

Natural Disasters, Public Debt, and Fiscal Vulnerability: Evidence from Emerging and Developing Economies

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Abstract— Natural disasters have become increasingly frequent and severe in recent decades, posing significant challenges to fiscal sustainability in emerging and developing economies. This paper investigates how natural disaster shocks influence public debt dynamics and fiscal vulnerability across a panel of emerging and developing countries over the period 2001–2025. Using a fixed-effects framework with Driscoll–Kraay standard errors to address cross-sectional dependence and serial correlation, the analysis examines both the direct fiscal impact of disasters and the role of initial debt levels in amplifying these effects. The results indicate that natural disasters tend to increase public debt levels, reflecting reconstruction expenditures and revenue disruptions following disaster events. More importantly, the debt-increasing effect is significantly stronger in countries with already high public debt burdens, suggesting the presence of a fiscal vulnerability mechanism in which limited fiscal space constrains governments’ ability to absorb shocks. Additional results highlight the importance of financial development and governance capacity in mitigating the fiscal consequences of disasters. These findings highlight the need for improved fiscal buffers, disaster-risk financing mechanisms, and resilient fiscal institutions in emerging and developing economies facing rising climate-related risks.

Keywords: climate shocks, fiscal vulnerability, natural disasters, public debt dynamics, emerging economies

I. INTRODUCTION

For many nations, natural catastrophes have evolved into a growing major source of financial and economic risk. Over the past two decades, the frequency and intensity of disasters—including floods, storms, droughts, and earthquakes—have risen noticeably in many regions of the world. According to the Centre for Research on the Epidemiology of Disasters (CRED), more than 400 disaster events were recorded globally in 2024 alone, affecting millions of people and generating substantial economic losses (CRED, 2025). While disasters are often discussed primarily in terms of humanitarian and environmental consequences, they also have significant implications for public finances. Governments typically respond to disaster shocks by increasing spending on emergency relief, infrastructure reconstruction, and economic recovery programs. At the same time, disasters may disrupt economic activity and weaken tax revenues. These combined pressures can lead to fiscal deficits and rising public debt, especially in countries with limited fiscal buffers.

A large body of literature has examined the macroeconomic effects of natural disasters. Early research mainly focused on their effects on economic growth and macroeconomic stability. Cavallo and Noy (2011) provide a comprehensive survey of this literature and show that disasters can generate substantial economic disruptions, particularly in developing economies. More recent studies have increasingly examined the fiscal consequences of disasters. Noy and Nualsri (2011) document that government spending typically rises after disasters as countries finance relief and reconstruction programs. Similarly, Lis and

Nickel (2010) find that extreme weather events can weaken fiscal balances by increasing expenditures and reducing government revenues. These findings suggest that disaster shocks may have important implications for government budgets.

A related strand of research focuses on how disasters influence public debt dynamics. Mohan and Strobl (2021) show that tropical storms contribute to the accumulation of government debt in vulnerable economies, as borrowing is often used to finance recovery and reconstruction efforts. Using cross-country data, Fan et al. (2023) also find that disaster shocks can lead to persistent increases in debt levels in developing countries. Other studies emphasize that the fiscal consequences of disasters may depend on institutional capacity and fiscal resilience. For example, Cabezon et al. (2019) argue that countries with stronger fiscal frameworks and macroeconomic institutions are better able to absorb disaster shocks without generating large increases in public debt.

Despite these insights, several questions remain insufficiently explored. First, much of the existing literature focuses on specific countries, regions, or types of disasters. While these studies provide valuable insights, they may not fully capture broader patterns across a large group of emerging and developing economies. Second, the role of fiscal vulnerability has received relatively limited attention. Countries with already high levels of public debt often face tighter borrowing constraints and reduced fiscal space (Kose et al., 2018; Ostry et al., 2010). Under such conditions, governments may have fewer options for financing disaster recovery without increasing debt further. Understanding whether high initial debt levels amplify the fiscal impact of disasters is therefore an important question.

