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Examining Flood Insurance Claims in the United States: Six Key Findings

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Abstract

We undertake the first large-scale analysis of flood insurance claims in the United States, analyzing over 1 million claims from the federally managed National Flood Insurance Program (NFIP) over the period 1978–2012. Using fixed effects regressions and other statistical analyses, we test several hypotheses about the nature and drivers of flood claims (e.g., the impact of flood zone, characteristics of the house, individual and collective mitigation, and repetitive loss properties), as well as uncover quantitative relationships on the determinants of claims payments. We also examine how claims are distributed across time and space. Our findings, several surprising, provide a quantitative basis for exploring the challenges associated with low insurance demand and also can contribute to more informed policy decisions regarding reform of the NFIP, as well as flood insurance markets around the world.

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INTRODUCTION

Recent catastrophes have inflicted significant economic losses. The global average cost of natural disasters between 2000 and 2012 has been estimated to be around $100 billion per year (Kousky, 2014). During the period 2001 to 2010, insured losses from weather-related disasters averaged $30 billion annually (Swiss Re, 2011). Of all natural disasters, floods are the most costly (Miller, Muir-Wood, and Boissonnade, 2008) and have affected the most people (Stromberg, 2007). This is true worldwide, as well as in the United States, where floods accounted for the most lives lost and the highest amount of property damage over the 20th century (Perry, 2000).

In the United States, residential flood insurance has been available through the federally managed National Flood Insurance Program (NFIP) since 1968.[1] Recent disasters—Hurricanes Katrina in 2005, Ike in 2008, and Sandy in 2012—triggered significant amounts of flood-related losses and more than $25 billion in insured claims from NFIP policyholders (Kunreuther and Michel-Kerjan, 2013). Hurricane Katrina alone triggered more flood insurance claims payments by the NFIP ($16 billion) than had been made over the life of the program to that point. The program is now deeply in debt to the U.S. Treasury.

These recent disasters renewed interest in the U.S. flood insurance market by the academic community, policymakers, and the private insurance market, as shown by an increase in NFIP scholarship and policy debate. Some research was commissioned by the U.S. government, even before Hurricane Katrina hit, to examine insurance take-up rates in the program and the NFIP's impact on development (e.g., Blais et al., 2006; Dixon et al., 2006; Galloway et al., 2006). Academics have focused on examining the demand for flood insurance (e.g., Browne and Hoyt, 2000; Michel-Kerjan and Kousky, 2010; Kousky, 2011; Landry and Jahan-Parvar, 2011; Petrolia, Landry, and Coble, 2013; Atreya, Ferrera, and Michel-Kerjan, 2015), the overall operation of the program and alternative design options (Michel-Kerjan, 2010; Michel-Kerjan and Kunreuther, 2011), flood insurance pricing (Czajkowski, Kunreuther, and Michel-Kerjan, 2012; Kousky and Shabman, 2014), as well as estimating how flood risk and flood insurance might influence property values (e.g., Bin and Polasky, 2004; Kousky 2010; Atreya, Ferreira, and Kriesel, 2013; Bin and Landry, 2013). To date, however, there has been almost no work on flood insurance claims. While scholars might have some intuitive notions of the nature of flood insurance claims, there has not yet been a detailed analysis of claims paid over the life of the NFIP. In part this is because the data have not been publicly available.

Benefiting from unique access to the NFIP claims database, we present in this paper the first large-scale analysis of all the residential NFIP claims filed between January 1978 and the end of December 2012: a total of over 1 million claims distributed across the entire United States over this 35-year period.

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[1]There is a very small private market as well, often above the $250,000 limit available from the federal program for building coverage, although a few insurance firms do write full flood policies (Dixon et al., 2007).

Using fixed effects regressions and other statistical analyses of the claims database, we test several hypotheses about the influence of various factors on claims, as well as uncover quantitative relationships on the determinants of claims payments. We discuss our hypotheses when we provide background on the specifics of the NFIP; they address the role of risk, type of flooding, hazard mitigation, and other variables on claim payments in terms specific to the structure of the NFIP. In addition, we examine how claims are distributed across time and space. We primarily examine single-family building claims as a percent of building value, but also examine uncorrected claims (i.e., total dollar amount of the paid claim) and claims as a percentage of coverage levels.

