Household Finance in the Aftermath of Floods and Wildfires

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Abstract

This paper investigates the impact of exposure to flood, wildfire and wildfire smoke events on household debts and assets. Focusing on a panel of households located in the contiguous United States between 2011-2019, we examine several categories of debts: total, credit card, medical, mortgage; and assets: total, savings, financial, non-financial. Using information from the Federal Disaster Management Agency (FEMA) on disaster declarations we provide estimates of the contemporaneous treatment effect on households exposed to small scale flood and wildfire events, as well as those that experience major disasters. Using a two-way fixed effects approach, we find that households exposed to non-FEMA floods see an increase in total debt, credit card debt and mortgage debt, while assets are decreasing across all categories. FEMA wildfires mortgage debt decreases, as do total, financial and non-financial assets.

Keywords: debt, assets, disaster, climate change, heterogeneous treatment effects

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The last 50 years have seen a five-fold increase in the incidence of weather related disaster events (World Meteorological Organization 2021). This increase is directly attributed to anthropological factors, characterized by changes in temperature, precipitation, and wind, all of which are markers of climate change. These events are only expected to increase as the climate change situation worsens (Field et al. 2012; Abatzoglou and Williams 2016). Focusing on the distribution of events within the United States (USA), we see that nearly 90% of all weather related events result in flooding (World Meteorological Organization 2021), while wildfires events see the biggest increase in incidence (Liao and Kousky 2022). This paper studies the impact of flood and wildfire events on household finance, specifically: total debt, credit card debt, medical debt, and mortgage debt; total assets, savings, financial assets and non-financial assets. Using the restricted access Panel Study on Income Dynamics (PSID) we identify households located in the contiguous United States between 2011-2019 that were exposed to a flood, wildfire, wildfire smoke event.

Damages from flood events has been a recognized concern in the US for a long time, and measures such as the National Flood Insurance Program (NFIP) established in 1968 following Hurricane Betsy, are in place to respond to household distress from flood events. However, in recent years, the NFIP has come under much scrutiny for its failure to adequately recompense households suffering from flood damage (Kousky, Michel-Kerjan, and Raschky 2018; Michel-Kerjan 2010). Wildfire events cause destruction of property and significant health concerns through smoke exposure and have no institutional safeguards in place. Households may or may not be covered by private insurance that can mitigate some of the post-event expenses. Governmental aid whether state or federal is available only in the case of a disaster proclamation. Most event occurrences do not qualify or even require disaster declarations. However, households are still affected and are responsible for their recovery from the event. As the effects of climate change fully realize, the frequency and intensity of weather related events is expected to rise indicating that that households must contend with unanticipated losses and expenses to recover from frequent and intense event exposure.

Studies on the impacts of weather related events find that households respond to these shocks in several ways – through consumption smoothing, remittances and savings

(Henry, Spencer, and Strobl 2020); dis-investments in health leading to higher infant female mortality rates (Anttila-Hughes and Hsiang 2013); dis-investments in human capital resulting in lower college enrolments and high dropout rates (Billings, Gallagher, and Ricketts 2020); higher dependence on social safety nets (Deryugina, Kawano, and Levitt 2018). Households that experience severe property damage tend to reduce their risk through property divestment thereby also lowering their mortgage and overall debt (Ouazad and Kahn 2019; Gallagher and Hartley 2017). Major disasters cause out migration that affects not just survivors, but also the destination of migration, resulting in lower incomes, and fewer employment opportunities for the survivors (McIntosh 2008; Deryugina, Kawano, and Levitt 2018). While much of the literature in this space focuses on the immediate impact of major disaster events, few focus on the debt and assets aspects of household finance. The focus on debt and assets is relevant to the US economy. Debts and assets are the most important indicator of household well-being and resilience. Households take on debt to create wealth generating and income increasing assets (e.g. mortgage financing, student loans). However, as we see in this paper, households must contend with external shocks that would not only potentially damage these assets, but also lead to a delay and probably an increase in paying off the debt. The ability of the household to withstand and recover from these shocks is an important indicator of how well the household as well as the economy at large can adapt and respond to climate change.

Our study is perhaps most closely related to the work of Gallagher and Hartley (2017) examining the impact of Hurricane Katrina on debt (total, credit card, mortgage) and delinquency rates among other aspects of household finance. An, Gabriel, and Tzur-Ilan (2023) use difference-in-differences to study the effects of four major wildfire events and the corresponding smoke exposure on household mobility, housing prices and financial outcomes. However, there are several aspects of our study that set it apart from the current literature analyzing the effects of weather events.

This paper has several contributions to the literature. First, this paper provides estimates on the effects of exposure to distinct weather related events. Providing comparable estimates across event types is crucial to develop event response strategies. It is also important to note here, that wildfires also increase the risk of flash floods and mudflows by destroying foliage and causing soil char thereby reducing the ability of the land to absorb rainfall (Yilmaz et al. 2023; FloodSmart 2020).

Second, we distinguish between FEMA designated disasters and non-declared events. This is an important distinction for several reasons. The current literature in this domain focuses on major events, such as hurricanes, typhoons and bushfires, which arguably have a larger impact. However, as the frequency of events increases, not every occurrence qualifies for governmental or public assistance meaning that affected households must rely on other options to cope with financial distress and welfare losses. By providing estimates on the effects of non-FEMA event exposure, this paper informs the conversation on household financial resilience and responses in a changing climate.

Third, by providing comparable estimates for exposure to FEMA and non-FEMA events, we can test whether the influx of financial assistance enabled by FEMA declarations counteract the heightened damage borne by households from severe events. Additionally, by virtue of our treatment construction, we capture the spillover effects of a FEMA declaration on households that did not experience any event but were located in an affected county.