This paper addresses these issues by examining the relationship between natural disasters and public debt dynamics in a panel of 150 emerging and developing economies over the period 2001–2025. The study asks the following research question: Do natural disasters lead to higher public debt in emerging economies, and does fiscal vulnerability amplify this effect? To answer this question, the empirical analysis employs panel data methods that exploit variation across countries and over time. Fixed-effects models are estimated to control for unobserved country characteristics and global shocks, and Driscoll–Kraay standard errors are used to address cross-sectional dependence and serial correlation in the data (Driscoll & Kraay, 1998; Hoechle, 2007).

This study contributes to the literature in three main ways. First, it provides new cross-country evidence on the fiscal consequences of natural disasters using a large panel of emerging and developing economies. By covering 150 countries over more than two decades, the analysis offers a broader perspective on the relationship between disaster shocks and public debt. Second, the paper highlights the role of fiscal vulnerability by examining whether the impact of disasters depends on initial debt levels. This approach helps identify a potential amplification mechanism through which disasters may lead to stronger increases in public debt in countries with already high fiscal burdens. Third, the findings provide policy-relevant insights for countries facing increasing climate-related risks. In particular, the results suggest that maintaining fiscal space and strengthening fiscal preparedness may help governments better manage the fiscal consequences of natural disasters.

II. HYPOTHESIS DEVELOPMENT

Natural disasters place immediate pressure on public finances. Emergency relief, reconstruction spending, and income support programs increase government expenditures, while disaster-related economic disruptions weaken output and reduce the tax base. As a result, government revenues may decline at the same time that fiscal demands increase. When these fiscal pressures are financed through borrowing rather than through immediate fiscal adjustment, public debt ratios are likely to rise. Even after controlling for country-specific characteristics and global macroeconomic conditions, disaster exposure should therefore be associated with higher levels of government debt within countries over time.

H1: Natural disasters increase government debt.

However, the fiscal adjustment following a disaster is unlikely to be completed within the same year as the shock. Reconstruction programs are often implemented gradually, and supplementary budgets may be approved only after the disaster year. In addition,

the economic slowdown caused by disasters may continue to affect fiscal balances in subsequent periods. Because public debt is a stock variable and fiscal responses unfold over time, the full fiscal impact of a disaster may become visible with a delay rather than immediately. If borrowing and output effects persist beyond the initial shock, the lagged effect should be observable in the data.

H2: The positive effect of natural disasters on government debt is stronger in the year following the disaster.

The scale of disaster-induced borrowing is also likely to depend on pre-existing fiscal conditions. Countries with high initial debt levels may face greater rollover risks, higher borrowing costs, and more limited fiscal adjustment capacity. Financial markets may demand higher risk premiums on new government debt issuance, and governments may have less flexibility to smooth shocks through countercyclical fiscal policy. By contrast, countries with lower baseline debt may retain greater fiscal space and absorb disaster shocks without comparable increases in debt ratios. As a result, the same disaster event may produce different fiscal outcomes depending on a country's initial debt burden.

H3: The debt impact of natural disasters is larger in countries with high initial debt.

III. METHODOLOGY AND DATA

III.I. DATA AND SAMPLE

The empirical analysis is based on an annual country-level panel covering emerging and developing economies over the period 2001–2025. The initial dataset includes 150 economies. After merging all required variables and removing observations with substantial missing values, the final estimation sample contains 2,130 observations across 119 countries. Restricting the analysis to a consistent estimation sample ensures that results are comparable across different model specifications.

The time span of the dataset is determined by the common availability of government debt, disaster exposure, and the full set of macroeconomic and institutional control variables. Because the empirical strategy relies on within-country variation over time, country fixed effects are included to absorb time-invariant structural characteristics across countries. Year fixed effects capture global shocks that affect multiple economies simultaneously, such as financial crises, commodity price fluctuations, and global economic cycles.

The dependent variable in this study is government debt, which is widely used as an indicator of fiscal sustainability and public debt dynamics in the macroeconomic literature (Reinhart & Rogoff, 2010; Baum et al., 2013). The key explanatory variable captures exposure to natural disasters. Following previous studies on the macroeconomic and fiscal consequences of disaster shocks, disaster exposure is measured using a country–year indicator that records whether a natural disaster occurs in a given year (Noy & Nualsri, 2011; Mohan & Strobl, 2021; Fan et al., 2023). This approach focuses on the occurrence of disaster events and allows the analysis to capture the average fiscal impact of disaster shocks across countries.

