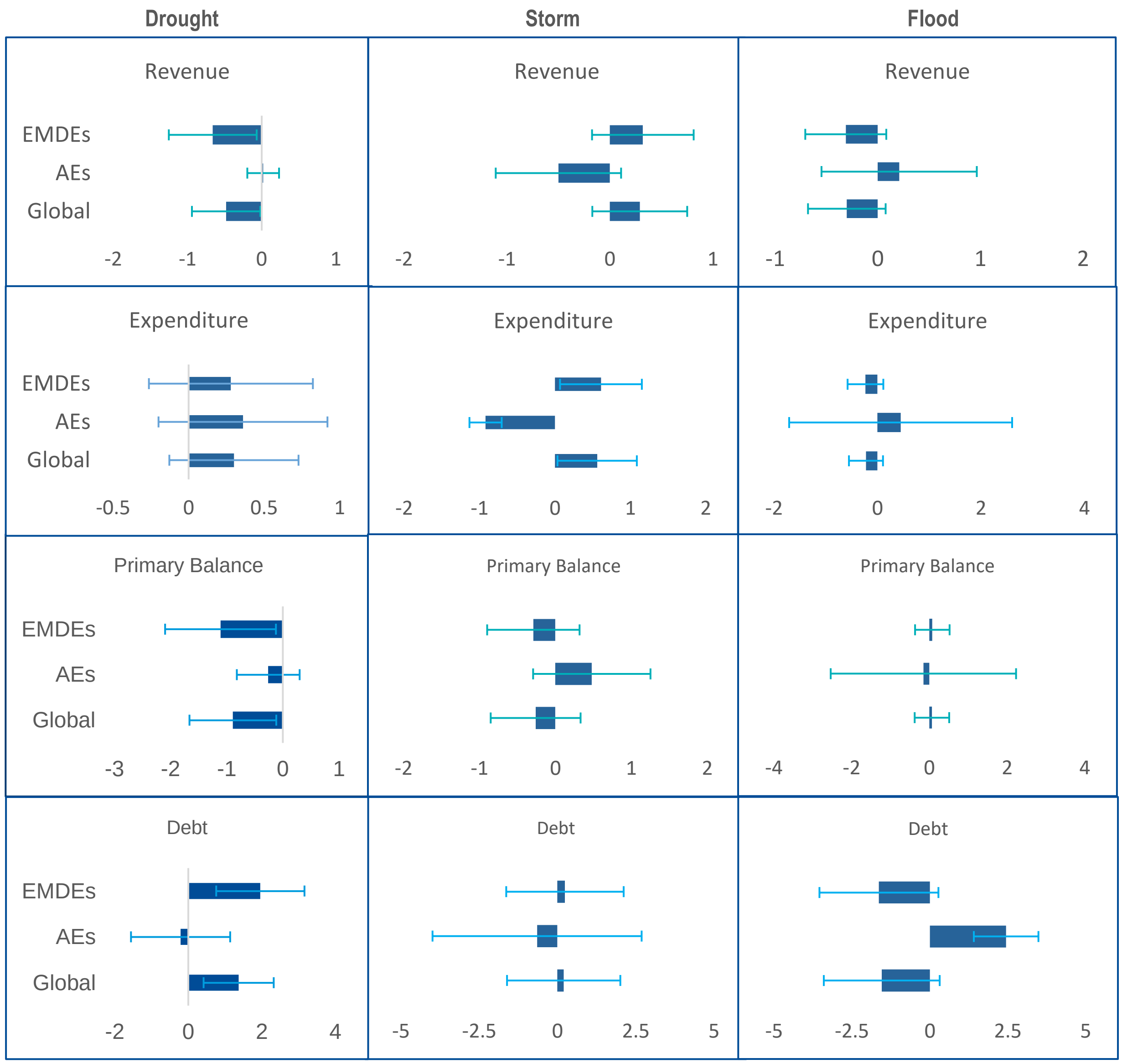
Despite dragging growth, storms have muted fiscal impact both in EMDEs and AEs. Declines in the absolute magnitude of revenue and expenditure were marginal, significant for AEs only (Table A.1). As a result, a slight increase in revenue and expenditure as percentage of GDP, which has shrunk, was observed globally and in EMDEs. Whereas, in AEs, where growth increased after storms, expenditure as a share of GDP declined by 1 percent. However, the impact on primary balance and debt was negligible for both EMDEs and AEs (Figure 5).

[11] Note that all fiscal indicators (revenue, expenditure, primary balance, and debt), except Tables A.1, are expressed as a percentage of GDP. Therefore, the fact that revenue, for example, as a percentage of GDP has not decreased does not mean that the absolute amount of revenue has not declined, but instead it has declined by the same or slower rate than GDP.

Fiscal expenditure and revenue also do not change much after floods, except in AEs where revenue appears to decline. Massive flooding episodes that affect more than 30 percent of a country's population led to a decrease in public spending by 4.7 percentage points in AEs (Table A.1), but this change is negligible as a share of GDP and yet adds to debt (Figure 5). On the other hand, in EMDEs, where fiscal space for reacting to disasters is generally limited, neither revenue nor expenditure responds to floods.

Figure 5. Instantaneous *Fiscal* Impacts of Disasters: International Comparison

(Change, as percent of GDP)



Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.
Note: As robustness checks for the baseline results presented in Figures 4 and 5, we have implemented (i) regressions with addition year FEs; (ii) dynamic panel model with two years lag of the dependent variable (Arellano and Bond 1991); and (iii) regressions by accounting for historical shock, last year. These results (Appendix B) are consistent with the main findings.
AEs = advanced economies, EMDEs = emerging market and developing economies.