The rest of the paper is structured as follows: in the next section we discuss the conceptual framework and the mechanisms by which household debts and assets are impacted. In section 3 we describe the data, present summary statistics, and discuss the construction of the treatment variables. In section 4, we present the empirical strategy. In section 5 we present results, discuss the interpretation and implications for future policy applications. We conclude with a discussion on next steps and thoughts on future research.

2 Conceptual Framework and Mechanisms

Any weather related events, in our case floods and wildfires, can affect household financial stability in a couple of different ways. First, through damage to physical assets, such as water or smoke damage to the living space and vehicles. Second, through loss of income – if the event causes the place of employment to temporarily or permanently shut down. Third, through individual health effects – developing or worsening physical and mental health concerns. Stagnant water in a flood event is breeding ground for bacteria, viruses and mold, all of which cause respiratory ailments the severity of which ranges from allergic reactions to lung disease (American Lung Association 2023). The effects of wildfire smoke which comprises primarily of PM2.5 particles ranges from eye irritation to pulmonary inflammation (EPA 2022). In terms of mental health, we expect the survivors to experience elevated levels of stress, and in more severe instances PTSD, anxiety, and depression. These physical and mental ailments as a result of event exposure can potentially lead to decreased productivity in school or work, resulting in a loss of income, and increases in medical expenses over time. We examine the mental health effects of these events in a another paper.

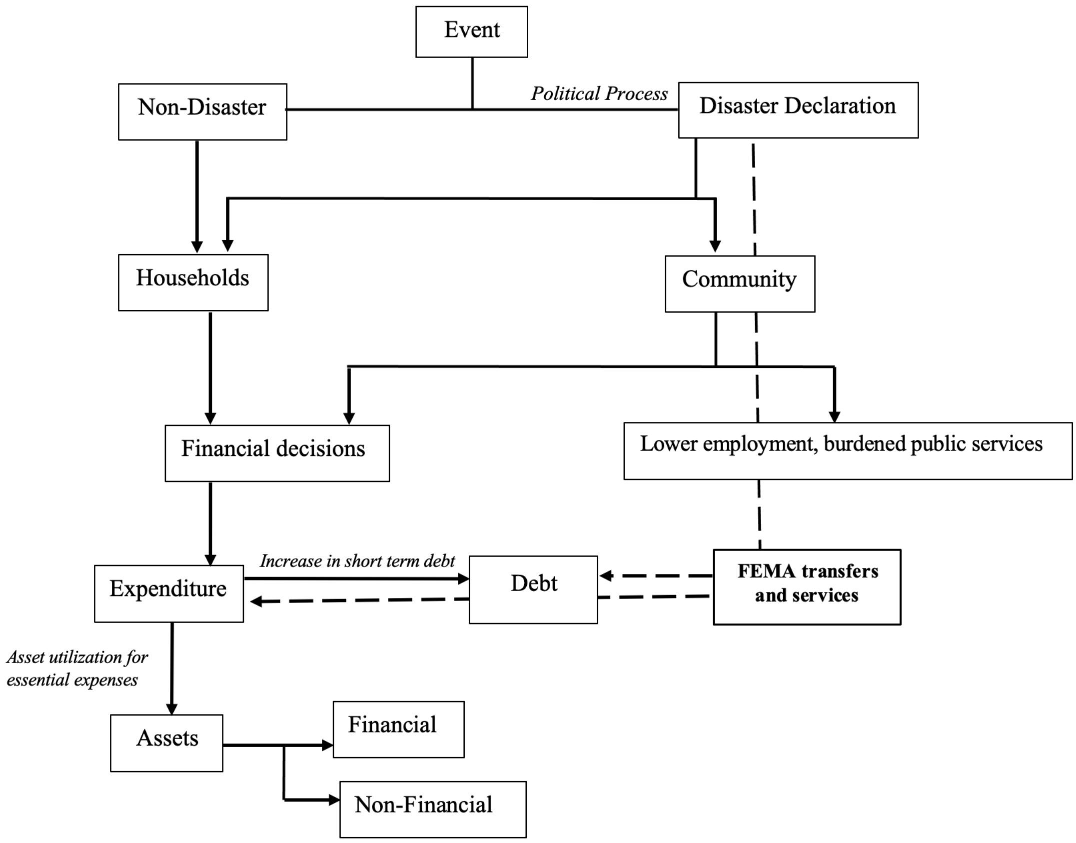

Figure 1: Conceptual Framework

In this paper, distinguish between the effects of FEMA and non-FEMA events. In the United States, an event is declared as a disaster through a Presidential Disaster Declaration (PDD), as laid out in the Stafford Act[1]. However, given the wide scope of the governing law, there is no specific criterion based on which an event is qualified to be

1. The Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. §§ 5121-5207

designated as a disaster. This means that disaster proclamations are entirely susceptible to influence by factors that have nothing to do with the potential damage to and loss of life and property or the disruption and loss of livelihoods (Sylves and Búzás 2007; Salkowe and Chakraborty 2009; Schmidtlein, Finch, and Cutter 2008; Reeves 2011). This is a relevant observation since a PDD activates FEMA intervention, essentially pouring millions of funds for emergency response, aid, and recovery. FEMA also supports rehabilitation and recovery for eligible uninsured and under-insured survivors through the Individuals and Households Program (IHP) which can temporarily offset expenses.

In the US 90% of all weather related events result in flooding and are the most expensive of all weather related disasters both economically as well as in terms of mortality (NOAA 2020a). The federal National Flood Insurance Program (NFIP) is designed to be a low premium financial safety net for households. Homes and businesses in high flood risk areas with mortgages from government backed lenders are required to have flood insurance. While on the face of it, it seems that a robust policy is in place to secure households financially, it is pertinent to note that these requirements are based on FEMA flood maps, identifying high risk Special Flood Hazards Areas (SFHAs) are sorely outdated. It is estimated that the NFIP fails to secure more than 50% of homes located in the SFHAs (Ahmadiani, Ferreira, and Landry 2019; Kousky 2018; Landry, Turner, and Petrolia 2021). Add to this fact that low income and minority households are more likely to be in high flood risk areas (Bakkensen and Ma 2020), and that the NFIP is not designed to respond to truly major disaster events (Michel-Kerjan 2010) the context for this study starts to emerge.