To examine fiscal vulnerability, countries are further classified according to their initial debt conditions. This classification follows the literature on fiscal space and debt sustainability, which suggests that high initial debt levels may constrain governments' ability to respond to economic shocks (Reinhart, Rogoff, & Savastano, 2003; Ghosh et al., 2013).

In addition to disaster exposure and fiscal vulnerability, the empirical specification includes several macroeconomic and institutional controls commonly used in cross-country fiscal analyses. These include indicators of financial development, institutional quality, and macroeconomic conditions, which have been shown to influence fiscal outcomes and public debt dynamics (Beck, Levine, & Loayza, 2000; Levine, 2005; Kaufmann, Kraay, & Mastruzzi, 2010).

Data for natural disasters are obtained from the Emergency Events Database (EM-DAT) compiled by the Centre for Research on the Epidemiology of Disasters (CRED). Macroeconomic variables are collected from international databases, including the World Development Indicators (WDI) published by the World Bank and datasets from the International Monetary Fund (IMF). Detailed definitions of all variables used in the analysis are provided in Table 1.

Table 1: Variable Definitions and Measurement

Variables		Symbol	Definition	Source
Dependent Variable	Government Debt	Gov_Debt	General government gross Debt	World Economic Outlook
Independent Variable	Natural disaster exposure	Disaster_Dummy	Indicator equal to 1 if a country experiences at least one disaster event in year t, and 0 otherwise.	EM-DAT
Control Variables	Domestic credit to private sector	Credit_Private	Domestic credit to the private sector as a share of GDP (%).	World Development Indicators
	Government effectiveness	WGI_ge	World Governance Indicators (WGI) – Government Effectiveness (standardized index).	Worldwide Governance Indicators
	Economic growth	GDP_Growth	Annual GDP growth rate (%).	World Bank
	Inflation	Inflation_CPI	Annual inflation rate measured by the consumer price index (CPI, %).	World Bank
	Government consumption	Gov_Cons	General government final consumption expenditure as a share of GDP (%).	World Bank

III.II. MODEL DESIGN

To examine the relationship between natural disasters and government debt dynamics, this study constructs a series of panel-data regression models based on both theoretical considerations and the structure of the dataset. The sample consists of a country-year panel covering emerging and developing economies over the period 2001–2025. Given the cross-country nature of the data and the need to control for unobservable heterogeneity across economies as well as global macroeconomic shocks over time, the empirical analysis adopts a two-way fixed-effects (TWFE) framework.

We begin by estimating a baseline specification designed to examine the relationship between disaster exposure and government debt. The empirical model can be expressed as:

$$Gov_Debt_{it} = \alpha_i + \gamma_t + \beta_1 Disaster_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$

where i denotes countries and t represents years. Gov_Debt measures government debt as a share of GDP, while $Disaster$ indicates whether a disaster occurs in a given country-year. The vector X includes macroeconomic and institutional controls capturing financial development, governance quality, and α_i represents country fixed effects, which control for time-invariant

structural differences across countries, such as fiscal institutions or accounting conventions. The term γ_t denotes year fixed effects that capture global shocks affecting many economies simultaneously, including changes in international financial conditions or global economic cycles. The coefficient β_1 measures the within-country relationship between disaster exposure and government debt over time.

Because government debt is a stock variable that evolves gradually, fiscal responses to disasters—such as reconstruction spending or borrowing—may persist beyond the disaster year. This persistence may generate serial correlation in regression residuals. Moreover, cross-country panels are likely to experience correlated shocks driven by global financial conditions, commodity price cycles, or synchronized macroeconomic fluctuations. Countries may also differ in fiscal volatility and exposure to external shocks, implying that the variance of the disturbance term may vary across panels. To address these econometric concerns, the estimation employs Driscoll–Kraay standard errors, which provide inference robust to heteroskedasticity, serial correlation, and general forms of cross-sectional dependence in macro panels with a sufficiently long time dimension (Driscoll & Kraay, 1998; Hoechle, 2007).