Table 2: Differential Impact of Disasters in LICs, SSA, other-EMDEs, and EMs

(for column (1), percentage point change; for columns (2)-(5), change as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Drought					
SSA, relative to other-EMDEs	-0.03	-0.77	-0.44	-0.20	-0.33
	(0.92)	(0.59)	(0.38)	(0.49)	(1.17)
LICs, relative to EMs	0.02	-0.28	-0.12	-0.06	0.18
	(0.83)	(0.62)	(0.57)	(0.49)	(1.70)
Storm					
SSA, relative to other-EMDEs	0.33	1.36	2.09***	-0.97	-1.56
	(0.74)	(0.98)	(0.65)	(1.40)	(2.03)
LICs, relative to EMs	-2.19**	0.50	0.73*	-0.21	0.41
	(1.02)	(0.45)	(0.42)	(0.42)	(1.69)
Flood					
SSA, relative to other-EMDEs	-0.03	-0.73	-0.22	0.03	-4.07
	(0.47)	(0.70)	(0.57)	(0.88)	(4.23)
LICs, relative to EMs	0.15	-0.55	-0.15	0.16	-2.26
	(0.37)	(0.40)	(0.30)	(0.46)	(2.45)
SSA, relative to other-EMDEs					
Observations	2921	2881	2880	2873	2832
R-squared	0.084	0.494	0.572	0.343	0.829
LICs, relative to EMs					
Observations	1549	1526	1522	1520	1498
R-squared	0.027	0.465	0.590	0.187	0.837

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: These results compare differential impacts of disasters in SSA and LICs relative to other-EMDEs and EMs and are estimated by running regression on the interaction of disaster indicators with region dummy (R) as follows:

$$Y_{it} = \gamma_i + \pi Y_{it-1} + \alpha_R D_{it} * R_i + X'\beta + e_{it}, \text{ where } R = SSA, LICs.$$

EMs = Emerging Markets, EMDEs = Emerging Markets and Developing Economies, LICs = Low-Income Countries, SSA = Sub-Saharan Africa.

Mitigating or aggravating factors

Access to international aid has helped ease the adverse growth and fiscal impacts of climate-change induced shocks on EMDEs. EMDEs with access to a larger ODA inflow have managed to attenuate headwinds to economic growth in the aftermath of disasters. When suffering from droughts and storms, countries with limited access to ODA saw a greater decrease in growth (1.9-2.4 percentage points) compared to an almost negligible reduction for those with better access to international aid (Table A.2). In the absence of ODA, these countries are forced to spend out of public budget to respond to disasters, and hence non-grant public expenditure increases—swelling deficit and adding to debt. While the role of ODA in attenuating growth and fiscal impacts of floods is unclear, with both revenue and expenditure declining for countries with low ODA.

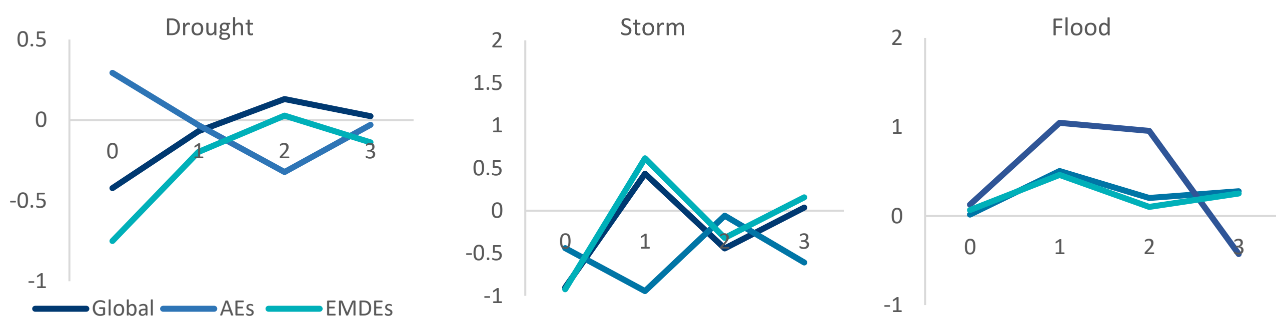
Countries that rely heavily on import-export markets, and hence likely to face larger trade disruptions and losses of export base, experienced larger adverse impacts from climate shocks. Droughts, for example, decrease agriculture production and hence drag growth of countries that rely heavily on export of primary products, resulting in higher fiscal deficit and debt.[12] While storms that sometimes cripple the entire logistic and transportation apparatus could put a stronger drag on the growth of more export-oriented economies (Table A.3). These countries would be compelled to spend more, including by importing heavily, to restore destroyed infrastructure and production bases, leading to a higher public expenditure. Floods do not appear to have any differential impact on growth of countries with low and high trade openness, but both revenue and expenditure of countries with low exposure to global market decline after exposure to the disaster.

Good governance appears to minimize macroeconomic effects of climate-related disasters. But the attenuation effects of governance quality vary by type of disaster. Countries with better regulatory quality, for example, managed to contain growth reduction effects of droughts. On the contrary, those with below average regulatory quality faced a larger growth reduction and deterioration of fiscal position after droughts. When it comes to the impact of storms, growth reduced regardless of the regulatory quality—but magnitude of the decline appears to be greater for those with better regulatory quality—and the fiscal impact is muted for both groups. Gap in the fiscal impact of floods is also minimal, and yet growth of those with better regulatory quality seems to have decline strongly (Table A.4).

4.2. Persistence of Fiscal and Growth Impacts

Natural disasters' negative impact on growth appears to be short-lived. Droughts and storms have a negative knock-on effect on growth for EMDEs, which dissipates within a year (Figure 6, and Appendix C with the confidence intervals). The initial growth impact of droughts and storms is more adverse in EMDEs, but EMDEs also recover more quickly and return to higher growth subsequently. Floods, on the other hand, have negligible initial impacts but in subsequent years they seem more beneficial for growth, especially in AEs. In general, they have a positive impact over the medium term both in EMDEs and AEs.

Figure 6: Growth Impact of Natural Disasters
(Change, percentage point)



Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.
Note: These results are from the local projection method, equation (5). EMs = Emerging Markets, EMDEs = Emerging Market and Developing Economies.

The fiscal impact tends to last longer than the drag on growth. Moreover, the effect is heterogeneous across country groups and types of disaster. For EMDEs, droughts reduce revenue and raise expenditure in

[12] Trade openness is used as proxy for a country's reliance on import and export as it is defined by the GDP share total export and import.

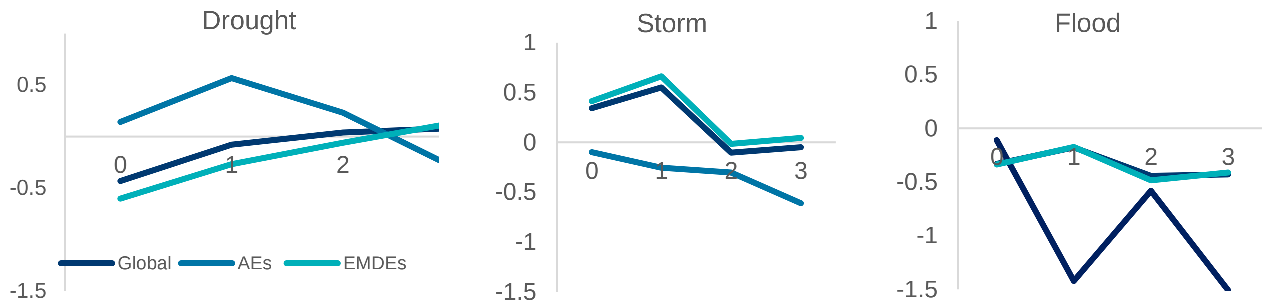
the medium term, resulting in persistent primary deficit (Figure 7 and Appendix C). Flood depresses both revenue and expenditure, leading to a small primary balance surplus. Storms exert a small positive impact on revenue but a much larger reduction in expenditure, giving rise to a sizeable increase in primary surplus. For AEs, drought has a more positive impact on revenue and expenditure while flood and storm have a more negative impact compared to EMDEs. On average, however, natural disasters' impact on AEs' primary balance is not statistically significant.