As climate change causes fluctuations in temperature and precipitation, leading to warmer drier conditions that are conducive to fire ignition, as well as a longer fire season, wildfires have become a major concern (Zhuang et al. 2021). In addition to the damage and loss of life and property, there is also the burden of the fires releasing carbon dioxide into the air, which in turn exacerbates climate change (NOAA 2022). Federal Wildland-Urban Interface (WUI) maps present an updated picture of wildfire risk. But as recent research has shown, more and more affordable housing is in areas with high wildfire risk (Radeloff et al. 2018), indicating that households with lower financial resilience are at greater risk of exposure. In terms of safety nets, wildfires are covered only through regular homeowners' insurance and unlike floods do not have a separate coverage. Through anecdotal evidence, we see that insurance premiums for household's skyrocket when exposed to a wildfire, with insurance companies often choosing to refuse renewal of coverage (Associated Press 2022; Bloomberg 2022).

These factors come together to paint a picture of financially distressed households, that may or may not have public or private safety nets to aid in their recovery from exposure to events. We expect to our results to reflect an increase in all the debt categories, particularly that of credit card debt for non-FEMA event categories, and a decrease in medical debt for the FEMA event categories. In terms of assets, we expect that total assets, financial assets and savings will decrease following exposure to a

3 Data

This study focuses on households exposed to flood and wildfire events located in the contiguous United States between 2011-2019. We utilize publicly available information from the Federal Emergency Management Agency (FEMA), the National Oceanic and Atmospheric Administration (NOAA), the United States Geological Survey (USGS) to compile a panel of flood and wildfire events. Household information is provided by the restricted access Panel Study on Income Dynamics (PSID).

3.1 Panel Study on Income Dynamics

The PSID is a nationally representative database following households since 1968 to collect information on various aspects such as finances, education, time use, health and so on. The sample was expanded in 1997 and most recently in 2017 to reflect the national demographics and post-immigrant families. Starting 2001, the PSID conducts its main survey every alternate year, with supplementary surveys being conducted over time. A portion of the original PSID sample was drawn from the Survey of Economic Opportunity (SEO) that over-sampled poor families in the 1960s, resulting in a sizeable presence of low-income African American families. Thus, the nature of PSID has led to significant research on economic transitions, poverty, health, and other social indicators. In this paper, we restrict our sample to respondents located in the contiguous United States, and to those households that participate in the survey at least 2 times between 2011-

Table 1: Description of Outcome Variables

Outcome	Description	Source
Total Debt	Sum of Credit Card, Student, Medical, Family and Other	Author generated
Credit Card Debt	Amount owed on credit cards and store cards for the entire household	Main Family Interview
Medical Debt	Amount owed toward medical bills by any member of the household	Main Family Interview
Mortgage Debt	Amount owed toward mortgage by any member of the household	Main Family Interview
Total Assets	Sum of Financial and Non-Financial Assets	Author generated
Financial Assets	Sum of Annuity, IRA; Stocks and Bonds; Checking and Savings; and Other Assets	Author generated
Savings	Total $ amount in checking/savings account for the household	Main Family Interview
Non-Financial Assets	Sum of Farm/Business; Home Equity; vehicles; Other Real Estate	Author generated

2019. To maintain consistency, we limit our sample to households with the same family composition over our study period, meaning that as long as the reference person or head and their spouse are in the survey and participating, the household is a part of our sample.

While the PSID reports a wealth of financial information, changes in the survey definition mean that we limit our study to a few relevant categories: total debt, credit card debt, medical debt, mortgage debt; total assets, financial assets, savings, non-financial assets. All these assets are defined net of any associated debt. Table 1 lays out the definitions of the outcomes and their sources. Tables 2 shows the mean and standard deviation for never treated and ever treated households.

3.2 Disaster Declarations

Published by FEMA, the Disaster Declaration summarizes all official disaster declarations since 1963. This dataset contains information on three declaration types: major disaster, fire management, and emergency declaration (FEMA 2023). We focus on events categorised as major disasters and emergency declarations. Using the declaration title variable, which contains a summary of the event, we again conduct a keyword search to identify events that included a flood and/or wildfire phenomenon.

Table 2: Summary Statistics: Outcomes ('000 USD)

Variable	**Never Treated** Mean (SD)	**Ever Treated** Mean (SD)
Total Debt	11.83	13.91
	(37.52)	(40.33)
Credit Card Debt	2.14	2.60
	(7.86)	(6.88)
Medical Debt	1.63	1.40
	(20.93)	(24.92)
Mortgage Debt	39.11	53.84
	(90.25)	(105.73)
Total Assets	55839.79	56750.81
	(246096.8)	(245359.40)
Savings	16.50	21.16
	(67.54)	(99.76)
Financial Assets	55708.66	56607.13
	(246104.1)	(245356.10)
Non-Financial Assets	131.13	143.68
	(941.23)	(636.78)
Observations (N)	7478	35858

3.3 Flood Events

The Storm Events Database (SED) is an open access dataset of 71 categories of weather phenomenon published by the National Centers for Environmental Information (NOAA 2020b). This database reports weather phenomenon that has significant potential to cause injury to or loss of life, crop, and property damage, and significantly disrupt day-to-day workings. The National Weather Service (NWS 2021) categorizes the reported event based on meteorological phenomenon, begin-end latitude and longitude, state, and county information.

Most significantly the SED provides descriptive details through the episode and event narrative variables. It is important to note the difference between episodes and events here. An episode refers to an entire storm system that can contain many different types of events. For each event, the SED also reports death, injury, damage estimates, inundation among others. However, these variables are based upon the assessment of the reporter and not an established metric, and so it is unwise to use them for analysis.

