Fiscal Federalism in the Face of Flood Disasters: Evidence from U.S. States

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Abstract: This study examines the impact of frequent and severe flooding events on state intergovernmental revenue and expenditure, as well as on total revenue, tax revenue, and total expenditure. Panel data from 50 U.S. states between 1997 and 2020 are constructed, and the analysis employs a two-way fixed-effects model. The results show that increased severity of flooding leads to higher state intergovernmental revenue two years after the disaster, but states do not necessarily pass down more funds to localities. There is also evidence that increased flooding severity coincides with higher state tax revenue and larger total expenditure.

Keywords: fiscal federalism, public budgeting, emergency management, flooding, state government
JEL codes: Q54, H7, H12, H30, H53

1. Introduction

The United States has seen an increasing frequency and intensity in disaster events over the last few decades. According to the National Centers for Environmental Information (NCEI), under the National Oceanic and Atmospheric Administration (NOAA), the average count of disasters with larger-than-$1-billion costs quadrupled from 3.1 per year in the 1980s to 12.8 per year in the 2010s. As Figure 1 demonstrates, in 2022 alone, there were 18 major disaster events recorded across the country, including severe storms, tropical cyclones, wildfires, winter storms, drought, and flooding. This study focuses on one type of disasters, flooding, for three reasons: the damage level it has caused, the increasing intensity associated with climate change, and the ubiquity across the U.S.

First, a NOAA technical memorandum marks that flooding was responsible for more than 100 fatalities per year from 1959 through 1991 (Dittmann, 1994). A separate record reports that between 1974 and 2014, the average damage due to flooding was around $8 billion annually (NOAA, 2015). Accounting for major events in the last five years, flood events have cost the federal government an aggregate of $49 billion and 93 deaths (NOAA NCEI, 2022a). The Federal Emergency Management Agency (FEMA, n.d., para. 3) additionally noted that "flooding causes more damage in the United States than any other severe weather-related event, an average of $5 billion a year." Beyond these, flood events also cause incalculable harm, such as maternal health, injuries, psychological trauma, and displacement (Doocy et al., 2013; Rufat et al., 2015; Sugg et al., 2023).

[Figure 1 here]

Second, several observational studies have shown that flooding is becoming more intense across the globe, including in large areas of the U.S. (Archfield et al., 2016; Mallakpour & Villarini, 2015; Slater & Villarini; Tellman et al., 2021; Wing et al., 2022). Scientists have not unanimously attributed the increase of flood events solely to climate warming, noting certain societal factors (i.e., urban development and water management) might have concurrently influenced their prevalence (Hirsch & Ryberg, 2012; Hodgkins et al., 2017; Intergovernmental Panel on Climate Change [IPCC], 2014; Pielke, 1999; Prein et al., 2017). But it is undeniable that extreme precipitation contributes to flooding and, as suggested in the federal government's Fourth National Climate Assessment, that "observed increases in the frequency and intensity of heavy precipitation events in most parts of the United States are projected to continue" (Hayhoe et al., 2018).

Third, unlike some other forms of disasters, flooding is possible in all of the 50 states in the U.S. at any time of the year (National Severe Storms Laboratory, n.d.). The ubiquity of flooding is essential for this study as it helps with the estimation strategy employed in the analysis (more on this later in the Methodology section). By way of comparison, other notable disasters like wildfires are typically found in the Western region of the U.S., while hurricanes mostly happen only in the Southern region; these limit the variability necessary to empirically estimate the average impact of a specific disaster across *all* states.

From a policy perspective, the notable scale of flooding in the U.S. raises important questions: what are the implications of flooding events for the government budget and what can be done to maintain fiscal resilience? This study attempts to address those questions by specifically evaluating how flooding impacts state intergovernmental revenue and expenditure. In the U.S., the function to manage disasters is shared primarily between the federal and state governments, therefore it is important to understand the fiscal dynamics between these levels of government. The analysis will additionally consider other components of the state budget, such as total revenue, tax revenue, and total expenditure. In addressing the research question, the analysis applies two-way fixed effects model on a panel data of 50 U.S. states between 1997 and 2020. To the best of the author's knowledge, no previous studies have specifically investigated the incidence of flooding in the state budgeting context. Accordingly, the research aims not only to contribute to the literature in public policy and administration but also to inform policy practitioners in the relevant domain.

Following this introductory section, this paper is organized as follows: Section 2 provides a discussion of the analytical framework relevant to the fiscal implications of natural disasters; Section 3 describes data collection and sources; Section 4 outlines the methodology; Analysis results and discussion are presented in Sections 5 and 6; and finally, Section 7 presents conclusions.

2. Theoretical framework

Disaster management is a shared function between the federal and state governments in the US.[1] Initially, the responsibility for carrying out post-disaster reconstruction efforts used to rest with states. However, it became evident that the burden was overwhelmingly beyond the capacity of individual states, paving the way for a greater federal role in preparing for and responding to

[1] Downey and Myers (2020) offer a valuable discussion of U.S. federalism from an international perspective, and explore how different systems compare with each other in their responses to disasters

disasters. In 1950, the US Congress passed the Federal Disaster Relief Act, which granted authority for federal actions, shifted the legislative responsibility to the executive branch of government, and committed the federal government to providing sufficient assistance to states and localities (Bea, 2012). The establishment of the Federal Emergency Management Agency (FEMA) by President Carter in 1979 led to a further expansion of the federal government's involvement in disaster response and recovery efforts. Upon the declaration of an emergency and requests from the state governor, a sitting president would have discretion over funding mobilization to states.

Given the shared nature of fiscal governance in the US, this study aims to explore the degree to which the state intergovernmental revenue, primarily sourced from the federal government, is responsive to disaster events. From the state government's perspective, intergovernmental revenue measures the availability of "extra" resources when the need arises. From the federal perspective, this budget component delineates the occasions and amounts of resources spent externally during emergencies.

Past studies that examined the fiscal implications of natural disasters at the state level did not specifically address flooding as a distinct form of disaster. For example, Fidrmuc (2015) and Miao et al. (2018) found that disasters, broadly defined, frequently lead to rises in state intergovernmental revenues that are largely financed through federal transfers. Other studies look at individual types of disasters, such as wildfires (Liao and Kousky, 2021), hurricanes (Deryugina, 2017; Jerch et al., 2023), as well as flooding (Crow et al., 2018; Sarmiento et al., 2006). Most of these, however, consider lower-level jurisdictions (i.e., counties or municipalities) as the unit of analysis. Sarmiento et al. (2006) found that a disaster could interrupt activities and resources that would have been eligible for federal grants, resulting in lower intergovernmental revenue. Beyond those, there were cases in which intergovernmental transfers were found to be unaffected by disaster events (Liao and Kousky, 2021). The study aspires to fill the gap in existing literature by integrating *state-level analysis* with the incidence of *flooding*.

Increased state intergovernmental revenue following disasters affirm a policy preference for response over mitigation – a tendency that has long been observed by many, especially at the federal level. As Rubin (2012, pp 7) asserted, "federal government by and large continued to be ad hoc and reactive until the latter half of the twentieth century." While conducted with state-level data, this study begins with the same hypothesis that state intergovernmental revenue is expected to increase after flooding events. Donahue and Joyce (2002) argue that this inclination is attributable to a combination of institutional rigidity and political incentives inherent within the US federal government. First, under the federal budget rules, the allocation of resources for *ex-ante* mitigation necessitates competing against other priorities through the regular appropriations process. In contrast, setting aside response funding *after* a disaster occurs with the emergency designation is more straightforward. Second, building on Peterson's (1995) functional and legislative theory of federalism, Donahue and Joyce (2002) posit that public officials typically steer clear of mitigation efforts as they involve minimal visible actions that can be translated into electoral gains. Consistent with this view, Healy and Malhotra (2009) analyze over 3000 counties across the US and present evidence suggesting that voters tend to reward the incumbent presidential party for delivering disaster relief, but not for investing in disaster preparedness.