However, surprisingly, the medium-term debt trajectory of EMDEs does not necessarily worsen following natural disasters. In fact, for droughts and storms, we find that debt-to-GDP ratio starts to decline after three years, while for flood, the reduction is almost immediate in the first year. A confluence of factors is at play in driving the dynamics of debt-to-GDP ratio. First, GDP growth tends to be higher in the years following natural disasters, partly due to a rebound effect, contributing positively to a reduction in debt-to-GDP ratio. Second, the primary balance worsens after droughts but improves following floods and storms, which may increase or decrease the debt-to-GDP ratio depending on the type of shock. Third, when inflation is under control, monetary policy response to natural disasters tends to lower domestic interest rates to boost the economy, therefore reducing interest payments on debt and improving the dynamics of debt-to-GDP ratio. Empirically, the average debt-to-GDP ratio shows signs of decline following droughts, storms, and floods. However, this also masks a large heterogeneity across countries.

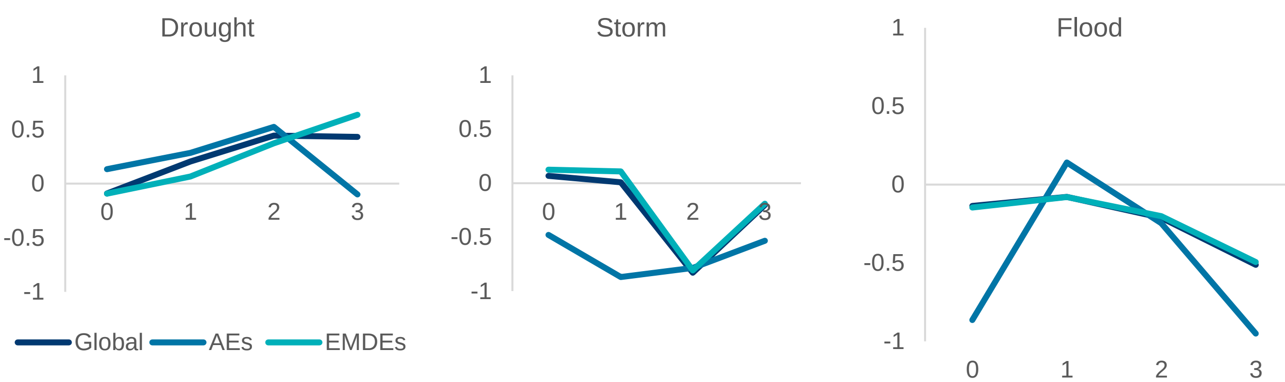
Figure 7: Fiscal Impact of Natural Disasters: International Comparison

(Change, as percent of GDP)

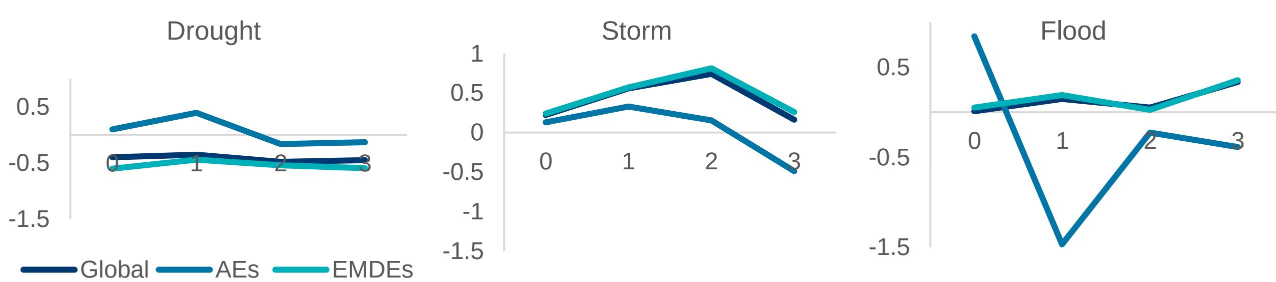
Revenue



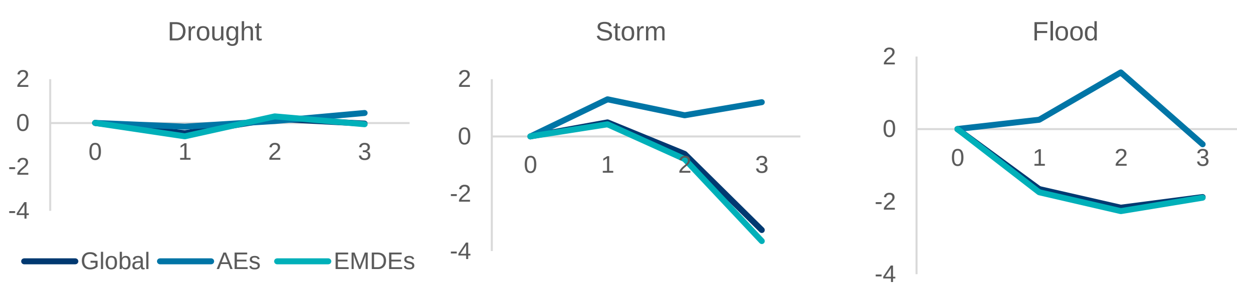
Expenditure



Primary Balance



Debt



Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: These results are from local projection method, equation (5). EMs = emerging markets, EMDEs = emerging market and developing economies.

5. Conclusions

The impact of natural disasters on economic growth and fiscal positions is heterogeneous. Not only does it depend on the types of disasters, but it varies across countries. While droughts and severe storms reduce growth, macroeconomic impacts of floods tend to be mild. Unsurprisingly, the negative economic consequences of natural disasters are usually larger for EMDEs than they are for AEs, but among EMDEs, the adverse impact on LICs is not always worse than that on EMs.