To further examine whether fiscal vulnerability conditions the impact of disasters, the empirical framework extends the baseline model by incorporating an interaction term between disaster exposure and the high-debt indicator:

$$Gov_Debt_{it} = \alpha_i + \gamma_t + \beta_1 Disaster_{it} + \beta_2 HighDebt_{it} + \beta_3 (Disaster_{it} \times HighDebt_{it}) + X_{it} + \varepsilon_{it} \quad (2)$$

Here, *HighDebt* classifies countries according to their baseline debt position relative to the 60% threshold defined in the empirical design. In this specification, β_1 captures the marginal effect of disasters in the low-debt regime, while the sum $\beta_1 + \beta_3$ represents the corresponding effect in high-debt economies. A positive and statistically significant interaction term indicates that the debt impact of disasters becomes stronger when countries enter the shock with elevated initial debt levels.

Before presenting the main empirical results, several diagnostic tests are conducted to assess potential econometric issues in the panel data. Tests for heteroskedasticity and serial correlation reject the null hypotheses of constant variance and no first-order autocorrelation, suggesting that standard fixed-effects inference may be unreliable. Given these results and the macro-panel structure of the dataset, the regressions are therefore estimated using Driscoll–Kraay standard errors to obtain robust statistical inference.

IV. EMPIRICAL RESULTS

IV.I. DESCRIPTIVE STATISTICS

Table 2: Descriptive statistics

Variable	N	Mean	SD	Min	P50	Max
Gov_Debt	2130	49.22236	30.17776	4.442	42.9395	232.428
Disaster_Dummy	2130	.7169014	.4506097	0	1	1
Credit_Private	2130	37.22438	28.90346	1.810709	29.73186	132.817
WGI_ge	2130	-.3899787	.6465621	-2.228161	-.4467313	1.42634
GDP_Growth	2130	3.797653	4.130421	-15.13647	4.152663	17.79911

Inflation_CPI	2130	6.27422	7.690786	-2.301876	4.450193	61.13493
Gov_Cons	2130	15.00833	5.653412	5.174383	14.35002	46.26219

Table 2 reports the descriptive statistics for the main variables used in the empirical analysis. Government debt averages about 49.2% of GDP across the sample, with a wide dispersion ranging from roughly 4.4% to over 232%, suggesting substantial cross-country heterogeneity in fiscal positions among emerging and developing economies. Disaster events are relatively common in the dataset: the mean of the disaster indicator is 0.72, implying that natural disasters occur in the majority of country-year observations. Financial development, measured by domestic credit to the private sector, also varies considerably across countries, with values spanning from very low levels to over 130% of GDP. Institutional quality, proxied by government effectiveness, displays notable variation as well, reflecting differences in governance capacity across the sample. In terms of macroeconomic conditions, average GDP growth is approximately 3.8%, although the range indicates the presence of both severe contractions and periods of strong expansion. Inflation shows substantial dispersion, which is typical in cross-country macro panels that include economies with different monetary environments. Government consumption averages about 15% of GDP, with moderate variation across countries. Overall, the statistics highlight the diversity of fiscal, institutional, and macroeconomic conditions across the sample, providing useful variation for the subsequent empirical analysis.

IV.II. CORRELATION ANALYSIS

Table 3 displays the pairwise correlations between the most important factors.

Table 3: Pairwise correlations

Variable	Gov_Debt	Disaster_ Dummy	Credit_ Private	WGI_ge	GDP_ Growth	Inflation_ CPI	Gov_Cons
Gov_Debt	1.0000						
Disaster_ Dummy	-0.0403	1.0000					
Credit_ Private	-0.0401	-0.0155	1.0000				
WGI_ge	-0.0317	-0.0948*	0.6077*	1.0000			
GDP_ Growth	0.1441	0.0000	0.0000	0.0347	1.0000		
Inflation_ CPI	-0.1398*	0.0165	-0.0571*	0.1097	0.0084	1.0000	
Gov_Cons	0.1886*	0.0640*	-0.2007*	-0.1952*	-0.0500*	0.0210	1.0000
	0.0000	0.0031	0.0000	0.0000	0.0210	1.0000	
	0.1448*	-0.1816*	0.1112*	0.2024*	-0.1770*	-0.1113*	