Between 2011-2019, the database returned nearly 800,000 observations under various event types. Given that the definition of event types and reporting standards have evolved over time, it was difficult to consistently identify events that led to flooding based on categorization as reported by the NWS. In restricting the data to stated categories, we noticed the loss of several relevant observations. To counter this, we used a keyword search on the episode and event narrative variables and identified observations that reported flooding and inundation. This left us with approximately 100,000 events observed over a 10 year period.

Table 3: Treatment definitions

Treatment	Variable	Description
Flood	*flood1*	Flood without FEMA
	flood2	FEMA without flood
	flood3	Flood with FEMA
Wildfire	*wildfire1*	Wildfire without FEMA
	wildfire2	FEMA without wildfire
	wildfire3	Wildfire with FEMA
Smoke	*moderate*	$12.4\,\mu g/m^3 \leq$ PM 2.5
	sensitive groups	$12.5\,\mu g/m^3 \leq$ PM 2.5 $\leq 35.4\,\mu g/m^3$
	unhealthy	$35.5\,\mu g/m^3 \leq$ PM 2.5 $\leq 55.4\,\mu g/m^3$
	very unhealthy	$55.5\,\mu g/m^3 \leq$ PM 2.5 $\leq 101.4\,\mu g/m^3$
	hazardous	$101.5.5\,\mu g/m^3 \leq$ PM 2.5

3.4 Wildfires - Burned Areas

Monitoring Trends in Burn Severity (MTBS) is an open access database jointly published by the US Geological Survey, US Department of Agriculture, US Forest Service and the US Department of Interior. This database reports all known large fires since 1984 within the US regardless of fire origin or type (Eidenshink et al. 2007; MTBS 2022). The MTBS classifies fire occurrences under six types - wildfires, prescribed fires, wildland fire use, fires of unknown origin, complex, out-of-area response. For the purposes of this study, we focus on events classified as wildfires, fires of unknown origin and complex fires. Wildfire effects are twofold. First is the effect of being the direct path of the fire, which is captured by the burned area polygons reported in the MTBS. The second are the effects of smoke that goes beyond burned areas and can be widespread.

3.5 Wildfires - Smoke Exposure

Wildfires have widespread affects, well beyond their burned area boundaries. To account for households exposed to wildfire smoke, we utilize the dataset compiled by Childs et al. (2022) that provides daily local level estimates of wildfire smoke from 2006-2020. The paper uses a binary classification to identify smoke days as days when smoke from wildfires was overhead. This classification is based on hand anointed smoke plume data from NOAA's Hazard Mapping System, and fire location specific air particle trajectory models. As wildfire smoke is primarily made up of PM 2.5 particles, the dataset reports the date, census tract and level of PM 2.5 attributed to wildfire. Adapting the available information to our study, we utilize the standards established by the EPA (2012) to identify households located in census tracts that are exposed to PM 2.5 levels. For the purposes of this study, we consider each smoke day to be an event, and calculate the number of smoke days in a given year.

3.6 Constructing treatment

Access to the restricted PSID enables us to identify the census tract in which a respondent household is located. Using this information in combination with the date of interview we construct the treatment as the number of events a household was exposed to in the previous 12 months from the date of interview.

One of the challenges of this paper is reconciling the different sources of information on to construct consistent treatment variables. To construct the flood exposure variable, we use latitude-longitude information in the SED to identify the begin point of the event. We then identify census tracts located within a 1 mile buffer of this point. Similarly for wildfire events we overlay the burned area shapefiles with TIGER/Line shapefiles from US Census Bureau (2010) to identify the affected tracts.

Based on the county FIPS codes reported in the disaster declarations dataset, we are then able to identify census tracts that came under a FEMA declaration. Using this information, we generate six mutually independent treatment variables, three per flood and wildfire categories as: a) tracts where non-FEMA events; b) households that come under a FEMA declaration when they did not experience an event; and c) households that were exposed to a FEMA event. For the smoke exposure variable, we count the number of days at in the past 12 months that the amount of PM2.5 in the census tract were reported to be at moderate and greater than moderate levels. Table 3 describes the treatment variables and table 3 shows summary statistics, where N is the number of non-zero observations.

Table 4: Summary Statistics: Treatment

Variable	N	Mean	SD	Median	Min	Max
flood1	3606	1.34	0.95	1	1	13
flood2	1957	1.03	0.17	1	1	2
flood3	276	1.01	0.10	1	1	2
wildfire1	163	1.37	1.04	1	1	7
wildfire2	164	1.87	0.34	2	1	2
wildfire3	4	1.00	0.00	1	1	1
moderate	12044	2.71	2.80	2	1	33
sensitive groups	1193	2.15	1.71	1	1	14
unhealthy	545	3.81	3.47	2	1	26
very unhealthy	80	1.59	0.95	1	1	5
hazardous	2	2.00	1.41	2	1	3

4 Empirical Strategy

We begin our econometric analysis with the traditional two-way fixed effects approach. To estimate the effect of event exposure on household i in time t we use the following equation:

$$Y_{it} = \alpha + \sum_{d=1}^{3} \beta_d Event_{it}^d + \gamma_{it}\vec{Z}_{it} + \delta_{st} + \varphi_g + \eta_m + \nu_i + \epsilon_{it} \tag{1}$$

where, $Event_{it}^d$ is the treatment for household i in time t, as defined in table 3. $\vec{Z}_{it}$ is the vector of household characteristics such as size of family unit, number of dependents, marital status, employment status (reference person and spouse if relevant), location (urban or rural); whether they are covered under home, health and/or auto insurance. We use state-by-year fixed effects (δ_{st}) to account for annual changes in the economic trends of states and φ_g for census tract fixed effects since households migrate to new tracts in between waves, as well as for characteristics such as geography and location. The use of η_m as month fixed effects is important to account for the seasonality of event occurrences, for example, the occurrence of flooding in hurricane season, or wildfire ignition in dry months. Household fixed effects are included as ν_i.Outcome variables are transformed using the inverse hyperbolic sine method to account for zero and negative values in the analysis.