The paper is organized as follows. The next section introduces the NFIP, focusing on aspects that are relevant to this article. We also present our research hypotheses in the context of the overall design and operation of the program. We then discuss our data, provide summary statistics of our key variables, as well as a better understanding of the average claim amount, number of claims, and claim rate over time, both overall and in high- versus low-risk zones. We then give an overview our methods and provide our results. The final section summarizes our findings, discusses policy implications, and concludes.

BACKGROUND ON FLOOD INSURANCE IN THE UNITED STATES: RESEARCH HYPOTHESES

The NFIP was established in the United States in 1968, partially in response to a lack of private sector availability of flood coverage. Due to the catastrophic nature of the peril, the spatial correlation of claims, and the difficulty in addressing adverse selection, private flood insurance has been largely unavailable in the United States since the large 1927 Mississippi flood (Gerdes, 1963; Anderson, 1974). Creation of the NFIP was also driven by concerns about the increasing burden that uninsured victims of flood were putting on the federal government through disaster relief (see Michel-Kerjan, 2010, for a review of the first 40 years of operation of the program).

The NFIP, currently housed in the Federal Emergency Management Agency (FEMA), is designed to be a partnership between the federal government, communities, and insurers. Communities can join the program, adopting minimum floodplain development regulations; flood insurance is then made available to homeowners and small businesses in those communities. As currently structured, 90-plus private insurance companies partner with FEMA to write NFIP flood insurance policies and process flood claims on behalf of the NFIP in exchange for a fee, allowing the federal government to benefit from the insurers' network and outreach. Insurers are only financial intermediaries, though; the NFIP sets prices and bears all the risk.

Today, over 22,000 communities across the United States participate in the program, covering almost all areas of flood risk in the country. Homeowners in these communities can insure their homes for up to $250,000 in building coverage, a limit that has remained unchanged since 1994. In addition, they can choose to purchase up to $100,000 in contents coverage.

The program has grown significantly over time. The total property value insured was $178 billion in 1978, $375 billion in 1990, and more than $755 billion in 2000 (all in 2012 dollars). From 2001 through 2012, total insured values reached nearly $1.28 trillion. In 1980, the program issued 2 million policies. This number had doubled by 1997 and continued to increase in the following years. Another significant jump in demand for flood insurance occurred right after seven major hurricanes hit the Gulf Coast in 2004 and 2005 and caused severe flood losses.[2]

As of December 2012, there were 5.63 million policies-in-force nationwide, with the NFIP receiving a total of $3.62 billion in annual premiums. These policies are not equally distributed around the country, however. Florida accounts for roughly 37 percent of all NFIP policies; the next largest percent is in Texas, 11.5 percent. The top five states—Florida, Texas, Louisiana, California, and New Jersey—account for almost 66 percent of all policies nationwide (as of December 2012).

While the number of policies-in-force has increased over time, low take-up rates have long plagued the program. In 1973, Congress passed the Flood Disaster Protection Act, which established the mandatory purchase requirement for property owners with a mortgage from a federally backed or regulated lender in a 100-year floodplain (considered high risk). Exact determination of take-up rates by flood risk area and whether or not a property is subject to the mandatory purchase requirement are hindered by lack of nationwide data. Several studies have attempted to estimate take-up rates, however, and their findings are fairly consistent. An estimate of take-up rates from a random sample of homes across the country by the RAND Corporation suggests that only about half of single-family homes in 100-year floodplains have flood insurance, although this average masks high regional variation, with the Midwest having the lowest take-up rates—20 to 30 percent—and the South and West having take-up rates closer to 60 percent (Dixon et al., 2006). A survey of coastal areas also found participation rates around 50 percent (Kriesel and Landry, 2004). An estimate of take-up rates in census tracts along the New Jersey and New York coasts immediately preceding Hurricane Sandy suggests market penetration was generally in the range of 5 percent to 50 percent (Kousky and Michel-Kerjan, 2012). Overall, a report by the New York City Mayor's Office published after Sandy revealed that 80 percent of residents living in areas inundated by storm surge had no flood insurance (New York City, 2013).