The interplay between economic growth, changes in the tax base, and the availability of fiscal space to respond to disasters, however, is crucial in determining the size of fiscal outcomes. Typical expected impact of natural disasters on fiscal positions, i.e., reduced revenue as the economic activity shrinks and elevated expenditure as the government responds, does not always materialize. In fact, a muted expenditure response in EMDEs signals the absence of fiscal space, highlighting the tension between the need to react and the constraint of financial resources.

Enhancing disaster monitoring and impact analysis is a crucial first step towards preserving macro-fiscal stability. With natural disasters' impact on fiscal outcomes being heterogeneous across several dimensions, it is paramount to have a data-driven approach to understand the nature of the disaster in question, including its type and severity, and its transmission channels to fiscal positions. Such channels may well vary across countries, and their relations to other macro variables cannot be overlooked.

Building fiscal buffers and maintaining ample fiscal space are essential for effective response to natural disaster shocks. Disasters impose physical and financial damages, more so on the most vulnerable in society. The discord between the need to help and the lack of expenditure response documented in this analysis underscores the necessity of building fiscal capacity that promotes resilience to disasters. Otherwise, countries would face a difficult choice of spending on disaster response or maintaining non-disaster related fiscal operations. In this vein, the traditional IMF advice on revenue mobilization, expenditure control, and public financial management remain no less relevant.

International support for disaster preparedness and adaptation is instrumental in attenuating the effects of climate-related disasters. This paper shows that while natural disasters' negative impact on growth is short-lived, the fiscal impact tends to linger. Financial support from the international community is therefore important to help contain the scarring effect of natural disasters. In countries where fiscal space is limited, faster mobilization of international support is needed to help alleviate the fiscal burdens.

Annex

Appendix A. Instantaneous Impacts of Natural Disasters

Table A.1. Impacts of Disaster on Revenue and Expenditure

(Percentage change, in levels)

	(1) Revenue	**(2)** Expenditure	**(3)** Debt
Drought			
Global	-3.40**	-1.50*	0.73
	(1.64)	(0.90)	(1.18)
AEs	-0.43	0.76	-0.30
	(0.47)	(0.64)	(1.18)
EMDEs	-4.52**	-2.36*	1.21
	(2.22)	(1.20)	(1.62)
Storm			
Global	-0.34	-0.93	-3.86***
	(1.86)	(1.52)	(1.43)
AEs	0.42	-0.50*	-0.41
	(0.53)	(0.28)	(1.26)
EMDEs	-0.37	-0.95	-4.03***
	(1.93)	(1.58)	(1.50)
Flood			
Global	-1.17	-0.99	-0.73
	(1.48)	(0.93)	(1.45)
AEs	-4.67**	-2.15	-0.28
	(1.87)	(3.87)	(6.04)
EMDEs	-1.09	-0.96	-0.75
	(1.51)	(0.95)	(1.48)
Observations	3410	3407	3195
R-squared	0.078	0.049	0.073

Source: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Table A.2: Heterogenous Impacts of Disasters in EMDEs by Access to ODA
(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Drought					
Low ODA	-1.89***	-0.55	0.71*	-1.58*	2.51***
	(0.50)	(0.45)	(0.40)	(0.81)	(0.71)
High ODA	-0.79	-0.83	-0.37	-0.42	1.37
	(0.72)	(0.54)	(0.51)	(0.62)	(1.24)
Storm					
Low ODA	-2.40***	-0.44**	0.60*	-1.02**	1.43
	(0.79)	(0.19)	(0.32)	(0.41)	(1.59)
High ODA	-0.86	1.72**	0.67	0.99	-1.66
	(0.75)	(0.66)	(0.75)	(1.08)	(1.53)
Flood					
Low ODA	0.65	-0.44*	-0.51**	0.11	-1.01
	(0.40)	(0.24)	(0.22)	(0.25)	(0.92)
High ODA	-0.27	-0.27	-0.05	0.08	-2.11
	(0.34)	(0.39)	(0.33)	(0.46)	(2.02)
Observations	2921	2881	2880	2873	2832
R-squared	0.088	0.490	0.568	0.346	0.827

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: High official development assistance (ODA) refers to countries that have received below median per capita ODA, compared to their peer EMDEs. The median ODA per capita in EMDEs is US$ 31 per person per year. Below median countries are considered as low ODA recipients.

Table A.3: Impacts of Disasters Across Countries with Varying Levels of Trade Openness
(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Drought					
Low Openness	-0.67	-0.36	0.05	-0.36	1.22
	(0.61)	(0.35)	(0.29)	(0.34)	(0.96)
High Openness	-1.28***	-0.52	0.72*	-1.41*	1.26*
	(0.37)	(0.44)	(0.41)	(0.84)	(0.72)
Storm					
Low Openness	-0.86**	0.10	0.25	-0.16	-0.50
	(0.38)	(0.34)	(0.41)	(0.40)	(0.92)
High Openness	-3.12***	0.50	1.09**	-0.61	0.86
	(0.92)	(0.43)	(0.47)	(0.58)	(2.23)
Flood					
Low Openness	0.06	-0.89**	-0.45*	-0.20	-2.13
	(0.39)	(0.35)	(0.24)	(0.35)	(2.42)
High Openness	0.48	0.19	-0.06	0.42	-2.26**
	(0.36)	(0.27)	(0.32)	(0.36)	(0.98)
Observations	3557	3501	3498	3493	3459
R-squared	0.100	0.506	0.578	0.389	0.833

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Table A.4: Governance: Regulatory Quality (EMDEs)

(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Drought					
High Governance	-0.82	-0.72*	-0.62*	-0.00	0.75
	(0.61)	(0.38)	(0.35)	(0.35)	(1.07)
Low Governance	-2.05***	-0.95	1.49***	-2.78**	1.92
	(0.56)	(0.67)	(0.42)	(1.07)	(1.29)
Storm					
High Governance	-2.49**	0.43	0.67	-0.32	1.03
	(0.98)	(0.49)	(0.49)	(0.52)	(1.52)
Low Governance	-1.22**	0.42	0.69	-0.26	-1.39
	(0.59)	(0.44)	(0.55)	(0.57)	(0.90)
Flood					
High Governance	0.10	-0.28	-0.20	0.11	-2.31
	(0.37)	(0.34)	(0.29)	(0.39)	(1.84)
Low Governance	1.06**	-0.29	-0.23	0.13	-1.91**
	(0.46)	(0.32)	(0.38)	(0.53)	(0.85)
Observations	2470	2444	2441	2437	2414
R-squared	0.101	0.480	0.591	0.364	0.848

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: Governance index runs from 0 to 100 with higher values indicating better regulatory quality, and countries with above the median values of 50 are classified as ‘High Governance’, and the rest are classified as ‘Low Governance’.