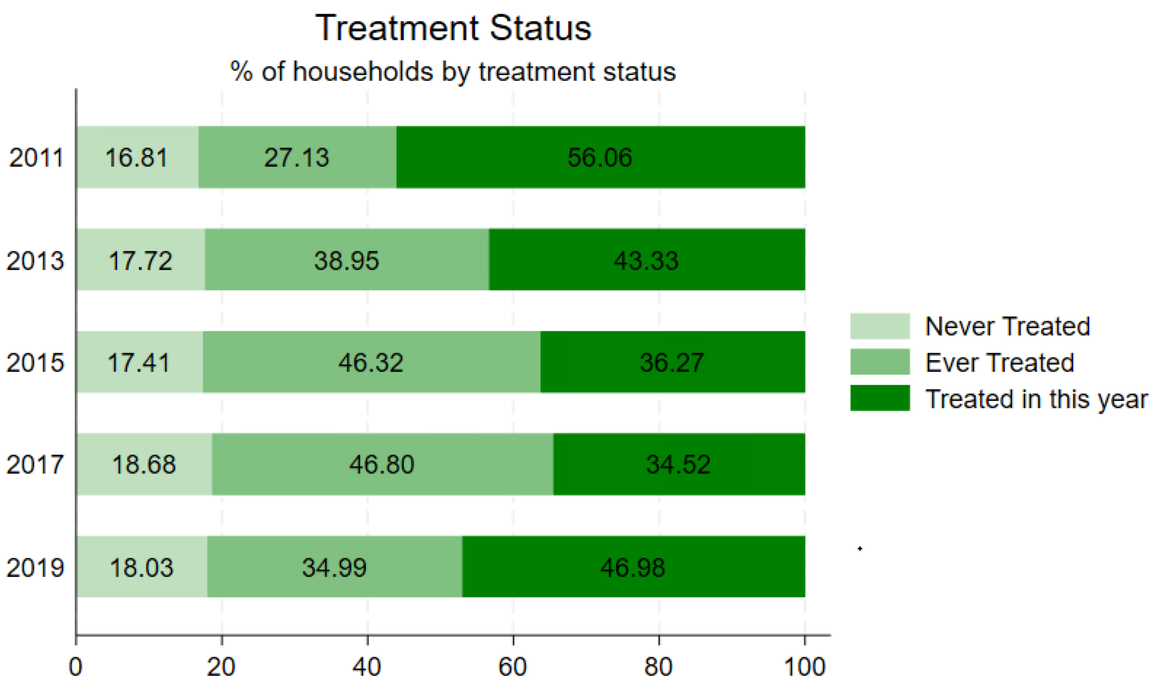

Figure 2: Treatment over the study period

5 Results

Using the method proposed by Norton (2022), we re-transform our inverse hyperbolic sine coefficients to dollar amounts for ease of interpretation. As we discuss the results from the two-way fixed effects model, we are conscious of the lack of statistical significance in these results, which is due to reasons discussed in section 6 and suggest strategies to improve our results. We urge the reader to consider these as baseline results, focusing on the sign of the coefficients. Regression results are reported in appendix A. The coefficients are interpreted as the marginal change in the outcome for each subsequent event.

5.1 Debt

Our results show (A1) that broadly in the case of flood events, debt is increasing, supporting our hypothesis. Total debt is increasing substantially, with total debt upon exposure to a non-FEMA flood event increasing by $900 approximately. Increasing credit card debt by $229 in the case of non-FEMA flood events is evidence of short-term increases in expenses as the household recovers from the shock, while for FEMA flood events it increase by $651.98. In the case of FEMA designated flood events, we see a substantial increase in mortgage debt per table A1. This is consistent with the literature indicating that households may incur greater mortgage debt through delinquencies, or possibly taking out a second mortgage to assist in recovering from the event.

For non-FEMA wildfires we find that total debt, credit card debt and medical debt decreases (table A2), while mortgage debt is increasing in this scenario. The decrease in credit card and medical debt is indicative of the fact that the household is receiving some support, maybe in the form of emergency services in the immediate aftermath of the event. We consider that non-FEMA wildfires are severely damaging, but affect a relatively smaller number of households, but would still require fire management and emergency services utilization to aid in rescue and fire management. For FEMA wildfires, mortgage debt is decreasing, indicating that the damage to the housing unit is substantial enough that the household may choose to shed its debt through sale and relocation. This treatment focuses on burned areas, where the potential damage to property is significant, and households migrate out of the area in the aftermath of a major event as evidenced in An, Gabriel, and Tzur-Ilan (2023).

In the case of wildfire smoke, table A3, find that the sign for total debt changes from negative to positive as the household is exposed to higher concentrations of PM 2.5. At exposure to hazardous levels of wildfire smoke, the household incurs positive total and credit card debt, but negative medical and mortgage debt. This makes sense if the household is located in close proximity to the wildfire perimeter, enough to maybe incur smoke damage that possibly triggers the use of home and health insurance, but does not actually experience a burn that would cause the household to become delinquent or incur large medical bills.

5.2 Assets

Few studies if any, look at the impact of weather events on household asset outcomes, particularly being able to distinguish between the varying impact of such events on financial and non-financial assets. Our results indicate a decrease in assets across the board for non-FEMA flood events, indicating that the household must utilise its resources to recover from the events. For FEMA flood events, we expect that the household is able to utilize the several programs designed to assist in recovery, such as the use of the Individuals Assistance (IA) or the use of Disaster Housing Assistance Program (DHAP).