It is not clear whether those living in flood-prone areas understand the damage that would be sustained in the event of floods of various magnitudes (Petrolia, Landry and Coble, 2013). Most public outreach and communication about flood risk focuses on

[2]This increase in insured value is due to several factors. First, policyholders purchased more flood insurance to protect their assets. Inflation-corrected data show that the average quantity of insurance per policy almost doubled over 30 years, from $114,000 in 1978 to $217,000 in 2009. Second, many more people now live in exposed areas such as coastal states, which account for a very large portion of the portfolio of the NFIP. For instance, according to the U.S. Bureau of the Census, the population of Florida has increased significantly over the past 40 years: it was 6.8 million in 1970, 13.0 million in 1990, and nearly 19.3 million in 2012. Over the same period, the number of flood insurance policies-in-force in the state increased by a multiple of more than seven (Michel-Kerjan, 2010).

the probability of a flood, not on potential damage. This could be particularly problematic if most individuals underestimate their damage, as they may then fail to see the value of purchasing flood insurance or investing in risk reduction measures. This underestimation of flood damage was shown for the first time empirically in a recent survey of over 1,000 residents in floodplain areas in New York City (Botzen, Kunreuther, and Michel-Kerjan, 2015). We hope our current analysis on flood insurance claims will help improve communications about flood risk, on both the likelihood and damage from flood. We will come back to this point in the concluding section when we discuss the policy implication of our results.

We turn now to explaining various aspects of the NFIP. As we do this, we also introduce the hypotheses that will be tested in our analysis.

High - Versus Low-Risk Zones

Floodplains in all participating communities have been mapped by FEMA to determine program requirements, set premiums, and aid local governments with land-use planning. These flood insurance rate maps (FIRMs) delimit different flood zones. High-risk areas have a 1 percent chance of flooding each year according to FEMA; these are called Special Flood Hazard Areas (SFHAs), which are divided into zones A and V, the latter being coastal areas subject to wave action (storm surge). Flood heights are also more likely to reach a certain level above the base flood elevation as defined by FEMA in SFHAs than in lower risk zones, which include the 500-year floodplain and outside it.[3] *We hypothesize that claims will be more frequent in SFHAs than outside SFHAs (H1a). We also hypothesize that claims in V zones (wave action) will be higher than in A zones, which themselves will be higher than outside SFHAs (H1b).*

Early Construction

When the NFIP was established in 1968, many homes had already been built in areas at high risk for flooding. Homes built *before* the FIRMs for a community were established by FEMA, and thus before any federal floodplain management regulations were in place to mitigate flood risk on those structures, are referred to as "pre-FIRM." Whether pre-FIRM residences have higher flood claims than post-FIRM properties (those that were built *after* the maps were published) is not clear *a priori*. Pre-FIRM properties were built to less stringent building standards and so should be at greater risk. That said, post-FIRM properties might be higher value, leading to larger absolute claims.[4] The NFIP estimates that the minimum regulations for new construction avoid $1 billion in flood losses each year and that structures built in compliance with NFIP criteria experience 80 percent less flood damage (NFIP, 2002), suggesting post-FIRM claims should be lower. A study commissioned by FEMA using different methods similarly found that the mitigation provisions of the

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[3]See http://www.fema.gov for a full description of all the zones.

[4]According to the U.S. Census, the average size of newly constructed single-family houses in the United States increased by 43 percent from 1,755 square feet (163 square meters) in 1978 to 2,519 square feet (234 square meters) in 2008. See http://www.census.gov/const/C25Ann/sftotalmedavgsqft.pdf.