The analysis also considers state intergovernmental expenditure, as flooding events can have implications for states not only on the revenue side but also on the expenditure side of the budget. As previously discussed, government actions to manage disasters in the US may be performed at the national or state level. There are also instances when local governments (e.g., counties or municipalities) use their resources to take actions, albeit on a limited scale. For instance, the 1000-year-rain event in St. Louis, Missouri in mid-2022 triggered major flooding resulted in the federal government's decision to provide emergency aid (Cappucci, 2022; FEMA, 2022b). In total, more than $33 million was approved to help flood victims in affected areas: $20.4 million in individual assistance grants for renters and homeowners, $8.6 million in claims for the National Flood Insurance Program policyholders, and $4 million in disaster loans for households and businesses. Meanwhile, minor flooding that inundated parts of Maryland, Virginia, and Washington D.C. just a few weeks later was locally resolved. More than $240 million were allocated by Maryland's Prince George's County (2022) for flood mitigation programs, including stormwater management and watershed protection and restoration in 2023.

In fiscal federalism theory, Oates (1972) introduces the term 'correspondence principle' to explain that ideally, the assignment of government expenditure for public goods should align with the benefit coverage. Applying this theory, Bisaro et al. (2020) develop a multilevel governance framework for managing coastal floods, which considers heterogenous local preferences, appropriate level of government responsible for making decisions, aligned financing sources and beneficiaries, and the extent of spillovers of the public goods. While spending through localities is more effective for programs that benefit from local implementation and monitoring, such as interactive flood risk maps and property acquisition and redevelopment (Fraser et al., 2003), spending through state agencies is better suited for programs that extend beyond local boundaries and require regional partnerships, such as major infrastructure projects (Caruson & MacManus, 2008; Lubell et al., 2021; McGlynn et al., 2024).

This study seeks to understand the directionality of state intergovernmental expenditure after flood disasters -- a phenomenon that has yet to be fully understood from a policy lens. Specifically, the analysis examines whether the state-local fiscal relationship, as indicated by state intergovernmental expenditure, mirrors the federal-state dynamic, as measured by state intergovernmental revenue.

3. Data

3.1. Constructing flooding dataset

FEMA (2020) describes flooding as “a general and temporary condition of partial or complete inundation of 2 or more acres of normally dry land area or of 2 or more properties.” Several things may cause this, such as an overflow of inland or tidal water, unusual runoff of surface waters, and collapse of land along the shore of a lake. In the U.S., however, there are no scales or indexes that are conventionally used to categorize flooding events based on their severity and frequency levels. As a result, it becomes quite challenging to study this disaster type through cross-sectional and intertemporal lenses. The NOAA database, for instance, includes four types of events -- “flood”, “flash flood”, “coastal flood”, and “lakeshore flood,”[2] but does not specify the magnitude of each event. In contrast, NOAA documents and classifies hurricanes into five Saffir-Simpson severity scales. Another example comes from the National Drought Mitigation Center at the University of Nebraska-Lincoln, which develops the Drought Severity and Coverage Index to monitor drought levels (Akyuz, 2017). This study makes use of data that are available and proceeds with two distinct measures of flooding: in a given state and year, the amount of flooding insurance claims as a proxy for flooding *severity*, and the number of flooding events as a proxy for *frequency*. As Figures 2 and 3 demonstrate, there has been an increasing trend in both flooding insurance claims and flooding events in the US since 1996.

[2] Flooding, which could last days or even weeks, is a longer-term event than a flash flood that typically clears within six hours or less (NOAA, 2022a). Flash floods are also often commonly referred to as rapid hydrological events triggered by local, intense rainfall (Kruczkiewicz et al., 2021).

Flooding insurance claims data are obtained from the National Flood Insurance Program (NFIP) records administered by FEMA (2022c). NFIP covers for buildings and contents within the building structures that are damaged by flooding events. This data set has more than 50 million transactions collected since the 1980s. Personally identifiable information is redacted, but other key information is retained, including types of damaged building structures, years of loss, locations, and claims. As part of data cleaning, total claims in each state throughout the years of observation are aggregated. Total claims represent amounts in dollar terms that are paid on the building claims as well as contents claims. To support that flooding insurance claims is an appropriate measure of severity, its correlation with the monetary damage of weather disasters in a given state and year as measured by the National Weather Service (2021) was tested. This exercise generated a strong correlation pattern with a correlation coefficient of 0.89. Higher flooding insurance claims are associated with more severe flooding incidence.

[Figure 2 here]

[Figure 3 here]

Flooding events data are collected from the NOAA's National Centers for Environmental Information (NCEI) official publication. The agency has recorded natural disasters in the U.S. since the 1950s. Until the 1990s, however, it documented only certain types of disaster events, such as tornados, thunderstorms, and hail. The agency then upgraded the database in 2000. Among the changes was the way an event was entered; instead of free-text entries, NOAA added predetermined types of disasters to improve data functionality and consistency. Previously, there had been up to 950 unique event types, but with the change the number was reduced to fewer than 50 event types (NOAA, 2022b). This standardization, applied to natural disasters recorded from 1996 onwards, allows for identification and analysis of a specific disaster type, like flooding. There are several types of floods in the NOAA database, such as flood, flash flood, coastal flood, and lakeshore flood, and all will be included in the analysis. This NOAA data further provides information as to when and where a disaster event occurred, which enables me to identify and quantify the number of flooding events in a given state and year.

There are potential limitations to the severity and frequency measures employed in this study. First, flooding insurance claims could be correlated with the quality of flood mitigation infrastructure provided by the government. A more severe disaster may not necessarily lead to higher damage if the government capacity to mitigate it is excellent. In contrast, with poor mitigation capacity, even a less severe disaster can result in an expensive monetary damage. To overcome potential endogeneity, the model will control for state government spending on sewerage. Second, flooding insurance claims could also be correlated with property values. For instance, flooding with the same magnitude can lead to higher (or lower) claims for households living in an affluent (or lower income) area. To address this potential endogeneity, per capita personal income will also be controlled for in the model. Other studies on natural disasters also use similar type of measurement, such as the monetary costs of property and crop losses (Miao et al., 2018). Third, frequency might not perfectly capture the magnitude of a disaster. But frequency is a distinct concept in and of itself, and it is arguably a more direct measure of any disaster type relative to claims and monetary damage. From a policy standpoint, more frequent flooding events, regardless of their magnitude, can still negatively affect communities in the short and long terms.

3.2. Measuring the state budget

Budget data were obtained from the U.S. Census Bureau. Every year, the agency conducts the Annual Survey of State Government Finances to collect budget data from all 50 states. The level of detail that goes beyond aggregate amounts (i.e., total revenue, total expenditure) provides an avenue for more granular analysis of the budget. Also, since data are stored in one place, accessing the database is more time efficient as compared to collecting the same information state by state (i.e., from each state government website.) An additional source for the state expenditure on sewerage data is the Willamette University's Government Finance Database (Pierson et al., 2015), which is a formatted and consolidated version of the U.S. Census Bureau's state finance data.

Figure 4 illustrates the state government budget structure analyzed in the study. At the broad level, the budget is comprised of two major flows: total revenue and total expenditure. Total revenue is subdivided into tax revenue, intergovernmental revenue, and other. State tax revenue is raised by the respective state and includes sales and income tax, among other subcomponents. Intergovernmental revenue, also included in the state budget structure, is money transferred from other government entities, almost exclusively from the federal government. On the expenditure side, the components, according to the entity responsible for executing the budget, are direct expenditure, intergovernmental expenditure, and other. This essentially is fiscal federalism at work (Oates, 1972). The federal, state, and local authorities in the U.S. each contributes to government functions, as reflected in the way revenue and expenditure are structured and managed. Figures 5 and 6 demonstrate state revenue per capita and state expenditure per capita, respectively, over the observation periods. Visually, revenue and expenditure increased over time, though total and tax revenues experienced dips around 2008-2009, due to the Great Recession.

[Figure 4 here]

[Figure 5 here]

[Figure 6 here]

3.3. Controlling for state economic conditions

Economic data and other control variables are obtained from the University of Kentucky Center for Poverty Research (UKCPR, 2022). The center collects relevant variables from various sources, such as U.S. Census Bureau (population, the number of state employees), Bureau of Labor Statistics (unemployment rate), U.S. Department of Commerce's Bureau of Economic Analysis (Gross State Product, personal income), and the Council of State Governments (governor's party affiliation). States like California and Texas are much different in terms of economic size and population from Wyoming and Vermont. Considering their influence on the size of the state budget, these need to be accounted for. Both unemployment rate and personal income are measures of affluence in a given state and year, which may correlate with how much a state collects in taxes and spends for public services. The number of full-time equivalent state employees are included in the analysis to control for government capacity. Lastly, governor's party affiliation reflects how the state government perceives and carries out tax policies and public spending.