For non-FEMA wildfire events, we see that total assets and non-financial assets are decreasing, while interestingly financial assets and savings are increasing. One plausible reason is that the household is reimbursed for its loss, and is possibly cash rich while choosing not to replace all the destroyed property. For FEMA wildfires, it is clear that the damages and losses are severe enough that the household takes a hit on all asset categories.

For wildfire smoke, we see that the results for the hazardous category are negative across the board, indicating that the household is incurring severe smoke damages requiring the household to off-load assets to finance recovery.

6 Conclusion

This paper contributes to the literature by providing evidence on the impacts of non-disasters events on household finance, particularly the impact of repeated non-severe weather induced phenomenon on household assets. However, given the multitude of complex mechanisms at play, the current results leave much room for further investigation. Given the substantial policy contributions of this paper, we will study the impact of these events based on various socio-economic characteristics such as race, age, income, education, and gender.

Several aspects of this study call for cutting-edge causal inference econometric techniques that can account for heterogeniety in treatment. Households roll in and out of the data throughout the study period, the household is exposed to multiple non-binary treatments, and households may switch in and out of treatment, there is variation in treatment timing, and households may switch in and out of treatment. Recent impact evaluation literature shows that applying traditional two-way fixed effects to such setups results in biased estimates that may be contaminated by negative weights arising from heterogeneous treatment effects and *'forbidden comparisons'* (Borusyak, Jaravel, and Spiess 2022; Athey and Imbens 2022; Callaway and Sant'Anna 2021; Goodman-Bacon 2021). We intend to revisit the estimation using the extended two-way fixed effects method developed by Wooldridge (2023) and *forward* DID_m proposed by de Chaisemartin and D'Haultfœuille (2023) to develop robust estimates.

References

Abatzoglou, John T., and A. Park Williams. 2016. "Impact of anthropogenic climate change on wildfire across western US forests." *Proceedings of the National Academy of Sciences* 113 (42): 11770–11775. https://doi.org/10.1073/pnas.1607171113.

Ahmadiani, Mona, Susana Ferreira, and Craig E. Landry. 2019. "Flood Insurance and Risk Reduction: Market Penetration, Coverage, and Mitigation in Coastal North Carolina." *Southern Economic Journal* 85 (4): 1058–1082. ISSN: 2325-8012. https://doi.org/10.1002/soej.12332.

American Lung Association. 2023. "Floods and Water Damage." Accessed May 2, 2023. https://www.lung.org/clean-air/emergencies-and-natural-disasters/floods-and-water-damage.

An, Xudong, Stuart A Gabriel, and Nitzan Tzur-Ilan. 2023. "The Effects of Extreme Wildfire and Smoke Events on Household Financial Outcomes." *Available at SSRN 4353113.*

Anttila-Hughes, Jesse, and Solomon Hsiang. 2013. "Destruction, disinvestment, and death: Economic and human losses following environmental disaster." *Available at SSRN 2220501.*

Associated Press. 2022. "California bans insurers from dropping customers in wake of largest wildfire." *The Guardian,* ISSN: 0261-3077.

Athey, Susan, and Guido W. Imbens. 2022. "Design-based analysis in Difference-In-Differences settings with staggered adoption." *Journal of Econometrics* 226 (1): 62–79. ISSN: 0304-4076. https://doi.org/10.1016/j.jeconom.2020.10.012.

Bakkensen, Laura A., and Lala Ma. 2020. "Sorting over flood risk and implications for policy reform." *Journal of Environmental Economics and Management* 104:102362. ISSN: 00950696. https://doi.org/10.1016/j.jeem.2020.102362.

Billings, Stephen B., Emily Gallagher, and Lowell Ricketts. 2020. "Human Capital Investment After the Storm." *SSRN Electronic Journal,* ISSN: 1556-5068. https://doi.org/10.2139/ssrn.3592609.

Bloomberg. 2022. "California Becomes First US State to Mandate Wildfire Insurance Discounts." *Paris, Martine.*

Borusyak, Kirill, Xavier Jaravel, and Jann Spiess. 2022. "Revisiting Event Study Designs: Robust and Efficient Estimation." (Rochester, NY), no. 2826228, https://doi.org/10.2139/ssrn.2826228.

Callaway, Brantly, and Pedro H.C. Sant'Anna. 2021. "Difference-in-Differences with multiple time periods." *Journal of Econometrics* 225 (2): 200–230. ISSN: 03044076. https://doi.org/10.1016/j.jeconom.2020.12.001.

Childs, Marissa, Jessica Li, Jeffrey Wen, Sam Heft-Neal, Anne Driscoll, Sherrie Wang, Carlos F. Gould, Minghao Qiu, Jennifer Burney, and Marshall Burke. 2022. "Daily Local-Level Estimates of Ambient Wildfire Smoke PM2.5 for the Contiguous US." *Environmental Science and Technology* 56 (19): 13607–1361.

de Chaisemartin, Clément, and Xavier D'Haultfœuille. 2023. "Two-way fixed effects and differences-in-differences estimators with several treatments." *Journal of Econometrics* 236 (2): 105480.

Deryugina, Tatyana, Laura Kawano, and Steven Levitt. 2018. "The Economic Impact of Hurricane Katrina on Its Victims: Evidence from Individual Tax Returns." *American Economic Journal: Applied Economics* 10 (2): 202–233. ISSN: 1945-7782, 1945-7790. https://doi.org/10.1257/app.20160307.

Eidenshink, Jeff, Brian Schwind, Ken Brewer, Zhi-Liang Zhu, Brad Quayle, and Stephen Howard. 2007. "A Project for Monitoring Trends in Burn Severity." *Fire Ecology* 3 (1): 3–21. ISSN: 1933-9747. https://doi.org/10.4996/fireecology.0301003.