Appendix B. Robustness Checks

Table B.1: Instantaneous Growth and Fiscal Impacts of Disasters (Baseline)

(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Drought					
Global	-1.06***	-0.48*	0.30	-0.89*	1.37**
	(0.35)	(0.28)	(0.26)	(0.47)	(0.58)
AEs	-0.05	0.02	0.36	-0.26	-0.21
	(0.39)	(0.13)	(0.34)	(0.34)	(0.82)
EMDEs	-1.43***	-0.66*	0.28	-1.11*	1.96***
	(0.45)	(0.36)	(0.33)	(0.60)	(0.73)
Storm					
Global	-1.74***	0.29	0.56*	-0.26	0.20
	(0.55)	(0.28)	(0.32)	(0.36)	(1.10)
AEs	0.90***	-0.50	-0.92***	0.48	-0.65
	(0.15)	(0.37)	(0.13)	(0.47)	(2.03)
EMDEs	-1.84***	0.32	0.61*	-0.29	0.24
	(0.57)	(0.30)	(0.33)	(0.37)	(1.14)
Flood					
Global	0.12	-0.30	-0.22	0.07	-1.54
	(0.28)	(0.23)	(0.20)	(0.27)	(1.13)
AEs	-1.70***	0.21	0.45	-0.15	2.45***
	(0.37)	(0.46)	(1.31)	(1.45)	(0.63)
EMDEs	0.16	-0.31	-0.23	0.08	-1.63
	(0.28)	(0.24)	(0.21)	(0.27)	(1.16)
Observations	3783	3725	3724	3717	3681
R-squared	0.098	0.502	0.564	0.349	0.836

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: This table presents identical results as shown in Figures 4 and 5 to facilitate comparison with the subsequent robustness check tables.

AEs = Advanced Economies, EMDEs = Emerging Markets and Developing Economies.

Table B.2: Instantaneous Growth and Fiscal Impacts of Disasters **(Year FEs)**

(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Drought					
Global	-0.98***	-0.47*	0.29	-0.86*	1.22**
	(0.35)	(0.28)	(0.26)	(0.47)	(0.56)
AEs	0.22	0.05	0.28	-0.1	-0.67
	(0.39)	(0.14)	(0.34)	(0.34)	(0.71)
EMDEs	-1.42***	-0.66*	0.29	-1.13*	1.93***
	(0.44)	(0.37)	(0.33)	(0.60)	(0.70)
Storm					
Global	-1.50***	0.32	0.48	-0.12	-0.3
	(0.54)	(0.28)	(0.33)	(0.36)	(1.02)
AEs	0.81***	-0.51	-0.89***	0.41	-0.42
	(0.17)	(0.36)	(0.13)	(0.47)	(1.97)
EMDEs	-1.59***	0.35	0.54	-0.14	-0.3
	(0.56)	(0.29)	(0.34)	(0.37)	(1.06)
Flood					
Global	0.25	-0.28	-0.26	0.16	-1.77
	(0.27)	(0.23)	(0.20)	(0.27)	(1.10)
AEs	-1.63***	0.23	0.41	-0.06	2.19**
	(0.48)	(0.48)	(1.35)	(1.52)	(0.91)
EMDEs	0.29	-0.29	-0.28	0.16	-1.86
	(0.28)	(0.24)	(0.20)	(0.27)	(1.13)
Observations	3783	3725	3724	3717	3681
R-squared	0.131	0.502	0.567	0.358	0.838

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Note: AEs = Advanced Economies, EMDEs = Emerging Markets and Developing Economies.

Table B.3: Instantaneous Growth and Fiscal Impacts of Disasters (Dynamic Panel, Arellano-Bond)
(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Global					
Drought	-1.06***	-0.48*	0.3	-0.89*	1.37**
	(0.35)	(0.28)	(0.26)	(0.47)	(0.58)
Storm	-1.74***	0.29	0.56*	-0.26	0.2
	(0.55)	(0.28)	(0.32)	(0.36)	(1.10)
Flood	0.12	-0.3	-0.22	0.07	-1.54
	(0.28)	(0.23)	(0.20)	(0.27)	(1.13)
Observations	3783	3725	3724	3717	3681
R-squared	0.097	0.502	0.564	0.348	0.836

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Table B.4. Instantaneous Growth and Fiscal Impacts of Disasters (Lagged Disaster)
(Change, fiscal indicators as percent of GDP)

	(1) Growth	(2) Revenue	(3) Expenditure	(4) Primary Balance	(5) Debt
Global					
Drought	-0.98**	-0.53*	0.18	-0.78*	1.47**
	(0.38)	(0.27)	(0.26)	(0.43)	(0.59)
Lagged Drought	-0.38	0.23	0.62***	-0.53	-0.55
	(0.30)	(0.19)	(0.22)	(0.32)	(1.23)
Storm	-1.72***	0.30	0.55*	-0.25	0.18
	(0.56)	(0.29)	(0.32)	(0.36)	(1.13)
Lagged Storm	0.81**	0.15	-0.11	0.33	-0.54
	(0.41)	(0.34)	(0.57)	(0.53)	(1.23)
Flood	0.12	-0.30	-0.21	0.07	-1.57
	(0.28)	(0.24)	(0.21)	(0.27)	(1.15)
Lagged Flood	-0.04	-0.13	0.17	-0.21	-0.52
	(0.24)	(0.24)	(0.22)	(0.29)	(0.76)
Observations	3783	3725	3724	3717	3681
R-squared	0.098	0.502	0.565	0.349	0.836

Sources: World Economic Outlook (WEO) database; World Development Indicators (WDI); Palmer Drought Severity Index (PDSI) data; the Emergency Events Database (EM-DAT); and IMF staff calculations.