Accounting for data availability, this study constructs a panel data with 50 cross-sectional units (i.e., 50 states) for a 24-year period from 1996 through 2020. The result is a balanced panel data with 1200 observations altogether. Table 1 summarizes sources from which data are obtained in the study, and Table 2 reports the summary statistics for all variables in the analysis.

[Table 1 here]

[Table 2 here]

4. Methodology

4.1. Basic Approach

This study employs a two-way fixed effects regression model to estimate the impact of flooding events on state finances. The model is appropriate for panel data, in which a set of states is observed repeatedly across several years. Throughout the analysis, the identifying assumption is that some unobservable state characteristics that affect both the outcome variable and independent variable of the regression are time-invariant. With the fixed effects model, these unobserved variables need not be measured but could be controlled for. The threat of omitted variable bias is greatly reduced as a result. Examples of time-invariant state characteristics related to flooding are geographic and topographic features. Some states located near the coast (e.g., New York, South Carolina, and California) or bordering the Great Lakes (e.g., Wisconsin, Michigan, and Ohio) will unlikely change in the foreseeable future. Inclusion of state fixed effects removes these presumably time-invariant characteristics, measuring changes "within" each state over time.

Flooding, like many other disasters, is often unpredictable. While the weather forecast agency can predict whether the next few days or even weeks will have rain, the extent of likely flooding is typically assessed on a real-time basis (U.S. Geological Survey, 2022). A state can reasonably anticipate a flood, but it cannot fully control its occurrence. Studies report that flooding is influenced by not only the climate but also some societal factors (Kunkel et al., 1999; Changnon et al., 2000). For example, there is evidence that GDP and population, which account for social and economic conditions, can affect the level of flooding hazards (Barredo, 2006; Choi & Fisher, 2003; Pielke & Downton, 2000; Zhou et al., 2017). Others also discussed the role of government capacity in developing and implementing flood mitigation techniques (Brody et al., 2010; Shabman & Scodari, 2014). These variables vary from time to time and will not necessarily be accounted for by the fixed effects model. Since their omissions will cause bias, this study proceeds by including in the model several relevant time-varying indicators as control variables in each state and year, such as gross state product, population, unemployment rate, personal income per capita, number of state government employees, state government spending on sewerage, as well as the governor's party affiliation.

4.2. Econometric Model

The model takes the following functional form:

$$budget_{it} = \alpha + \sum_{k=0}^{3} \beta_k flooding_{it-k} + \beta_4 gsp_{it} + \beta_5 population_{it} + \beta_6 unemployment_{it} + \beta_7 pcincome_{it} + \beta_8 bureaucracy_{it} + \beta_9 governor_{it} + \beta_{10} sewerage_{it} + \lambda_i T + \tau_t + \mu_i + e_{it}$$

$budget_{it}$	: budget indicator in state *i* in year *t*
$flooding_{it}$	: flooding frequency or severity (log-transformed) in state *i* in year *t*
gsp_{it}	: gross state product (log-transformed) in state *i* in year *t*
$population_{it}$	: population (log-transformed) in state *i* in year *t*
$unemployment_{it}$	: unemployment rate in state *i* in year *t*
$pcincome_{it}$	: per capita personal income in state *i* in year *t*
$bureaucracy_{it}$	: number of fulltime equivalent employees per capita in state *i* in year *t*
$governor_{it}$	: governor's party affiliation in state *i* in year *t*
$sewerage_{it}$	: sewerage spending as a share of total expenditure in state *i* in year *t*
λ_i	: state-specific trend
T	: year
τ_t	: year fixed effect
μ_i	: state fixed effect
e_{it}	: idiosyncratic error terms
α	: intercept

This study will run multiple regression models individually using a set of budget indicators ($budget_{it}$) as the dependent variable. The budget indicators are (1) state intergovernmental revenue and (2) state intergovernmental expenditure, each in log-transformed terms. Additionally, in the analysis there is also a model using (3) state total revenue, (4) state tax revenue, and (5) state total expenditure as the dependent variables. This log transformation is helpful to get the variables closer to a normal distribution as well as to make the data easier to interpret.

The analysis aims to evaluate the impact of an increased frequency and severity of flooding on the state government budget indicators. The key independent variable is $flooding_{it}$ which is comprised of two measures: flooding severity (i.e., the amount of flooding insurance claims) and flooding frequency (i.e., the number of flooding events), both log-transformed, in a given state and year. The analysis also considers $lagged\ flooding_{it}$, separately and collectively, in addition to $flooding_{it}$ in the regressions. This allows the analysis to assess the impact of a natural disaster not only during the year it occurs but also up to three years after. Taken together, the dependent variables and the key independent variable test the hypotheses whether a budget indicator changes with increased frequency and increased severity of flooding.

The model includes several control variables. First, gsp_{it} is the gross domestic product of state i in year t, and $population_{it}$ measures the number of state population in state i in year t. Next, $unemployment_{it}$ is the unemployment rate of state i in year t while $pcincome_{it}$ is per capita personal income in state i in year t. To control for government capacity in providing public goods and services (i.e., capital outlay and maintenance expenditure) associated with flood mitigation, the model includes $sewerage_{it}$, sewerage spending as a share of total expenditure, and $bureaucracy_{it}$, the number of fulltime equivalent employees per capita in state i in year t. $governor_{it}$ denotes the governor's party affiliation in state i in year t.

λ_I is state-specific trend, which captures the budget trend over the years of observation. Year dummies (τ_t) are included to control for variables that are constant across states but may change through time. One example is the condition of the U.S. national economy (i.e., economic boom or economic crisis) that might have affected all 50 states. The state fixed effect is denoted μ_i. Finally, the model also considers robust standard errors, clustered at the state level, to overcome outliers in the observations. It will safely correct the standard errors under heteroskedasticity.

5. Results

5.1. Flooding implications for intergovernmental transfers

The first part of the analysis evaluates the relationship between the federal government and state governments in the aftermath of flooding events. It examines the impact of two distinct measures of flooding, increased *severity* and increased *frequency,* on state intergovernmental revenue. The baseline result indicates that state intergovernmental revenue tends to increase after flooding, though there is a nuance to this finding. Panels A and B of Figure 7 demonstrate increases in the first year after both flooding measures. However, none of the estimates are statistically significant. In the second year, the effect associated with an increased severity (Panel A) went further up, while that associated with an increased frequency (Panel B) moved closer to zero.

The full estimation results are provided in Tables 3 and 4. Holding all else equal, a 1-percent increase in the number of flooding insurance claims coincides with a 0.001-percent increase in intergovernmental revenue two years after flooding. The positive result is statistically significant at the 10% level. As an illustration, consider Florida's fiscal year 2019 budget, just before the COVID-19 pandemic. According to the US Census Bureau, intergovernmental revenue accounted for approximately $30 billion. A 0.001-percent increase in intergovernmental revenue equates to more than a quarter of a million dollars. This is significant in nominal terms and can substantially impact the quality and quantity of public goods and services that the state can afford. The accumulated amount may be even higher if the state experiences more severe flooding events in a given year.

The next part of the analysis investigates state-fiscal fiscal relations after flooding through examining the effect of flooding on state intergovernmental expenditure. As states generally receive more intergovernmental funding after flooding, it is worth exploring whether, and to what extent, state governments pass this funding down to localities. Significantly, however, the federal-state fiscal relationship – whereby federal authorities give help to the states -- may or may not be replicated in the state-local fiscal relationship. Panels A and B of Figure 8 illustrate statistically null results within three years after flooding, and Tables 5 and 6 report the full estimation results. The coefficients are not statistically distinguishable from zero, suggesting no changes in transfers from states to other government entities, most of which are local governments.

This study uncovers an asymmetry between federal-state and state-local relationships. Following flooding events, states receive higher intergovernmental funds but do not necessarily pass down more funds to localities. This finding is consistent with the study by Sarmiento et al. (2006), which indicates that flooding has little statistical relationship with inter-governmental revenues in local government.