EPA. 2012. *Revised Air Quality Standards For Particle Pollution And Updates To The Air Quality Index (AQI).*

———. 2022. "Health Effects Attributed to Wildfire Smoke." Overviews and Factsheets. Accessed May 2, 2023. https://www.epa.gov/wildfire-smoke-course/health-effects-attributed-wildfire-smoke.

FEMA. 2023. "Disaster Declarations Summaries." Disaster Declarations Summaries. Accessed January 18, 2023. https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2.

Field, Christopher B., Vicente Barros, Thomas F. Stocker, and Qin Dahe, eds. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change.* https://doi.org/10.1017/CBO9781139177245.

FloodSmart. 2020. "Flood After Fire: Your Increased Risk." Accessed May 2, 2023. https://www.floodsmart.gov/wildfires.

Gallagher, Justin, and Daniel Hartley. 2017. "Household Finance after a Natural Disaster: The Case of Hurricane Katrina." *American Economic Journal: Economic Policy* 9 (3): 199–228. ISSN: 1945-7731, 1945-774X. https://doi.org/10.1257/pol.20140273.

Goodman-Bacon, Andrew. 2021. "Difference-in-differences with variation in treatment timing." *Journal of Econometrics* 225 (2): 254–277. ISSN: 03044076. https://doi.org/10.1016/j.jeconom.2021.03.014.

Henry, Michael, Nekeisha Spencer, and Eric Strobl. 2020. "The Impact of Tropical Storms on Households: Evidence from Panel Data on Consumption." *Oxford Bulletin of Economics and Statistics* 82 (1): 1–22. ISSN: 1468-0084. https://doi.org/10.1111/obes.12328.

Kousky, Carolyn. 2018. "Financing Flood Losses: A Discussion of the National Flood Insurance Program." *Risk Management and Insurance Review* 21 (1): 11–32. ISSN: 1540-6296. https://doi.org/10.1111/rmir.12090.

Kousky, Carolyn, Erwann O Michel-Kerjan, and Paul A Raschky. 2018. "Does federal disaster assistance crowd out flood insurance?" *Journal of Environmental Economics and Management* 87:150–164. ISSN: 0095-0696. https://doi.org/10.1016/j.jeem.2017.05.010.

Landry, Craig E., Dylan Turner, and Daniel Petrolia. 2021. "Flood Insurance Market Penetration and Expectations of Disaster Assistance." *Environmental and Resource Economics* 79 (2): 357–386. ISSN: 1573-1502. https://doi.org/10.1007/s10640-021-00565-x.

Liao, Yanjun, and Carolyn Kousky. 2022. "The Fiscal Impacts of Wildfires on California Municipalities." *Journal of the Association of Environmental and Resource Economists* 9 (3). https://doi.org/https://doi.org/10.1086/717492.

McIntosh, Molly Fifer. 2008. "Measuring the Labor Market Impacts of Hurricane Katrina Migration: Evidence from Houston, Texas." *American Economic Review* 98 (2): 54–57. ISSN: 0002-8282. https://doi.org/10.1257/aer.98.2.54.

Michel-Kerjan, Erwann O. 2010. "Catastrophe Economics: The National Flood Insurance Program." *Journal of Economic Perspectives* 24 (4): 165–186. ISSN: 0895-3309. https://doi.org/10.1257/jep.24.4.165.

MTBS. 2022. "Monitoring Trends in Burn Severity." Direct Download. Accessed January 18, 2023. https://www.mtbs.gov/direct-download.

NOAA. 2020a. "Flood Basics." National Severe Storms Laboratory. Accessed January 16, 2023. https://www.nssl.noaa.gov/education/svrwx101/floods/.

———. 2020b. "Storm Events Database v3.1." National Centers for Environmental Information. Accessed January 18, 2023. https://www.ncdc.noaa.gov/stormevents/.

———. 2022. "Wildfire climate connection." Accessed January 16, 2023. https://www.noaa.gov/noaa-wildfire/wildfire-climate-connection.

Norton, Edward C. 2022. "The Inverse Hyperbolic Sine Transformation and Retransformed Marginal Effects," Working Paper Series, no. 29998, https://doi.org/10.3386/w29998.

NWS. 2021. "National Weather Service Instruction 10-1605." Accessed January 18, 2023. https://www.nws.noaa.gov/directives/sym/pd01016005curr.pdf.

Ouazad, Amine, and Matthew E Kahn. 2019. "Mortgage Finance in the Face of Rising Climate Risk." *NBER Working Paper Series* Working Paper 26322.

Radeloff, Volker C., David P. Helmers, H. Anu Kramer, Miranda H. Mockrin, Patricia M. Alexandre, Avi Bar-Massada, Van Butsic, et al. 2018. "Rapid growth of the US wildland-urban interface raises wildfire risk." *Proceedings of the National Academy of Sciences* 115 (13): 3314–3319. https://doi.org/10.1073/pnas.1718850115.

Reeves, Andrew. 2011. "Political Disaster: Unilateral Powers, Electoral Incentives, and Presidential Disaster Declarations." *The Journal of Politics* 73 (4): 1142–1151. ISSN: 0022-3816. https://doi.org/10.1017/S0022381611000843.

Salkowe, Richard S, and Jayajit Chakraborty. 2009. "Federal Disaster Relief in the U.S.: The Role of Political Partisanship and Preference in Presidential Disaster Declarations and Turndowns." *Journal of Homeland Security and Emergency Management* 6 (1). ISSN: 1547-7355. https://doi.org/10.2202/1547-7355.1562.

Schmidtlein, Mathew C., Christina Finch, and Susan L. Cutter. 2008. "Disaster Declarations and Major Hazard Occurrences in the United States−." *The Professional Geographer* 60 (1): 1–14. ISSN: 0033-0124, 1467-9272. https://doi.org/10.1080/00330120701715143.