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 1.0000

In general, the correlation coefficients are modest, indicating that extreme multicollinearity is not likely to be a significant issue in the regression analysis. Although the link is weak and not statistically significant, government debt exhibits a little negative correlation with disaster incidence. Although government consumption and inflation are positively linked with debt, GDP growth is negatively correlated. This is generally consistent with the theory that greater debt levels might be associated with worse macroeconomic performance and expansionary fiscal expenditure. While its relationship with other macroeconomic indicators seems rather weak, disaster exposure shows a little negative relationship with governmental effectiveness and government spending. Financial development and institutional quality show a rather stronger positive correlation, hence countries with more sophisticated financial systems usually also show greater level of governance capability. Importantly, most correlation coefficients remain well below traditional criteria suggesting major multicollinearity, thus supporting the inclusion of these factors in the following regression models.

IV.III. MULTICOLLINEARITY TEST

To further assess whether the explanatory variables exhibit problematic overlap, variance inflation factors (VIF) are reported in Table 4. All VIF values are well below conventional concern thresholds. The highest value is below 2, and the mean VIF equals 1.26. These results indicate that multicollinearity is not a substantive issue in the baseline specification.

Table 4: Multicollinearity diagnostics (VIF)

Variable	VIF	1/VIF
Disaster_Dummy	1.04	0.959379
Credit_Private	1.63	0.613919
WGI_ge	1.67	0.597021
GDP_Growth	1.05	0.948389
Inflation_CPI	1.06	0.939302
Gov_Cons	1.12	0.893134
Mean VIF		1.26

IV.IV. DIFFERENCES ACROSS DEBT REGIMES

It is clear that the sample is divided according to baseline debt levels. Countries classified as high-debt economies exhibit an average debt ratio above 62% of GDP, compared to roughly 40% in the low-debt group. The dispersion is also wider in the high-debt regime, indicating greater variability in fiscal positions once debt exceeds the threshold. However, disaster exposure appears almost identical across the two regimes. The mean of the disaster indicator is approximately 0.72 in both groups, suggesting that high-debt countries are not systematically more exposed to disaster events in simple frequency terms. This similarity is important because it indicates that any amplification effect identified in later regressions is unlikely to be driven by differences in disaster incidence alone.

Financial and institutional characteristics differ more sharply. Low-debt countries display substantially higher levels of private credit relative to GDP, nearly twice the average observed in high-debt economies. Government effectiveness scores are also notably higher in the low-debt regime. These patterns suggest that fiscal space is correlated with deeper financial systems and stronger institutional capacity. Macroeconomic performance shows smaller contrasts. Average GDP growth is similar across regimes, though inflation is somewhat higher in the high-debt group. Government consumption shares differ only modestly. The broad similarity in growth performance but divergence in institutional and financial indicators. It reinforces the idea that structural fiscal capacity may drive heterogeneous debt responses, rather than short-run growth conditions.

Table 5: Descriptive Statistics by Baseline Debt Regime

Variable	Regime	N	Mean	SD	Median	Min	Max
Gov_debt	Low debt	1051	39.551	21.112	37.988	4.442	155.665
	High debt	815	62.133	36.242	55.453	4.442	232.428
Disaster_Dummy	Low debt	1051	0.724	0.447	1	0	1
	High debt	815	0.723	0.448	1	0	1
Credit_Private	Low debt	1051	48.049	32.688	39.729	1.810	132.817
	High debt	815	26.936	20.339	19.947	1.810	106.568
WGI_ge	Low debt	1051	-0.133	0.662	-0.155	-2.228	1.426
	High debt	815	-0.611	0.541	-0.654	-1.881	0.723
GDP_growth	Low debt	1051	3.675	4.352	3.966	-15.136	17.799
	High debt	815	3.712	3.688	4.129	-15.136	15.844
Inflation_CPI	Low debt	1051	5.476	6.572	3.976	-2.302	61.135
	High debt	815	6.974	7.865	5.010	-2.302	61.135
Gov_Cons	Low debt	1051	14.926	5.439	14.127	5.174	41.856
	High debt	815	15.495	6.078	14.777	5.174	46.262

IV.V. BASELINE ESTIMATION RESULTS

Table 6 summarizes the baseline fixed-effects estimates column by column. Column (1) reports a baseline specification including only disaster exposure and fixed effects. The coefficient on Disaster_dummy is positive, indicating that government debt tends to rise in years when disasters occur, although the estimate is not statistically significant.