[Figure 7 here]

[Table 3 and Table 4 here]

[Figure 8 here]

[Table 5 and Table 6 here]

5.2. Flooding implications for state tax and total revenues

The previous section showed that intergovernmental revenue is responsive to severe flooding. Transfers may be justified during emergency as a countercyclical measure. It operates under the assumption that state economy weakens following flooding, thereby weakening the nation as a whole. To test this assumption, the next analysis considers the implications of flooding for state *total revenue* and *tax revenue*. When flooding occurs, affected governments likely face a fiscally challenging period. Flooding potentially disrupts local economic activities and, because residents are unable to work and run businesses, they pay fewer taxes to the government. The hypothesis is that flood disasters reduce revenue through local taxes.

Figure 9, Panels A and B, along with Tables 7 and 8, indicate that neither flooding *severity* nor *frequency* had significant effects on the state total revenues up to three years following the events. But a closer examination of a specific component, tax revenue, reveals a more interesting result. As Figure 10 Panels A and B show, state tax revenue was positively affected by an increased *severity* of flooding, but not by an increased *frequency* of flooding. The effect was observed during the year of flooding and one year after the disaster struck. Tables 9 and 10 provide the estimates of flooding severity and frequency effects on state tax revenues. Holding all other variables constant, a 1-percent increase in the severity of flooding coincides with a 0.001-percent increase in tax revenue during the year of flooding, and this effect was sustained one year after flooding. The results are statistically significant at the 10-percent level.

The positive effect of increased severity on state tax revenue, while disproving the prior hypothesis, might appear counterintuitive. Severe flooding, in theory, should have negatively impacted the economy. As the productivity of the economy was curtailed, tax collection by the state would likely have been lower. Considering disasters broadly, prior studies have attributed such adverse influences on the budget component to disruptions to local economic activities (Jerch et al., 2020) and reduced property values (Sarmiento et al., 2006; Miao et al., 2018). However, other studies have discussed alternative mechanisms through which tax revenues increased rather than decreased following a major disaster. A disaster event could lead to an uptick in tax revenue, partly attributable to a surge in recovery consumption (Ismayilov & Andrew, 2016; Miao et al., 2018) and property value reassessment (Liao & Kousky, 2021).

Gillespie (1991, p. 2 as cited in Baade et al., 2006, p. 2063) argued that in the aftermath of Hurricane Hugo, the economic disruption was just temporary and the reconstruction activities "more than offset the brief loss of jobs in the tourism and trade sectors." In a post-disaster study of Hurricane Andrew, Burrus et al. (2002, p. 118) observed that substantial damage to the local economy was "ameliorated by reconstruction-related local spending (financed largely from extra-regional sources, such as insurance claim payments and federal disaster funds)." Similarly, Baade et al. (2006, p. 2072) suggested that taxable sales in Miami reached their post-Andrew peaked "within 3 months and the bump in economic activity persisted for fully 18 months." Higher consumption associated with local reconstruction is more likely the case after major floods. The same argument might also explain the differential impacts of increased severity and increased frequency of flooding events.

[Figure 9 here]

[Table 7 and Table 8 here]

[Figure 10 here]

[Table 9 and Table 10 here]

5.3. Flooding implications for state expenditure

As previously discussed, higher federal transfers to states are intended to be a precautionary measure against the adverse impact of flooding, serving the federal government's stabilization function. In the same vein, higher state spending can be justified as a countercyclical measure by the state itself. In this context, state expenditure also becomes a mechanism for stabilizing the economy (Musgrave, 1959). An additional analysis is performed to estimate the implications of flooding events for the spending side of the state budget. The hypothesis is that total state expenditure increases following such flooding events.

Figure 11 Panel A shows that *more severe* flooding events increased total expenditure up to three years after the disaster. But Panel B of Figure 11 shows that *more frequent* flooding did not lead to higher state total expenditure. The full estimation results are presented in Tables 11 and 12, respectively. Holding all other things constant, a 1-percent increase in the severity of flooding, measured by the number of flooding insurance claims, coincides with a 0.001-percent increase in total expenditure on year 2 and 3 after flooding. Including all control variables, the results are statistically significant at the 1-percent level. Although the percentage may seem small, the numbers translate to a significant amount in dollar terms. Consider the annual budget of the same state as in the previous analysis, Florida. In Fiscal Year 2019, Florida's total expenditure was around $103.1 billion. A 0.001-percent increase in Florida's total expenditure is equal to an additional spending of more than one million dollars.

Taken together with the previous analysis, it appears that higher state spending in response to flooding is carried out through state agencies rather than localities. This approach is suitable for programs that extend beyond local boundaries and require regional partnerships. The results also reveal another contrasting effect between flooding severity and flooding frequency on state budgets. While state governments tend to be more responsive to *severe* flooding, it's important that the cumulative impact of small but frequent flooding events are not to be ignored. This insight highlights the need for a comprehensive strategy in flood disaster management and budget planning, one that accounts for both the *severity* and *frequency* of flooding. By adopting such a multifaceted approach, policymakers can better allocate resources and implement measures to mitigate the long-term ramifications of floods.

[Figure 11 here]

[Table 11 and Table 12 here]

6. Discussion

One of the key findings is that after severe flooding events, state governments receive increased federal funding. This might have been well-intentioned given the conventional view that natural disasters like flooding would have a negative impact on state economies. In such cases, higher federal transfers to states are expected to stimulate the economy. However, my analysis shows no evidence of weakened state economies within three years after flooding. Instead, the empirical results show that state tax collection, indicative of economic activities at the state level, was positively affected by increased flooding severity and was unaffected by increased flooding frequency.

There are two efficiency arguments to be made related to higher transfers post-disaster. First, it can reinforce the tendency for governments to underinvest in emergency preparedness. Within international aid allocated for disaster-related expenditures, only 12.7 percent are earmarked for preparedness, while the remainder is allocated to reconstruction, rehabilitation, and emergency response (Kellet & Caravani, 2013). For state governments, this situation could be exacerbated, albeit unintentionally, by federal assistance. If state leaders know that federal assistance is available whenever states experience an emergency, they may not act to sufficiently mitigate the harm caused by floods, leading them to favor ex-post response over ex-ante mitigation measures. While the predictable availability of federal assistance can help states after floods have occurred, it may also create problematic incentives for states experiencing high severity of flooding.

Second, the federal assistance is justified when it is needed, but inefficient when it is not. For decades, the federal government provides emergency funding to state governments through FEMA, whose mission statement is "helping people before, during, and after disasters." This commitment is manifested in various programs, including disaster relief and assistance during emergencies. Other federal agencies, such as the U.S. Departments of Agriculture, Commerce, Health and Human Services, Defense, Interior, and Justice, also provide emergency assistance to states for natural disasters (Healy & Malhotra, 2009). The thing about intergovernmental transfers are that they generate benefits that are geographically concentrated, but the burden is shared nationally. The transfer could be inefficient from a budgetary standpoint, therefore budget policies in this direction should be carefully developed and taken only when the overall socioeconomic benefit outweighs the cost.

After a disaster event, the undertaking geared toward response and recovery is indeed crucial as it determines how much time is required for the economy to recover. Ideally, however, the government also invests in mitigation and preparedness to the extent possible.[3] A study by the National Institute of Building Sciences (2020) estimated that for every $1 spent on federal mitigation grants for riverine floods, society saves up to $7. Phaup and Kirschner (2010) classified budgetary treatments before and after a disaster event as ex-ante budgeting and ex-post budgeting,

[3] According to the National Governors' Association (1979), the 'comprehensive emergency management' framework encompasses four main phases: mitigation, preparedness, response, and recovery. The first two are undertaken before a disaster, while the latter two are after. The framework is applicable to many forms of emergencies, including floods and other types of natural disasters.

respectively. They also argued that ex-ante budgeting is more favorable to reduce risk exposure, although it requires trade-offs of present consumption for disaster mitigation and preparedness.

Budgeting for mitigation is financially sensible, but one might well argue that it is not politically feasible. That is not entirely true. Surveys show that one-third of U.S. adults report personal experiences with extreme weather events in the past two years (Gallup, 2022a), and more than 70 percent of registered voters across the U.S. support policies that will enable communities to better prepare for and respond to floods (Pew Charitable Trusts, 2018). Flooding, like other types of disasters, can be politically appealing and provides electoral leverage. With the popular view favoring mitigation over response, allocating budget is within reach, which concludes the discussion with an optimistic lens.