Appendix C. Dynamic Impact of Natural Disasters

Figure C.1. Dynamic Response of GDP Growth to Natural Disasters

(Real, percentage points)

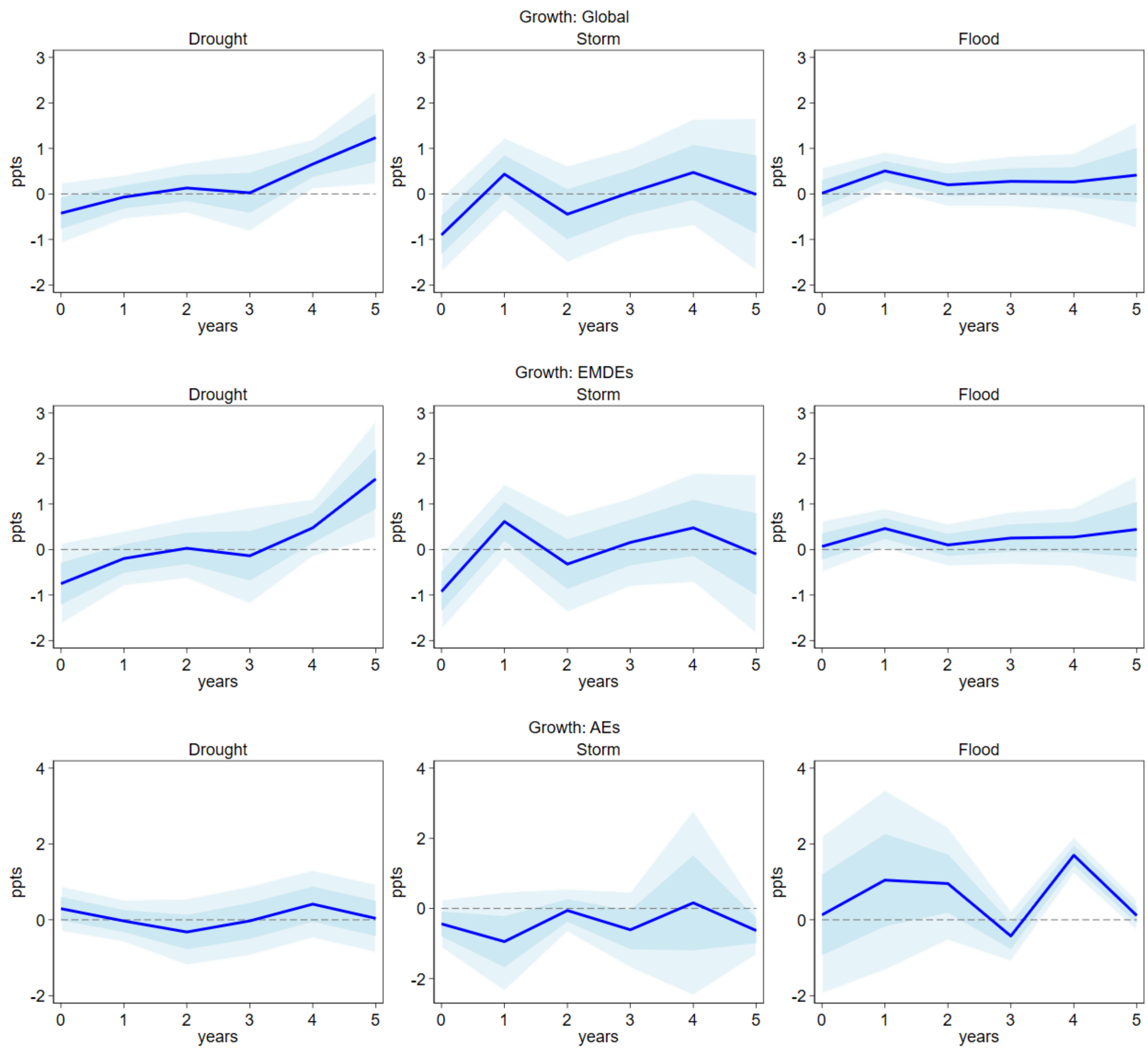


Figure C.2. Dynamic Response of Revenue to Natural Disasters

(Change, as percent of GDP)