Sylves, Richard, and Zoltán I. Búzás. 2007. "Presidential Disaster Declaration Decisions, 1953–2003: What Influences Odds of Approval?" *State and Local Government Review* 39 (1): 3–15. ISSN: 0160-323X. https://doi.org/10.1177/0160323X0703900102.

US Census Bureau. 2010. "TIGER/Line Shapefiles." *Census Mapping Files.*

Wooldridge, Jeffrey M. 2023. "Simple approaches to nonlinear difference-in-differences with panel data." *The Econometrics Journal* 26 (3): C31–C66.

World Meteorological Organization. 2021. *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019).* WMO 1267. Geneva: WMO. ISBN: 978-92-63-11267-5.

Yilmaz, Osman Salih, Dilek Eren Akyuz, Murat Aksel, Mehmet Dikici, Mehmet Adil Akgul, Oral Yagci, Fusun Balik Sanli, and Hafzullah Aksoy. 2023. "Evaluation of pre- and post-fire flood risk by analytical hierarchy process method: a case study for the 2021 wildfires in Bodrum, Turkey." *Landscape and Ecological Engineering* 19 (2): 271–288. ISSN: 1860-188X. https://doi.org/10.1007/s11355-023-00545-x.

Zhuang, Yizhou, Rong Fu, Benjamin D. Santer, Robert E. Dickinson, and Alex Hall. 2021. "Quantifying contributions of natural variability and anthropogenic forcings on increased fire weather risk over the western United States." *Proceedings of the National Academy of Sciences* 118 (45): e2111875118. https://doi.org/10.1073/pnas.2111875118.

A TWFE Regression Results

Table A1: Debt x Floods

	(1) Total Debt	(2) Credit Card Debt	(3) Medical Debt	(4) Mortgage Debt
Floods without FEMA	900.16	229.41**	-0.21	3193.60
	(699.14)	(91.11)	(43.61)	(3327.09)
FEMA without floods	-196.21	71.54	91.59	8429.13
	(1369.70)	(177.37)	(87.75)	(6047.46)
Floods with FEMA	3114.80	651.98	256.56	23516.59
	(4139.87)	(501.53)	(241.68)	(20299.68)
Observations	43266	43266	43266	43242

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A2: Debt x Wildfires

	(1) Total Debt	(2) Credit Card Debt	(3) Medical Debt	(4) Mortgage Debt
Wildfires without FEMA	-3068.06	-883.88*	-769.20***	31907.88
	(29158.18)	(522.41)	(296.93)	(2714980.51)
FEMA without wildfires	949.83	36.03	-44.15	-15121.31
	(7768.85)	(365.91)	(124.88)	(374585.75)
Wildfires with FEMA	-18366.00	1719.11	162.08	-407796.68**
	(16818.97)	(1171.76)	(141.17)	(195052.79)
Observations	43266	43266	43266	43242

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A3: Debt x Smoke

	(1) Total Debt	(2) Credit Card Debt	(3) Medical Debt	(4) Mortgage Debt
Moderate	-113.53	46.18	-14.56	2009.93
	(195.84)	(435.67)	(31.20)	(8074.60)
USG	-96.22	-77.22	-40.84	960.72
	(897.81)	(678.90)	(117.75)	(4852.42)
Unhealthy	517.13	-107.37	10.74	-2037.72
	(690.32)	(1108.04)	(81.52)	(5481.78)
Very Unhealthy	1494.86	53.87	334.11	-6002.63
	(5607.29)	(325.66)	(1248.09)	(18058.23)
Hazardous	26904.99***	361.44	-172.19	-2671.42
	(7781.66)	(981.76)	(363.18)	(26058.18)
Observations	43266	43266	43266	43242

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A4: Assets x Floods

	(1) Total Assets	(2) Savings	(3) Financial Assets	(4) Non-Financial Assets
Floods without FEMA	-2124688.19	-122.72	-1118672.08	-6691.23
	(3092773.39)	(1155.56)	(3248380.98)	(10674.39)
FEMA without floods	8660487.18	-5131.50**	-8302860.18	18007.13
	(7227837.76)	(2405.99)	(7175940.09)	(20212.31)
Floods with FEMA	29837519.13**	3177.38	8991297.90	53157.22
	(14632133.63)	(6081.06)	(18293266.93)	(42177.18)
Observations	43266	43266	43266	43266

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A5: Assets x Wildfires

	(1) Total Assets	(2) Savings	(3) Financial Assets	(4) Non-Financial Assets
Wildfires without FEMA	-29406541.13	6410.43	8078895.46	-67640.09
	(18629506.21)	(.)	(13592426.40)	(48146.15)
FEMA without wildfires	14023054.56	-8032.84	8305289.68	-7340.61
	(12893985.96)	(.)	(14071150.93)	(33556.05)
Wildfires with FEMA	-16082196.12	46674.20	-66961086.87	-297246.00
	(121840402.40)	(.)	(72274290.17)	(404334.12)
Observations	43266	43266	43266	43266

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A6: Assets x Smoke

	(1) Total Assets	(2) Savings	(3) Financial Assets	(4) Non-Financial Assets
Moderate	-10631.66	-701.21	-1763681.46*	6503.62**
	(10250699.35)	(8719.89)	(960072.72)	(3092.39)
USG	1094741.63	1004.72	1116152.61	6259.86
	(478238571.33)	(1524.35)	(19086304430.26)	(12962.49)
Unhealthy	-3050751.02	-23.30	-969941.14	1465.65
	(2995048.96)	(852.02)	(2944287.66)	(8943.43)
Very Unhealthy	14594760.94	-5615.97	5810643.90	61915.75
	(19624289.14)	(5299.18)	(18174231.74)	(52499.03)
Hazardous	-235045501.62***	-21013.92***	-70389691.43**	-758947.70***
	(50567562.82)	(7135.22)	(27333996.56)	(142069.54)
Observations	43266	43266	43266	43266

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$