7. Conclusion

The analysis estimates the impact of frequent and severe flooding events on state intergovernmental revenue and expenditure, as well as on total revenue, tax revenue, and total expenditure. A panel of 50 U.S. states between 1997 and 2020 is constructed and a two-way fixed-effects model is employed to address the research question. This study finds that while states receive higher intergovernmental funds after flooding, they do not always distribute more funds to localities. Reliance on federal assistance can help some states facing budget constraints, but this may also create problematic incentives for states, especially when the assumption of an economic downturn is disproven. The evidence indicates that more severe flooding coincides with higher state tax revenue. Knowing that federal assistance is, at least historically, of unlimited amount and is always available when states need an emergency response, they may not allocate enough resources for flood mitigation.

Beyond the scope of this study, another policy issue of importance is the socioeconomic impact of flooding. For example, a country-level study by Dottori et al. (2018) found that river flooding under some warming assumptions reduced global welfare, measured by changes in consumption, by 0.23-0.53 percent. Using a dynamic model of the global economy, Desmet et al. (2021) projected that coastal flooding will cut real GDP by 0.19 percent. Flooding also has disproportionate impacts across different income and ethnic groups, as evidenced in the U.S. A report by FEMA shows that lower-income households (earning below $30,000 annually), who presumably find affordable housing in higher-risk areas, endure more flood damage than other income groups (Sarmiento & Miller, 2006). Controlling for income, African Americans suffer greater flood damage on average compared to other racial or ethnic groups. The state budget plays a crucial role in effective flooding mitigation, yet admittedly it represents just a part of the broader spectrum. Future research directions may need to take equity dimension into account.

Flooding, like many other natural disasters, has become more frequent and destructive in recent decades in the U.S. and across the globe. In the last few years only, the U.S. witnessed flooding incidents spanning Texas, Mississippi, Kentucky, Missouri, and Colorado, among other places. The increasing prevalence of flooding, along with any response measures undertaken by the government, will certainly have fiscal implications. While this study focuses on U.S. fiscal federalism contexts, its core messages about what happens post-disaster and insights into what should be done in anticipation of future disasters are highly relevant to other countries as well. Moreover, intergovernmental collaboration in the face of emergencies has become a more common approach, especially due to the need to share resources that are essential for effective response and recovery. It is hoped that this study sheds light on the implications of flood disasters from a fiscal federalism perspective and encourages policymakers and scholars to collaboratively develop an enhanced framework for a comprehensive emergency management policy that incorporates sound fiscal planning.

Table 1. Data Sources and Collection

Variable	**Data source**	**Years Available**
Flooding insurance claims ($)	FEMA	1996-2021
Flooding frequency (count)	NCEI	1996-2021
Total revenue ($ m)	US Census Bureau	1992-2020
Total expenditure ($ m)	US Census Bureau	1992-2020
Tax revenue ($ m)	US Census Bureau	1992-2020
Intergovernmental revenue ($ m)	US Census Bureau	1992-2020
Intergovernmental expenditure ($ m)	US Census Bureau	1992-2020
Population (thousand)	UKCPR National Welfare Data	1980-2020
Gross State Product ($ m)	UKCPR National Welfare Data	1980-2020
Unemployment rate (%)	UKCPR National Welfare Data	1980-2020
Personal income per capita ($)	UKCPR National Welfare Data	1980-2020
Governor is democrat (1 = Yes)	UKCPR National Welfare Data	1980-2020
Sewerage spending ($ m)	Willamette University	1996-2020
Number of state employees (m)	US Census Bureau	1997-2020

Table 2. Summary Statistics

Variable	**(1) Mean**	**(2) Standard deviation**	**(3) Minimum**	**(4) Maximum**	**(5) Observations**
Flooding insurance claims ($ thousand)	10,136	110,646	0	3,015,920	1,250
Flooding frequency (count)	118	139	0	1,345	1,250
State total revenue ($ m)	35,695	47,016	2,146	433,081	1,250
State total expenditure ($ m)	34,074	44,611	1,983	422,066	1,250
State tax revenue ($ m)	14,539	19,497	626	188,235	1,250
State intergovernmental revenue ($ m)	9,383	12,053	650	102,420	1,250
State intergovernmental expenditure ($ m)	8,826	14,102	124	118,963	1,250
Population (thousand)	6,022	6,669	480	39,538	1,250
Gross State Product ($ m)	285,422	373,921	14,672	3,132,801	1,250
Unemployment rate (%)	5.41	1.94	2.30	13.70	1,250
Personal income per capita ($)	38,947	11,080	18,644	77,542	1,250
Governor is democrat (1 = Yes)	0.42	0.49	0	1	1,250
State sewerage spending ($ m)	42.7	119.1	0	2,019.6	1,250
Number of state employees	85,524	73,077	11,023	438,305	1,200

Note: Mean, standard deviation, minimum, and maximum values are calculated in 1996-2020, except for number of state employees 1997-2020.
Sources: FEMA (2022c); NOAA NCEI (2022b); UKCPR (2022); U.S. Census Bureau (2022a, 2022b)

Table 3. The Effect of Flooding Severity on State Intergovernmental Revenue

	(1) State intergovernmental revenue (log)	(2) State intergovernmental revenue (log)
Year of flooding	0.000422	-0.000581
	(0.000777)	(0.000720)
1 year after flooding	0.00195**	0.000726
	(0.000878)	(0.000792)
2 years after flooding	0.00242***	0.00134*
	(0.000781)	(0.000748)
3 years after flooding	0.00204*	0.00120
	(0.00103)	(0.000818)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.908	0.945

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4. The Effect of Flooding Frequency on State Intergovernmental Revenue

	(1) State intergovernmental revenue (log)	(2) State intergovernmental revenue (log)
Year of flooding	0.00149	-0.00120
	(0.00524)	(0.00499)
1 year after flooding	0.0137**	0.00591
	(0.00652)	(0.00576)
2 years after flooding	0.00820	-0.00141
	(0.00544)	(0.00502)
3 years after flooding	0.00851	-0.00117
	(0.00606)	(0.00461)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.908	0.944

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5. The Effect of Flooding Severity on State Intergovernmental Expenditure

	(1) State intergovernmental expenditure (log)	(2) State intergovernmental expenditure (log)
Year of flooding	-0.000504	0.000795
	(0.00116)	(0.000813)
1 year after flooding	0.000445	0.000964
	(0.000890)	(0.000638)
2 years after flooding	-0.000398	0.000360
	(0.00123)	(0.000563)
3 years after flooding	-0.0000159	0.000480
	(0.000993)	(0.000635)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.781	0.914

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. The Effect of Flooding Frequency on State Intergovernmental Expenditure

	(1) State intergovernmental expenditure (log)	(2) State intergovernmental expenditure (log)
Year of flooding	-0.0173	0.00000306
	(0.0115)	(0.00517)
1 year after flooding	-0.0101	-0.000308
	(0.00864)	(0.00320)
2 years after flooding	-0.00115	0.00421
	(0.00987)	(0.00445)
3 years after flooding	0.000601	0.000815
	(0.00707)	(0.00410)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.785	0.913

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7. The Effect of Flooding Severity on State Total Revenue

	(1) Total revenue (log)	(2) Total revenue (log)
Year of flooding	0.00112	0.000117
	(0.000975)	(0.000775)
1 year after flooding	0.00128	-0.000254
	(0.00131)	(0.000909)
2 years after flooding	0.00139	0.000275
	(0.000927)	(0.000825)
3 years after flooding	0.000635	-0.000200
	(0.00109)	(0.00116)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.893	0.923

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8. The Effect of Flooding Frequency on State Total Revenue

	(1) Total revenue (log)	(2) Total revenue (log)
Year of flooding	-0.000342	0.00419
	(0.00675)	(0.00516)
1 year after flooding	0.00000422	-0.00114
	(0.00636)	(0.00437)
2 years after flooding	0.00514	0.00318
	(0.00409)	(0.00346)
3 years after flooding	-0.00264	-0.00527
	(0.00519)	(0.00472)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.892	0.923

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9. The Effect of Flooding Severity on State Tax Revenue

	(1) State tax revenue (log)	(2) State tax revenue (log)
Year of flooding	0.00194	0.00156*
	(0.00124)	(0.000840)
1 year after flooding	0.00311	0.00139*
	(0.00195)	(0.000740)
2 years after flooding	0.00156	0.000626
	(0.00140)	(0.000534)
3 years after flooding	-0.000375	-0.000790
	(0.00109)	(0.000702)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.748	0.901

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10. The Effect of Flooding Frequency on State Tax Revenue