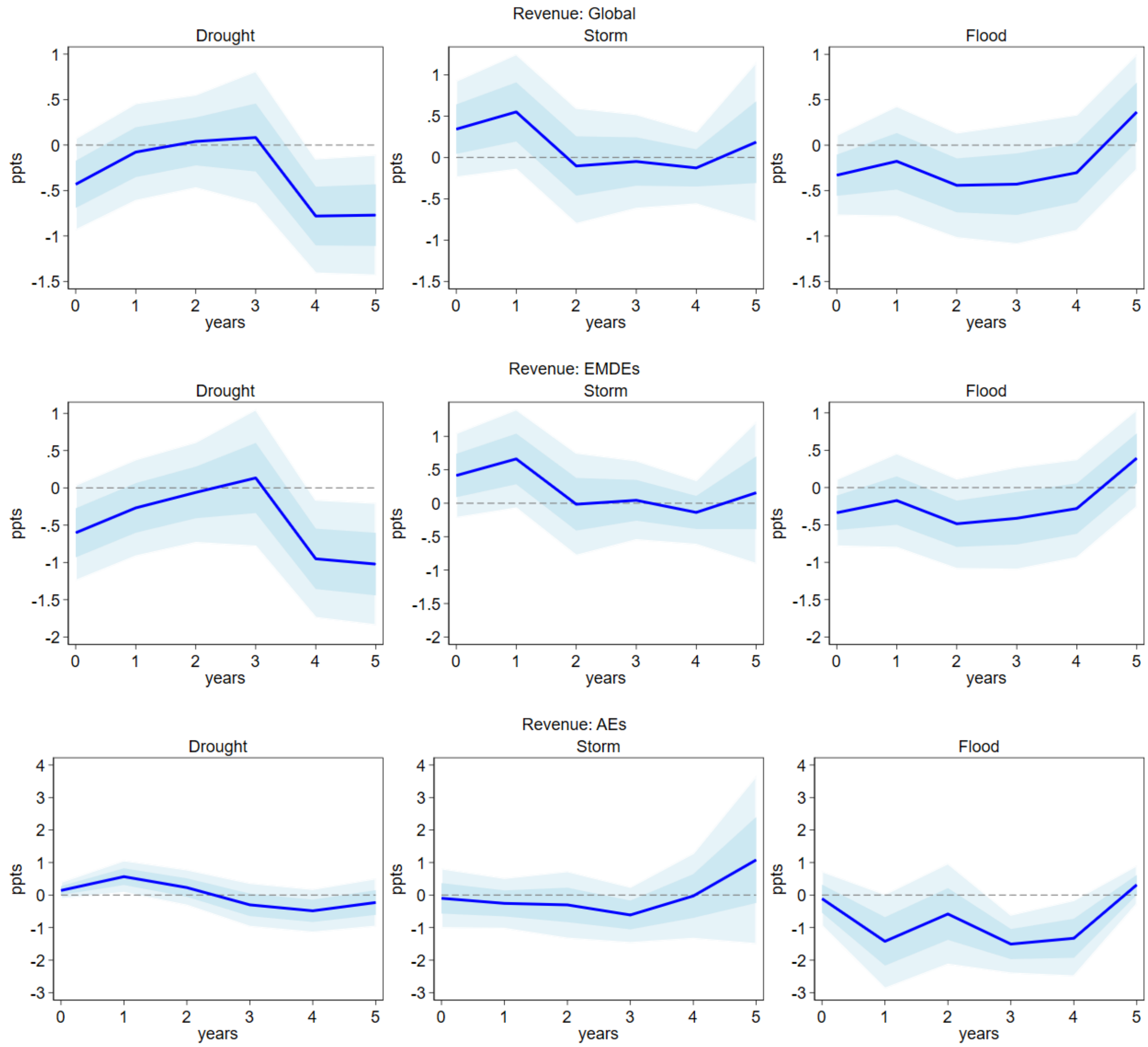


Figure C.3. Dynamic Response of Expenditure to Natural Disasters

(Change, as percent of GDP)

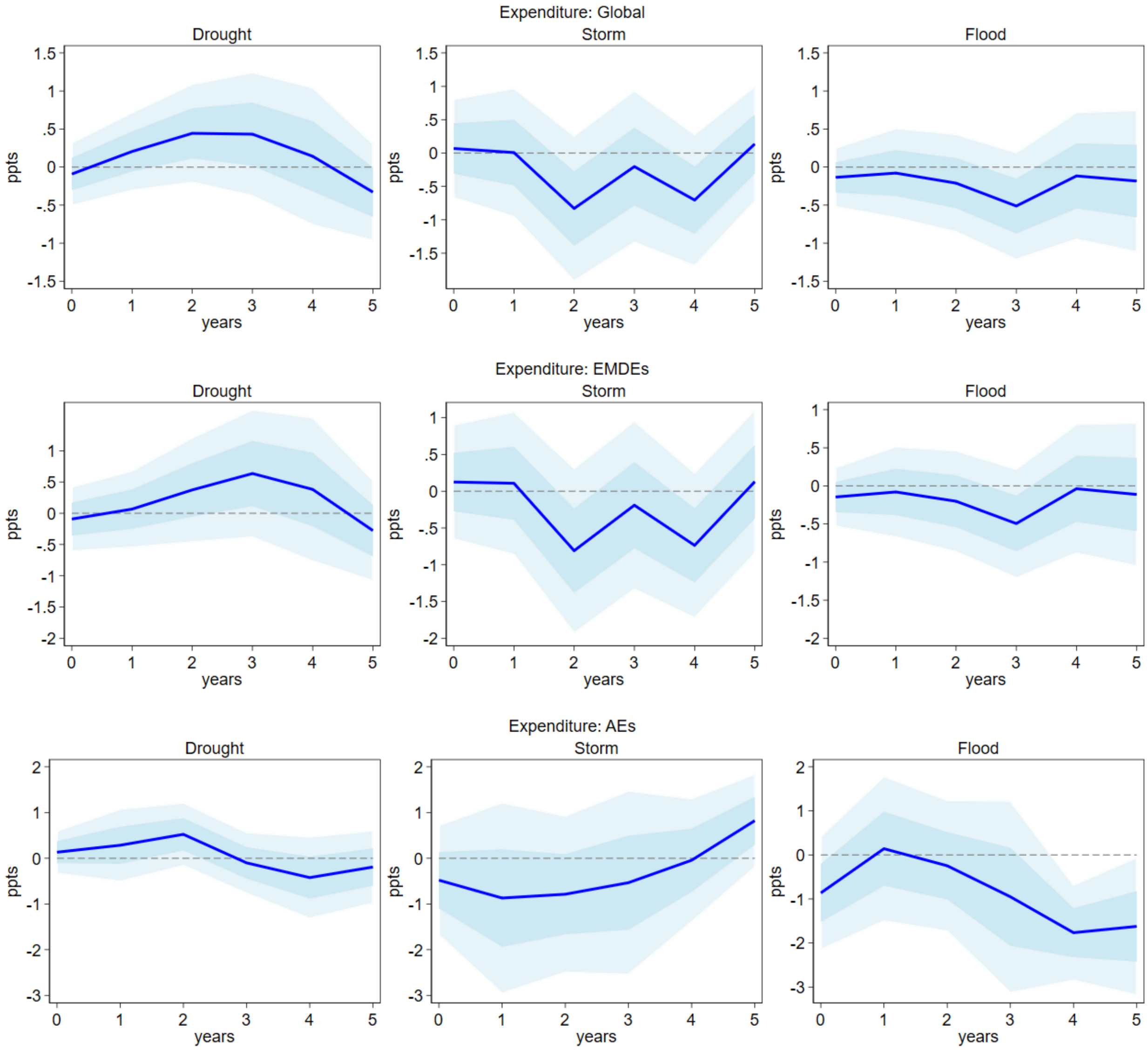


Figure C.4. Dynamic Response of Primary Balance to Natural Disasters
(Change, as percent of GDP)