Column (2) adds macroeconomic controls. GDP growth enters with a negative and significant coefficient, suggesting that stronger economic performance is associated with lower debt levels. In contrast, inflation and government consumption are positively related to debt, implying that higher price instability and public spending are accompanied by greater borrowing needs. The coefficient on Disaster_dummy becomes slightly larger but remains statistically insignificant.

Column (3) further introduces financial development and institutional quality. The coefficients on Credit_Private and WGI_ge are not statistically significant, and their inclusion does not materially change the estimated disaster effect. Overall, while disasters appear to be followed by higher debt on average, the contemporaneous effect remains statistically weak, suggesting that the fiscal impact of disasters may emerge with some delay or depend on initial fiscal conditions.

Table 6: Baseline fixed-effects estimates

Variables	Gov_Debt(1)	Gov_Debt(2)	Gov_Debt(3)
Disaster_dummy	1.520 (1.811)	2.034 (1.680)	2.004 (1.684)
Credit_Private			0.087 (0.084)
WGI_ge			-3.367 (5.156)
GDP_Growth		-0.703*** (0.188)	-0.666*** (0.190)
Inflation_CPI		0.677** (0.300)	0.670** (0.295)
Gov_Cons		0.962* (0.555)	0.930* (0.550)
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	2130	2130	2130
Countries	119	119	119
Within R ²	0.254	0.319	0.321

Note: * p<0.1, ** p<0.05, *** p<0.01; Standard errors in parentheses

IV.VI. DRISCOLL–KRAAY FIXED-EFFECTS ESTIMATES

Table 7 reports the fixed-effects estimates using Driscoll–Kraay standard errors.

Table 7: Driscoll–Kraay fixed-effects estimates

Variables	(1)	(2)
	Current	Lag Effect
Disaster_dummy	2.004* (1.118)	-
L.Disaster	-	3.718*** (1.291)
Credit_Private	0.087 (0.060)	0.066 (0.057)
WGI_ge	-3.367 (2.421)	-2.924 (2.508)
GDP_Growth	-0.666*** (0.151)	-0.701*** (0.159)
Inflation_CPI	0.670*** (0.166)	0.591*** (0.172)
Gov_Cons	0.930*** (0.219)	0.864*** (0.208)
Country FE	Yes	Yes
Year FE	Yes	Yes
Observations	2130	2074
Countries	119	119
Within R ²	0.321	0.321
Estimator	Driscoll–Kraay FE	

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parentheses

Column (1) reports the contemporaneous effect of disasters on government debt. The coefficient on Disaster_dummy is 2.004 and statistically significant at the 10% level. This estimate suggests that government debt increases by about 2% of GDP in years when a disaster occurs. Although the immediate effect is moderate, the positive sign is in line with the expectation that reconstruction and relief spending create additional borrowing needs.

Column (2) replaces the contemporaneous disaster variable with its one-year lag. The coefficient on L.Disaster equals 3.718 and is statistically significant at the 1% level. The magnitude is notably larger than in column (1), indicating that the fiscal impact of disasters becomes more pronounced in the year following the shock. This delayed pattern is economically reasonable, as reconstruction projects, supplementary budgets, and borrowing operations often extend beyond the disaster year itself. The stronger statistical significance in the lagged specification suggests that debt adjustment is not instantaneous but unfolds over time.

Across both specifications, the control variables display stable and intuitive patterns. GDP growth is negatively and strongly associated with debt, indicating that stronger economic performance helps contain debt ratios. Inflation is positively related to debt, which may reflect macroeconomic instability or higher nominal borrowing needs. Government consumption also enters with a positive and significant coefficient, suggesting that higher public spending shares are accompanied by greater debt accumulation. The coefficients on Credit_Private and WGI_ge are not statistically significant in these baseline specifications.