	(1) State tax revenue (log)	(2) State tax revenue (log)
Year of flooding	-0.00602	0.00743
	(0.0112)	(0.00546)
1 year after flooding	-0.00317	0.00339
	(0.00808)	(0.00391)
2 years after flooding	-0.00130	0.00329
	(0.00685)	(0.00279)
3 years after flooding	-0.00288	0.000345
	(0.00637)	(0.00325)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.745	0.900

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11. The Effect of Flooding Severity on State Total Expenditure

	(1) Total expenditure (log)	(2) Total expenditure (log)
Year of flooding	0.000246	0.000192
	(0.000518)	(0.000374)
1 year after flooding	0.000848	0.000588
	(0.000544)	(0.000360)
2 years after flooding	0.00107*	0.00118***
	(0.000610)	(0.000347)
3 years after flooding	0.00115**	0.00106***
	(0.000479)	(0.000357)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.956	0.984

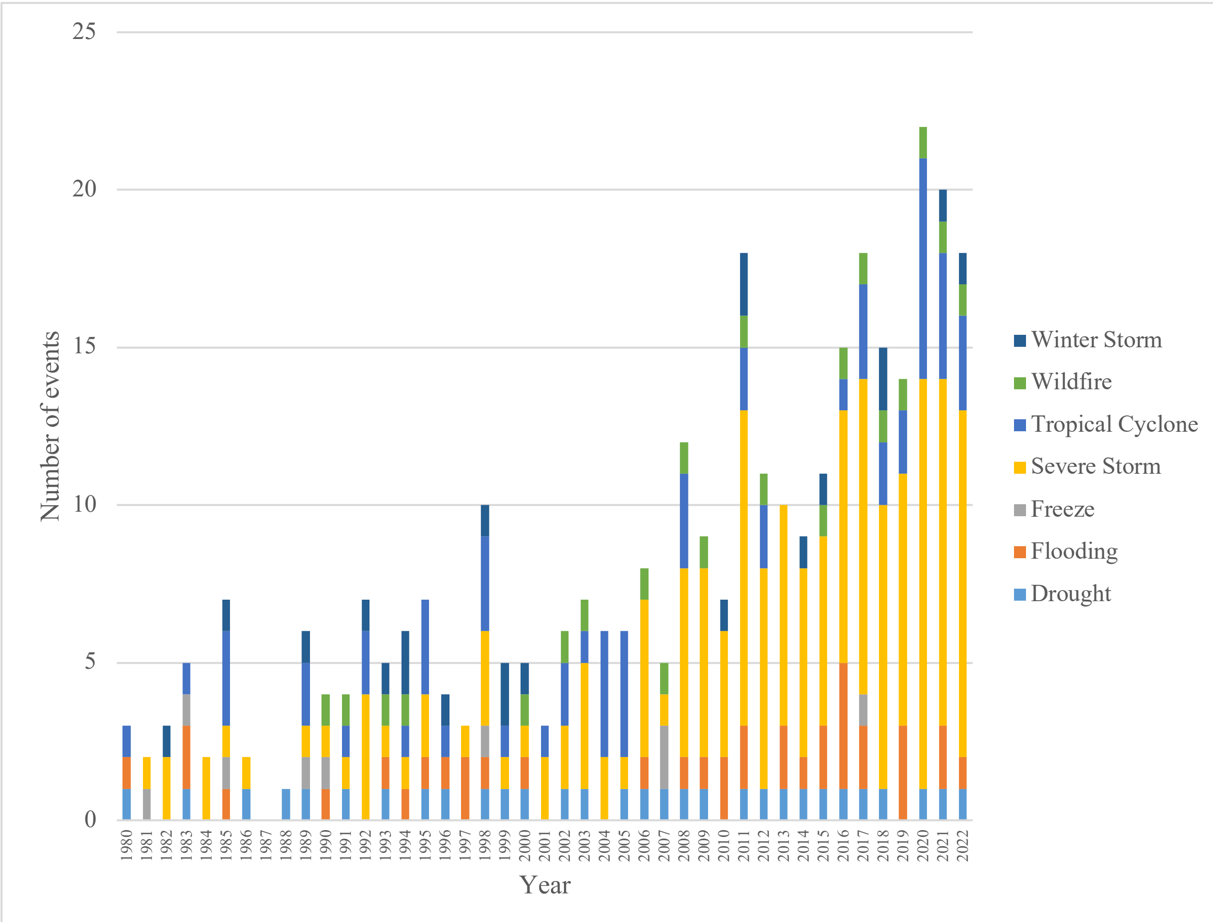
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12. The Effect of Flooding Frequency on State Total Expenditure

	(1) Total expenditure (log)	(2) Total expenditure (log)
Year of flooding	-0.00349	-0.00103
	(0.00555)	(0.00220)
1 year after flooding	0.0000756	-0.00100
	(0.00459)	(0.00215)
2 years after flooding	0.00329	0.00125
	(0.00470)	(0.00234)
3 years after flooding	0.00463	-0.000131
	(0.00414)	(0.00208)
Year FE	Yes	Yes
State FE	Yes	Yes
Controls	No	Yes
Observations	1100	1100
Adjusted R2	0.956	0.983

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1. Billion-dollar Disasters in the United States (1980-2022)



Source: NOAA NCEI (2023)

Figure 2. Flooding Insurance Claims (Aggregated at the State Level) from 1996-2020