NFIP save roughly $1.1 billion each year (Sarmiento and Miller, 2006). *We thus hypothesize that individual claims as a percent of building value will be higher for pre-FIRM properties than post-FIRM properties (H2a).* While it is not clear whether the absolute magnitude of a claim would be higher for pre- or post-FIRM properties, *we hypothesize that it is higher for pre-FIRM claims (H2b).*

Repetitive Losses

The NFIP is prevented from refusing coverage to any policyholder in a participating community. Some properties, however, referred to as repetitive loss properties, have seen frequent and possibly higher claims than others. Repetitive loss properties are defined by FEMA as those having two or more losses of at least $1,000 over a 10-year period. The U.S. Government Accountability Office (GAO) has reported that repetitive loss properties are only 1 percent of policies-in-force but they have accounted for around 38 percent of NFIP claims between 1978 and 2004 (GAO, 2004). Beginning in the mid-2000s, actions were taken by FEMA to mitigate these properties and increase their flood insurance premiums. Repetitive loss properties, as defined, could simply have more frequent claims, but not necessarily larger claims; empirical analysis is thus necessary. *We hypothesize that claims are higher for repetitive loss structures (H3).*

Characteristics of the Insured Residence

Structural characteristics of the house can also impact flood claims. All thing being equal, *elevating the house* limits the chance of it being flooded and should also lower the magnitude of claims. Structures *having more than one floor* should typically result in a lower claim (than having the whole house at ground level), and *having a basement* can also lower the magnitude of claims, since it is more likely that the basement will flood first (NFIP basement coverage is limited). *We hypothesize that these dwelling characteristics will lower claims (H4).* While this is quite intuitive, the magnitude of the effect of each of these three factors needs to be empirically quantified.

Participation in the Community Rating System (CRS)

In addition to individual characteristics of the house, we test how community-based flood risk management efforts impact flood claims. In order to encourage communities to increase their floodplain management activities, the Community Rating System (CRS) was established in 1990 as a voluntary program. The CRS is a community-level incentive program for reducing flood losses in the United States. A community can adopt recognized flood risk management activities, receiving points for doing so. As it accumulates points, that community moves up through the levels of the program (from 10 to 1, 10 being the lowest with no active participation in the CRS and 1 the highest). Communities with fewer than 499 points are classified as class 10. A community with between 500 and 999 points is a class 9; between 1,000 and 1,499 is a class 8; between 1,500 and 1,999 is a class 7, and so on. At each new level, residents of the community whose residence is located in a high-risk SFHA receive another 5 percentage point discount on NFIP flood insurance rates, up to a

45 percent discount for a class 1 community.[5] As of spring of 2014, 1,296 communities participated in the CRS. While these are only 5 percent of all communities in the NFIP, they cover over 67 percent of all policies-in-force (FEMA, 2014). As will be discussed in the next section, we were able to access CRS scores for all communities in our claim dataset from 1998 to 2012 and merge those two data sets in order to measure the effect on claims of a community reaching a specific CRS class or points over this period of time.

Only a handful of studies have analyzed the CRS. Results of these studies indicate that reductions in flood damages are greatest for communities with more advanced participation, and for certain actions (such as open space protection, higher elevation requirements, and small flood control projects) (Brody et al., 2007; Michel-Kerjan and Kousky, 2010; Highfield and Brody, 2013). Research on communities in Florida suggests that most communities earn very few of the total possible points, focus much more on public information and mapping activities, and score low on damage reduction and flood preparedness activities (Brody et al., 2009). *We hypothesize that a higher degree of participation in the CRS generally lowers the magnitude of flood claims in the community but it is unclear if this holds for the lowest score levels, which may not be associated with activities that substantially impact claim amounts (H5).*

Trends Over Time

Finally, there are many influences on claims that have been changing over time. Since new and post-FIRM upgraded construction are subject to FEMA building codes, these properties should be better mitigated against flood damage. On the other hand, there has been more new construction in risky areas, particularly along the coast, since the program's founding, which could mean larger and more frequent claims. Building values have also increased, as indicated above. *We hypothesize that claims as a percent of building value have been declining over time, but total claims have been increasing (H6).*

Table 1 summarizes the hypotheses we will be testing in the following sections. Of note, our goal is not only to validate which of these hypotheses hold, but also to provide a more detailed quantitative analysis of these effects.