To summarize, the Driscoll–Kraay estimates indicate that natural disasters contribute to higher public debt, with the effect becoming stronger when a one-year adjustment period is considered. It can be seen that this represents a gradual fiscal adjustment rather than a numerical simple fluctuation in debt.

IV.VII. HETEROGENEITY TEST

Table 8 examines whether the debt impact of disasters depends on the initial fiscal position of a country. It includes an interaction term between Disaster_dummy and the high-debt indicator.

Table 8: Heterogeneity by debt level

Variables	Gov_Debt
Disaster_dummy	0.280 (1.005)
Disaster × High-Debt	3.745** (1.663)
Credit_Private	0.086 (0.060)
WGI_ge	-3.353 (2.426)

GDP_Growth	-0.665***
	(0.150)
Inflation_CPI	0.673***
	(0.167)
Gov_Con	0.943***
	(0.220)
Country FE	Yes
Year FE	Yes
Observations	2130
Countries	119
Within R ²	0.323

The coefficient on Disaster_dummy alone is small and not statistically significant. This coefficient captures the effect of disasters in the low-debt regime, since High-Debt equals 0 in that group. The estimate suggests that, for countries with baseline debt below 60% of GDP, disasters do not lead to a statistically meaningful increase in debt within the same year. The interaction term between Disaster and High-Debt is positive and statistically significant at the 5% level. The coefficient equals 3.745, indicating that the disaster effect is substantially larger in countries that entered the shock with high debt levels.

To interpret the magnitude more clearly, the marginal effect in high-debt countries is obtained by adding the coefficient on Disaster_dummy and the interaction term. This implies an estimated increase of approximately 4% of GDP in high-debt economies following a disaster (0.280 + 3.745). The difference between regimes is economically meaningful.

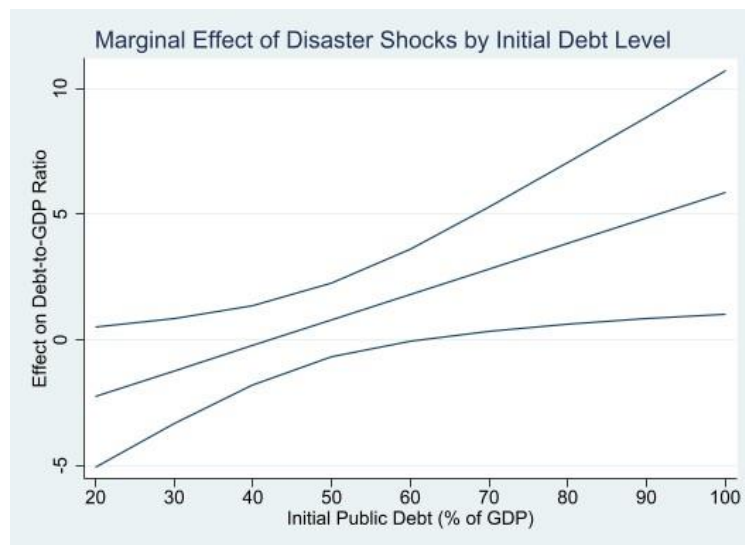


Figure 1. Marginal Effects of Disasters by Debt Regime

This result suggests that disasters do not affect all countries in the same way. When debt is already elevated, fiscal space is more limited and borrowing needs appear to translate more directly into higher debt ratios. In contrast, countries with lower initial debt may have greater room to absorb shocks without a comparable increase in public debt.

The control variables remain stable and consistent with earlier specifications. GDP growth continues to reduce debt, while inflation and government consumption are positively associated with debt accumulation. Financial depth and government effectiveness remain statistically insignificant in this specification.

The margins plot further illustrates the difference between regimes. The estimated effect of disasters in low-debt countries is close to zero and not statistically different from zero. In contrast, the effect in high-debt countries is clearly positive, and the confidence interval does not overlap with zero. The visual evidence reinforces the regression results and highlights the state-dependent nature of disaster-related debt dynamics.