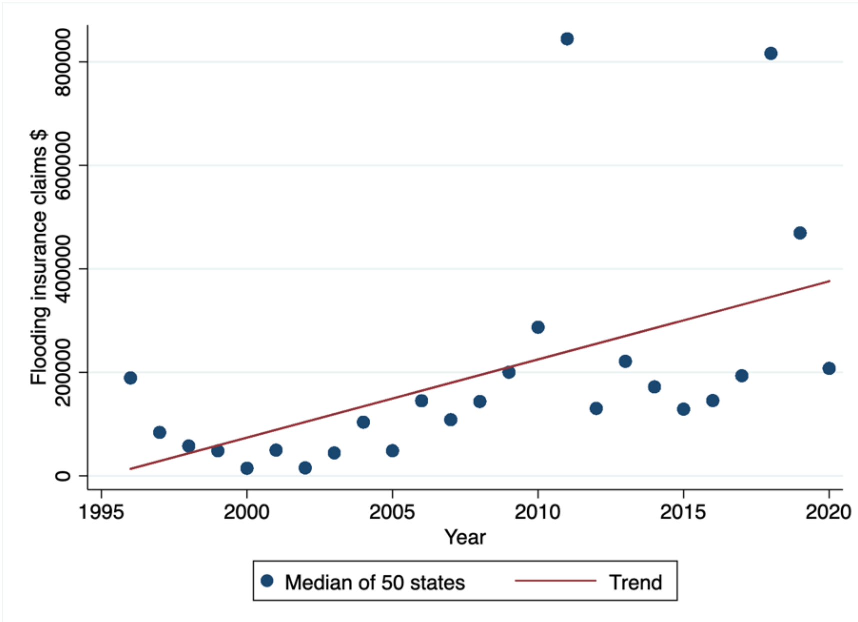


Figure 3. Flooding Events (Aggregated at the State Level) from 1996-2020

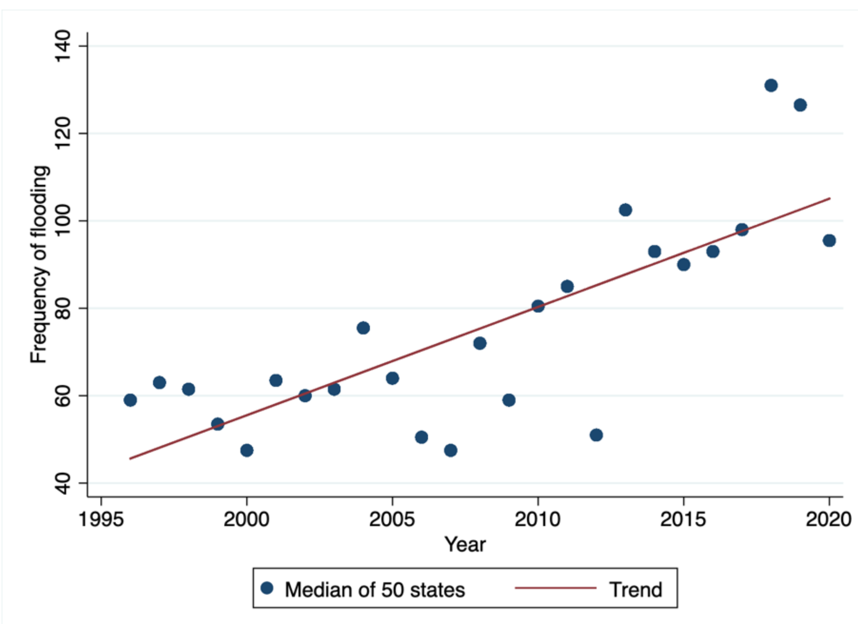


Figure 4. State Budget Structure

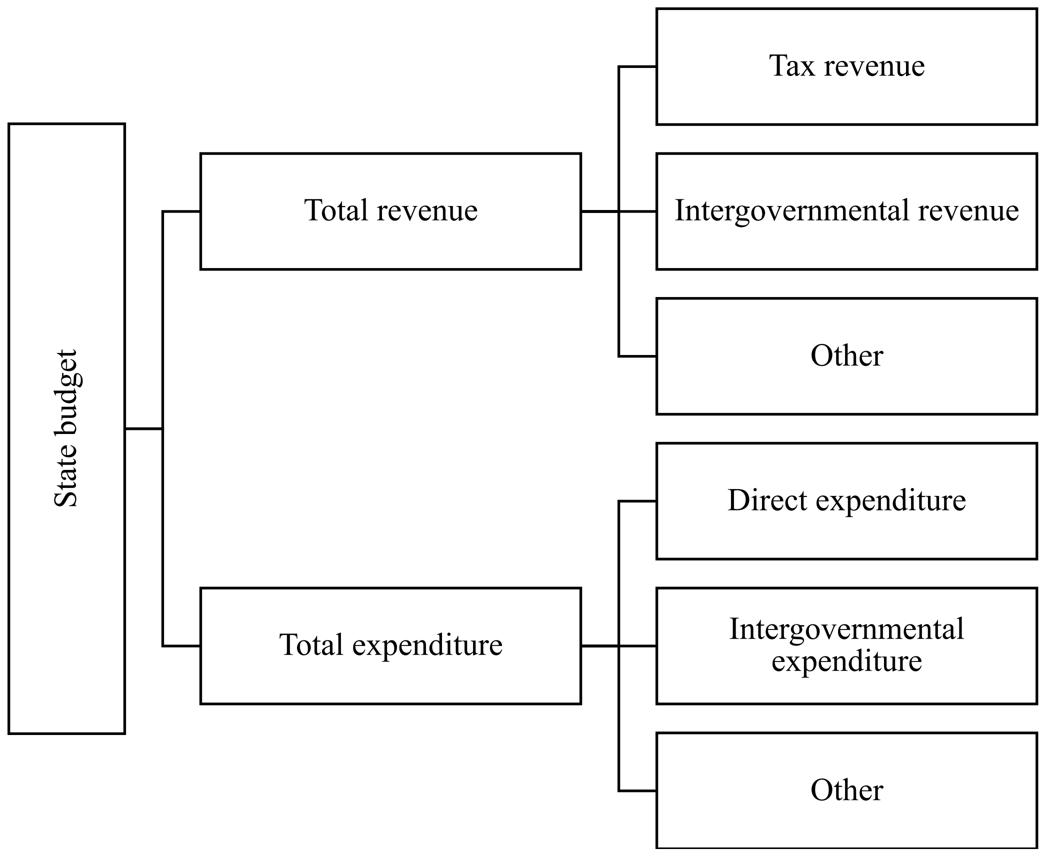


Figure 5. Per Capita State Revenues Trends

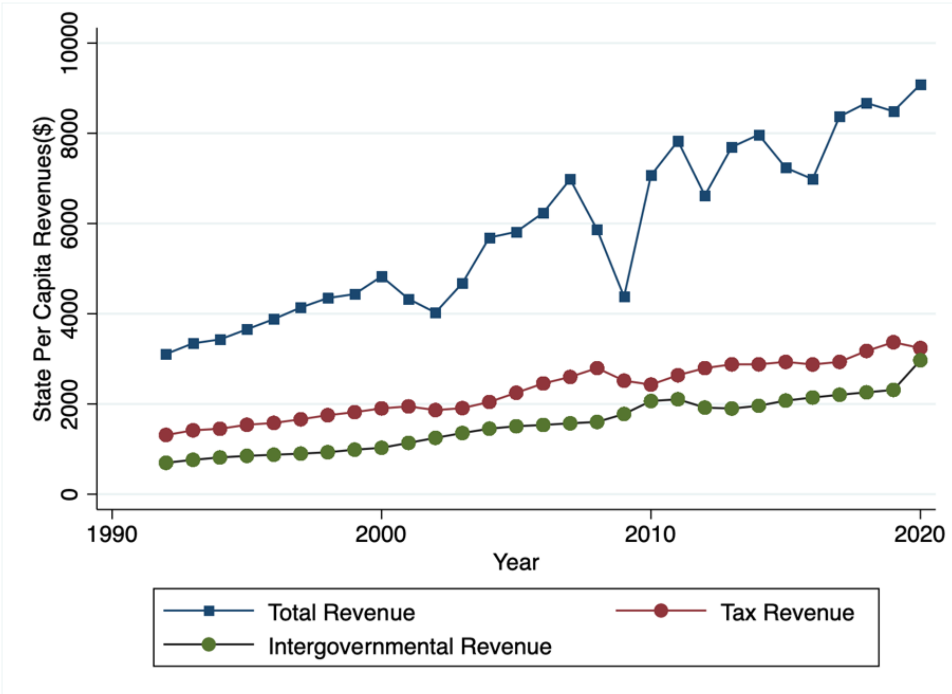


Figure 6. Per Capita State Expenditures Trends

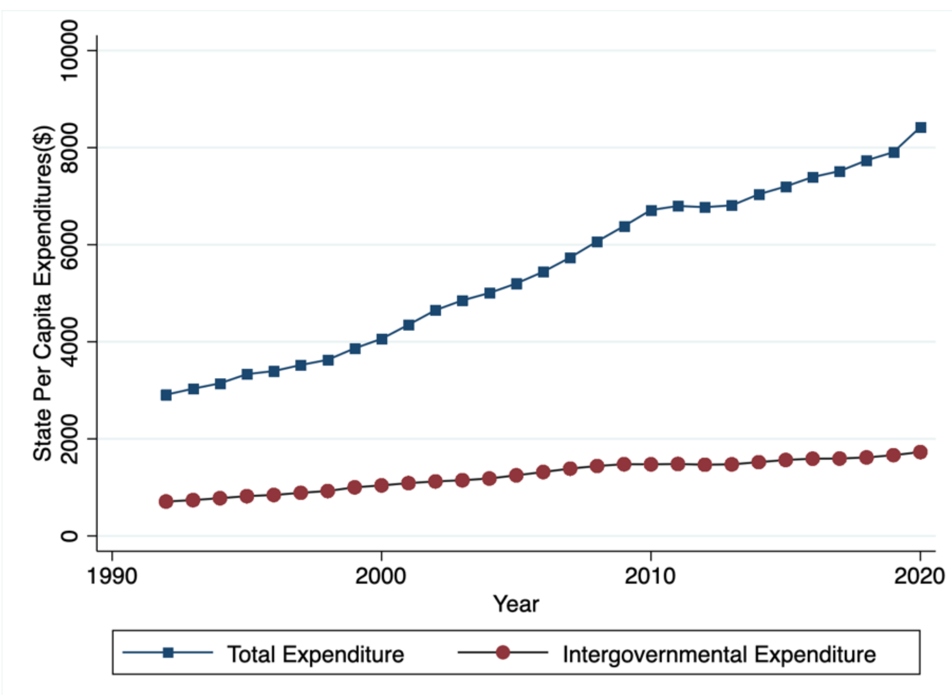
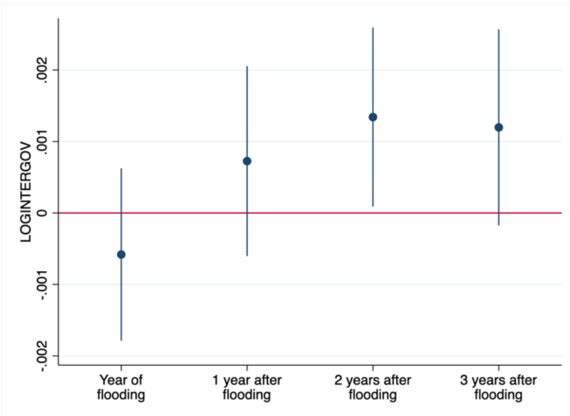
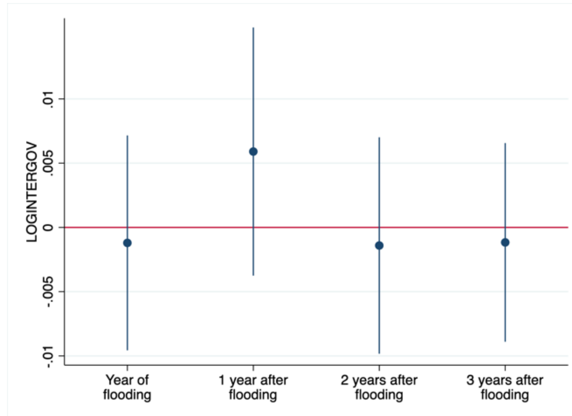