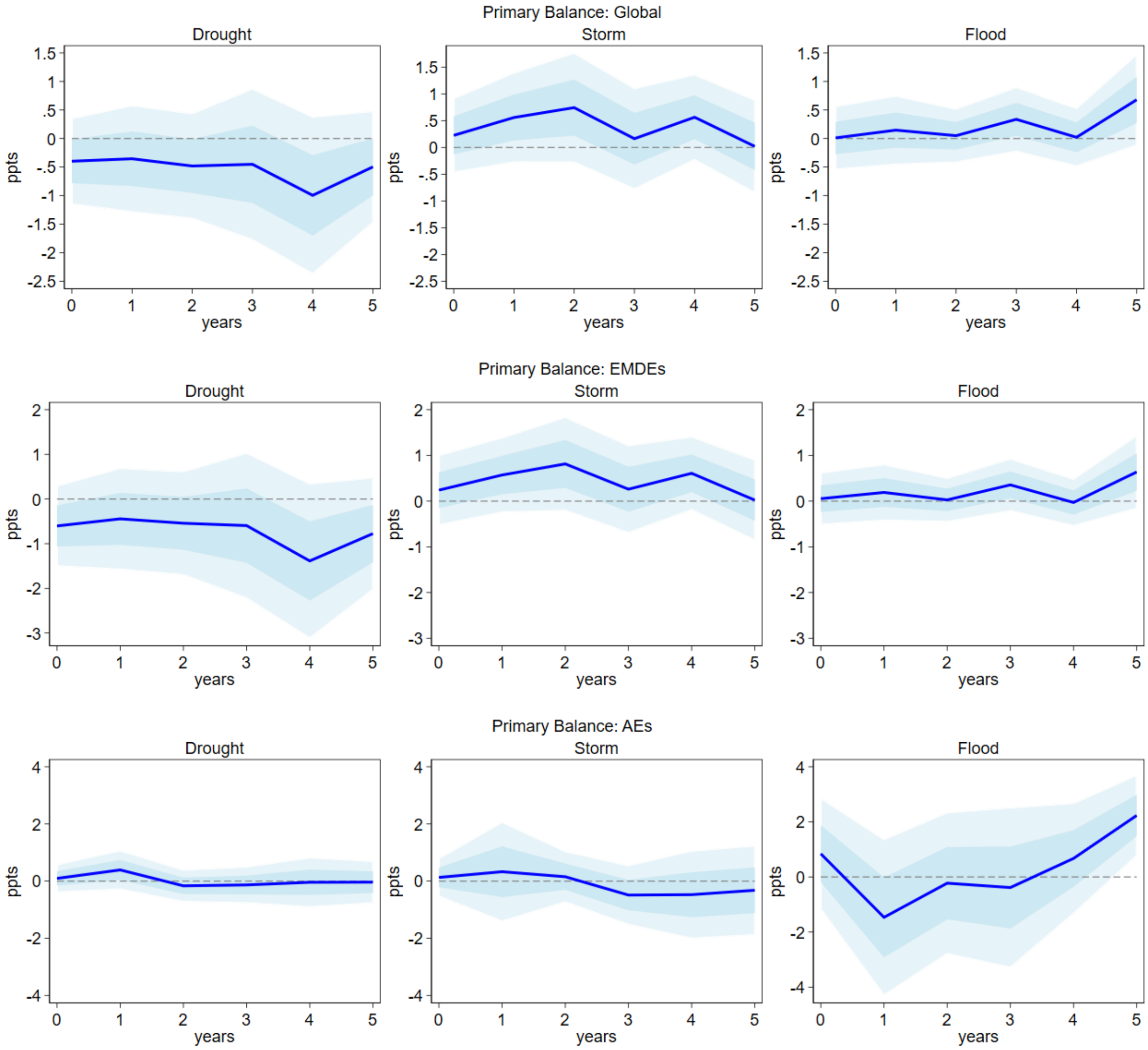
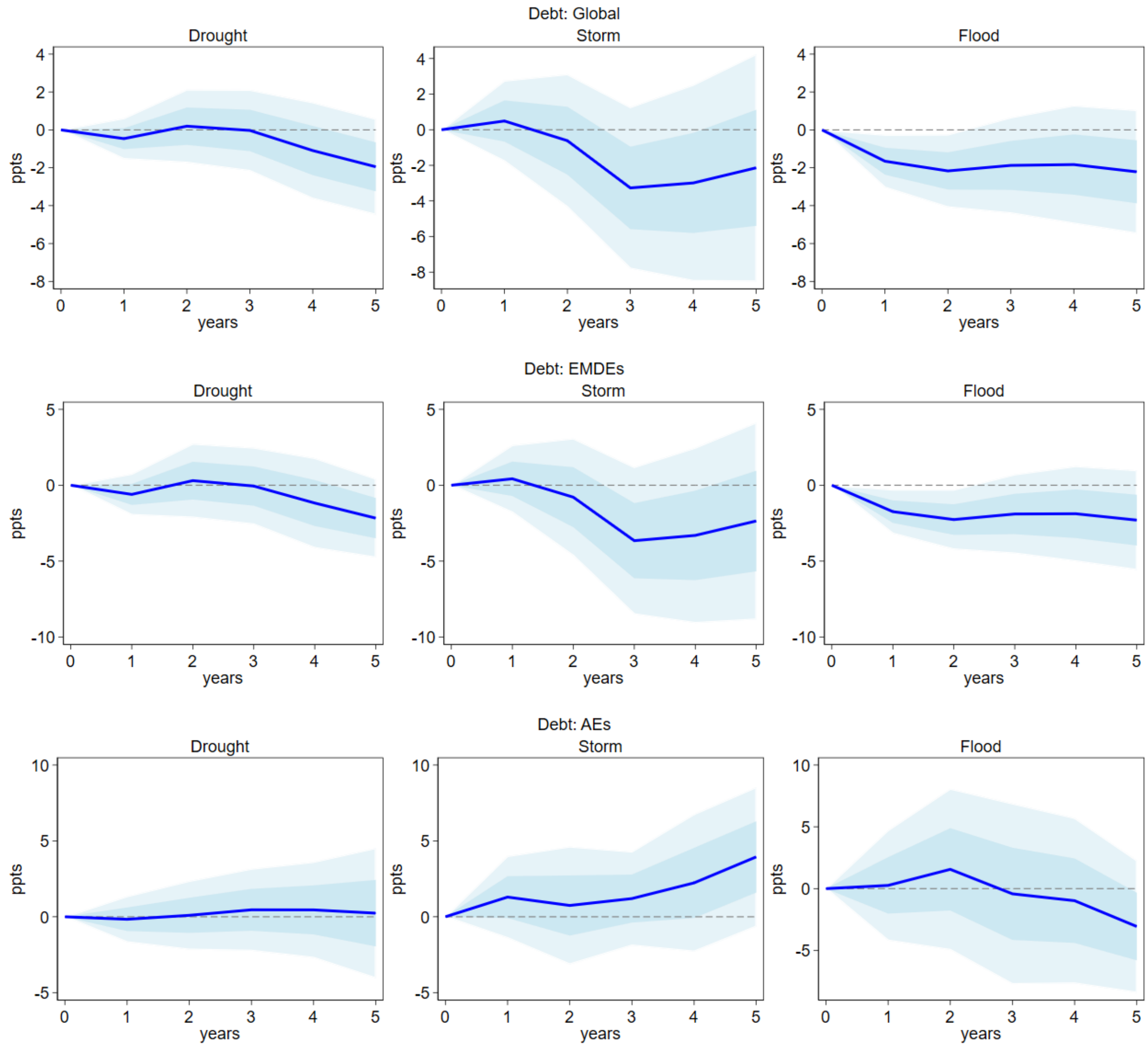


Figure C.5. Dynamic Response of Debt to Natural Disasters

(Change, as percent of GDP)



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