These findings indicate that the fiscal consequences of disasters depend on initial debt conditions strongly. High-debt countries experience a significantly larger increase in public debt following disaster shocks, supporting the hypothesis that fiscal vulnerability amplifies disaster effects.

IV.VIII. ROBUSTNESS CHECKS

Table 9 reports two additional specifications designed to test the robustness of the heterogeneous disaster effect. Column (1) introduces a lagged interaction between Disaster and the high-debt indicator. The coefficient on Disaster(t-1) is positive and statistically significant at the 5% level, indicating that disasters continue to raise debt in the following year. More importantly, the interaction term between the lagged disaster variable and the high-debt indicator is also positive and statistically significant. The estimated coefficient suggests that the delayed debt response is substantially larger in high-debt economies. Combining the main lag effect and the interaction term implies that the total increase in debt in high-debt countries exceeds 6% age points of GDP in the year after a disaster (1.683 + 4.400). This magnitude is economically meaningful and reinforces the earlier finding that fiscal vulnerability amplifies disaster impacts.

Column (2) tests whether the results depend on the 60% debt threshold by redefining the high-debt regime using a stricter 70% cutoff. Under this alternative classification, the interaction term remains positive and statistically significant. Although the contemporaneous disaster coefficient is not significant on its own, the amplification effect in high-debt countries persists. This suggests that the heterogeneity result is not driven by a specific threshold choice.

Across both robustness specifications, the control variables remain stable. GDP growth continues to reduce debt ratios, while inflation and government consumption are positively associated with debt. The consistency of these coefficients across models supports the reliability of the main findings.

In conclusion, the robustness checks confirm that the amplification of disaster effects in high-debt countries is not sensitive to timing assumptions or to the definition of the debt threshold. The results indicate that fiscal vulnerability strengthens the debt response to disaster shocks.

Table 9: Robustness checks

Variables	(1)	(2)
	Lag interaction	70% threshold
Disaster(t-1)	1.683** (0.700)	-

Disaster(t-1) ×High Debt	4.400*	-
	(2.076)	
Disaster	-	0.781
		(0.972)
Disaster(t-1) ×High Debt (70%)	-	3.302*
		(1.942)
Credit_Private	0.067	0.086
	(0.058)	(0.060)
WGI_ge	-2.872	-3.342
	(2.502)	(2.412)
GDP_Growth	-0.701***	-0.661***
	(0.158)	(0.152)
Inflation_CPI	0.590***	0.675***
	(0.174)	(0.167)
Gov_Cons	0.866***	0.946***
	(0.210)	(0.223)
Country FE	Yes	Yes
Year FE	Yes	Yes
Observations	2074	2074
Countries	119	119
Within R ²	0.322	0.322
Estimator	Driscoll–Kraay FE	

Note: * p<0.1, ** p<0.05, *** p<0.01; Standard errors in parentheses

V. CONCLUSION

This study examines how natural disasters affect government debt dynamics in emerging and developing economies. The empirical results indicate that disaster shocks are associated with increases in public debt, although the contemporaneous effect is relatively limited. Once a one-year adjustment period is considered, the debt response becomes larger and statistically significant, suggesting that fiscal consequences tend to materialize with a delay. This pattern is consistent with the timing of post-disaster reconstruction spending and borrowing decisions, which often extend beyond the year in which the disaster occurs.

The analysis also reveals strong heterogeneity across fiscal conditions. In countries with relatively low initial debt levels, disasters do not lead to a statistically significant increase in public debt. By contrast, high-debt economies experience a substantially larger debt response following disaster shocks. This finding indicates that fiscal vulnerability plays an important role in shaping the macro-fiscal consequences of disasters. When governments enter a disaster episode with already elevated debt burdens, limited fiscal space appears to translate reconstruction and stabilization needs more directly into higher borrowing.

Overall, the results suggest that maintaining fiscal space is an important component of macroeconomic resilience to natural disasters. As climate-related shocks become more frequent, governments may need to strengthen fiscal buffers and develop more effective disaster-risk financing mechanisms to reduce the long-run fiscal consequences of extreme events. Future research could further explore how disaster severity, financial development, or fiscal institutions influence the debt adjustment process following climate-related shocks.

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