Figure 7. The Effect of Flooding on State Intergovernmental Revenue

Panel A – Flooding severity



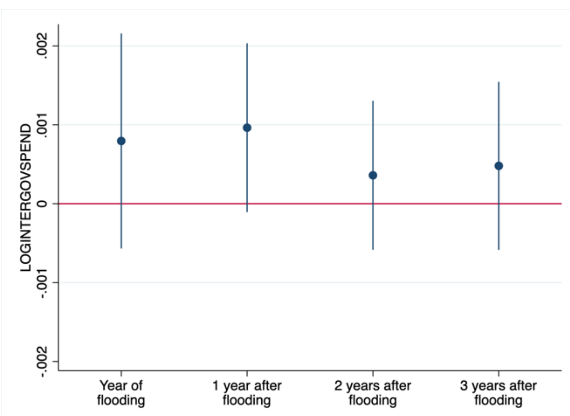
Panel B – Flooding frequency



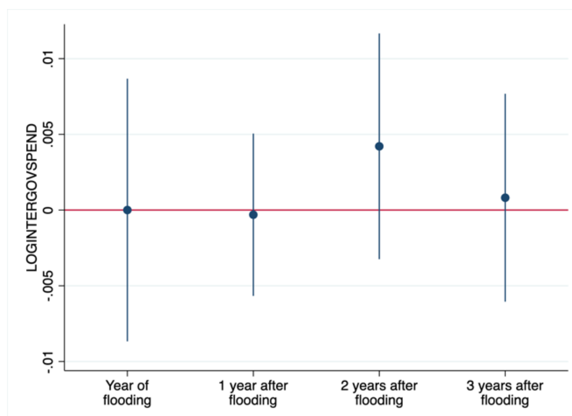
Note: Bars correspond to a 90% confidence interval around the point estimate.

Figure 8. The Effect of Flooding on State Intergovernmental Expenditure

Panel A – Flooding severity



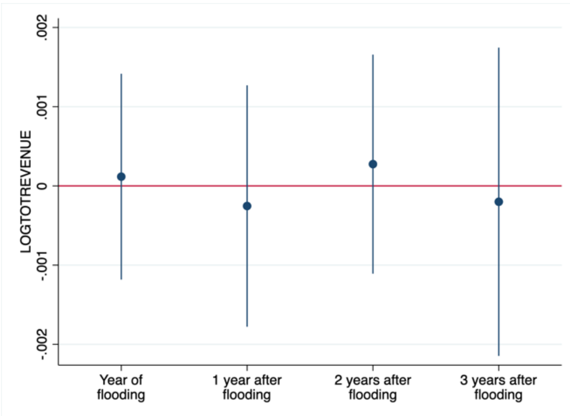
Panel B – Flooding frequency



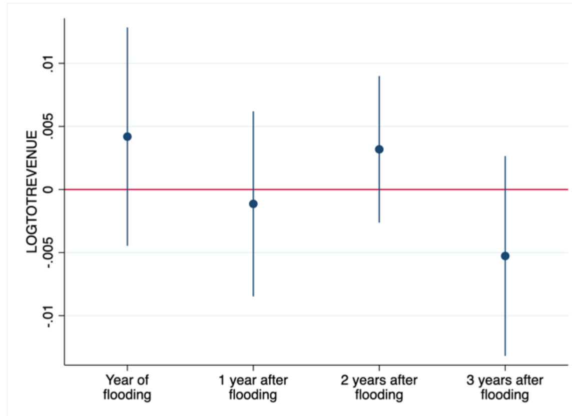
Note: Bars correspond to a 90% confidence interval around the point estimate.

Figure 9. The Effect of Flooding on State Total Revenue

Panel A – Flooding severity



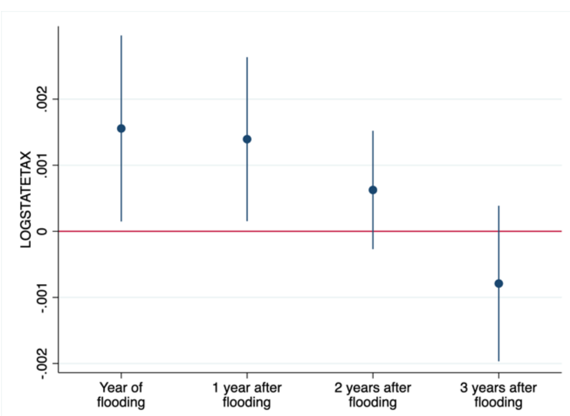
Panel B – Flooding frequency



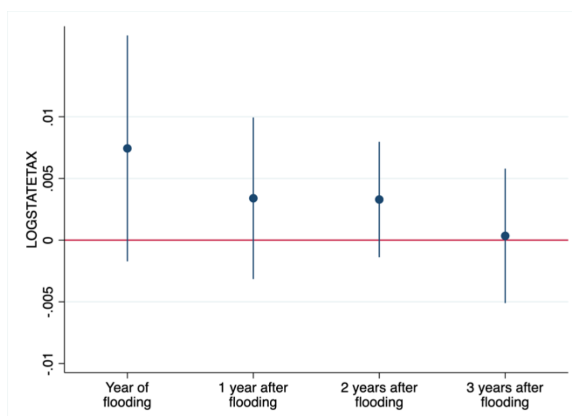
Note: Bars correspond to a 90% confidence interval around the point estimate.

Figure 10. The Effect of Flooding on State Tax Revenue

Panel A – Flooding severity



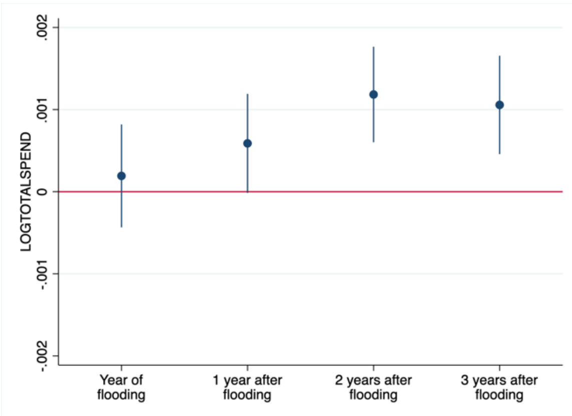
Panel B – Flooding frequency



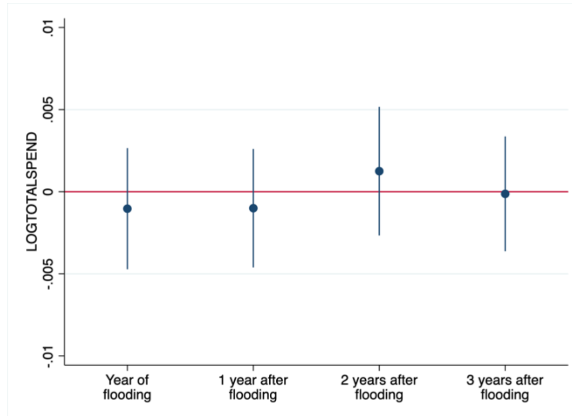
Note: Bars correspond to a 90% confidence interval around the point estimate.

Figure 11. The Effect of Flooding on State Total Expenditure

Panel A – Flooding severity



Panel B – Flooding frequency



Note: Bars correspond to a 90% confidence interval around the point estimate.

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