DATA OVERVIEW AND SUMMARY STATISTICS

In this article, we use four complementary data sets made available by FEMA to us for research purposes. Three are aggregate databases we use to examine overall claims and exposure by flood zone, the CRS, and repetitive loss properties. We return to these data sets below. The primary data set we use contains all NFIP claims in the United States with dates of loss between January 1, 1978 and December 31, 2012. We limit our focus to claims for single-family homes, as they have similar coverage levels and are more homogenous than including commercial, condominium, and mobile homes claims (which will be the focus of a companion paper). Single-family claims

[5]If the residence is located in a non-SFHA (as defined by FEMA) then the rebate is only 5 percent for classes 9 to 1.

Table 1
Hypotheses on Variables Impacting Flood Insurance Claims

H1a:	Claims are more frequent in SFHAs than outside SFHAs.
H1b:	Claims in V zones (wave action) are higher than in A zones, which will be higher than outside SFHAs.
H2a:	Claims as a percent of building value are higher for pre-FIRM claims than post-FIRM claims.
H2b:	The absolute magnitude of claims is higher for pre-FIRM claims.
H3:	Claims are larger for repetitive loss structures.
H4:	Elevated houses, houses with more than one floor, and houses with a basement have lower claims.
H5:	A higher degree of participation in the CRS by the community lowers the magnitude of flood claims, but it is unclear if this holds for the lowest score levels, which may not be associated with activities that substantially impact claim amounts.
H6:	Claims as a percent of building value have been declining over time, but total claims have been increasing.

are over 80 percent of all claims in our database[6] (as well as over 80 percent of the NFIP policies-in-force) at over 1 million observations across all years. To respect privacy, the data exclude personal information about the homeowner, including street address, but they do provide spatial resolution down to the five-digit postal code. The data include information on the claim, such as the date of the loss, the flood event with which it is associated, the amount of damage, and how much was paid by the NFIP. They also contain information for a subset of the policies on the house and contents associated with the claim. Finally, there is information on the community, the flood zone in which the property is located, whether the house is pre-FIRM or post-FIRM, what flood zone it is located in, whether it is elevated (i.e., above base flood elevation), and whether it has a basement.

Before we describe our empirical analysis, we present key summary statistics. Figure 1 shows the total claims paid by the NFIP by year. As already mentioned, the year 2005 stands out as the most costly. The year 2012, largely driven by insured flood losses from Hurricane Sandy, was the second most costly with $9 billion in paid claims, according to FEMA (our data only include claims closed as of December 2012 and thus do not include all Sandy claims; this explains why Figure 1 shows fewer claims in 2012 than FEMA actually paid). The year 2008 comes third, with $3.7 billion in paid claims, mainly for Hurricane Ike in Texas. Figure 1 shows that over the 35-year period, the 5 most costly years for the program all occurred after 2004. The figure also shows, in light gray, the percentage of claims each year that are for single-family homes, our focus.

[6]Claims for two-, three-, and four-family residences represent 6.3 percent of that total, other residential policies (e.g., mobile homes) are 3.6 percent, and claims from nonresidential NFIP insurance policyholders (e.g., small businesses) are 8.7 percent of the total number of claims paid.

FIGURE 1
Total Claims Paid by the National Flood Insurance Program as of December 2012, by Year (2012 Dollars)

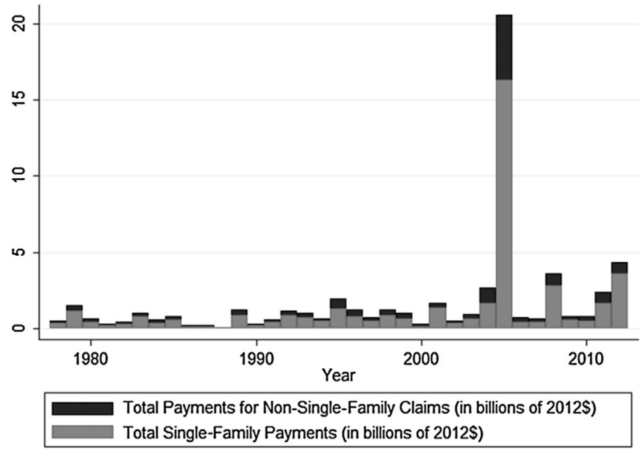


Table 2 examines the mean and median combined building and contents claim for single-family homes, in constant 2012 dollars, by year, along with the number of paid claims and the rate of paid claims for different groups of policyholders. For all years, the mean claim payment in inflation-adjusted terms is $33,764; it varies from a low of $11,738 in 1988 to a high of $91,911 in 2005 (largely driven by the flooding in Louisiana, where houses below sea level were destroyed when the levee system failed). The average claim value is heavily influenced by a fewer number of big claims. In fact, for all years, the median claim payment in inflation-adjusted terms is much lower than the average at $12,555. The median varies from a low of $4,594 in 1981 to a high of $72,887 in 2005. It is evident from Table 2 that the extraordinary losses of 2005 were due to both much higher claim amounts and a much larger total number of claims.

It is also worth noting the general evolution of the claims over several decades. From 1980 to 1989, the annual median paid claim ranged from $4,594 to $12,537; the median claim across this period was $7,735. In the following decade (1990–1999), the annual median paid claim for single-family homes ranged from $7,159 to $15,266, with a median across the period of $9,900—a nearly 30 percent increase from the previous period. The trend continues in the next 10 years. From 2000 to 2009, the annual median paid claims for single-family houses ranged from $7,185 to $72,887, with a median across the decade of $21,740 (more than double of what it was in the prior decade). If we exclude 2005 from this calculation, the median across the decade is substantially lower, at $12,600, but still greater by 27 percent than that of the previous decade. In other words, flood claims have been costing more to the NFIP over time, but catastrophic loss years (2005 and 2008) are responsible for a large portion of total losses. The much higher mean claims as compared to the median in most years suggest the presence of a few very high claim values that are increasing the average. When we look at the entire distribution over all years, we find that in 2012 dollars, half

TABLE 2
NFIP Claim Statistics (in 2012 USD) for Single-Family Homes Over the Period 1980–2012

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year	Mean Claim	Median Claim	Number of Paid Claims	Annual Claim Rate for Single-Family Policies	Annual Claim Rate for Single-Family Policies in the SFHA	Annual Claim Rate for Single-Family Policies Outside the SFHA
1980	$14,130	$6,378	32,514	2.65%	1.81%	3.84%
1981	$12,397	$4,594	17,963	1.30%	0.87%	1.94%
1982	$12,599	$5,605	25,919	1.91%	1.64%	2.34%
1983	$19,094	$8,086	42,156	2.93%	2.84%	3.10%
1984	$17,387	$7,712	21,058	1.40%	1.39%	1.42%
1985	$17,884	$9,228	31,346	2.00%	2.39%	1.20%
1986	$16,726	$7,746	10,892	0.66%	0.70%	0.57%
1987	$12,686	$5,940	10,445	0.62%	0.61%	0.63%
1988	$11,738	$5,019	5,981	0.34%	0.33%	0.37%
1989	$28,711	$12,537	30,001	1.78%	1.77%	1.80%
1980–1989	**$16,335**	**$7,735**	**228,275**	**2.30%**	**1.66%**	**3.44%**
1990	$17,322	$8,455	11,861	0.67%	0.68%	0.65%
1991	$19,327	$8,878	23,665	1.29%	1.38%	1.06%
1992	$23,780	$10,956	35,457	1.89%	2.19%	1.09%
1993	$25,773	$15,266	29,713	1.49%	1.75%	0.77%
1994	$29,588	$12,118	17,801	0.84%	0.79%	0.99%
1995	$26,934	$13,454	49,318	2.25%	2.23%	2.31%
1996	$18,997	$9,748	42,334	1.85%	2.03%	1.37%
1997	$21,427	$9,936	25,226	1.02%	0.96%	1.16%
1998	$18,909	$7,852	47,216	1.71%	1.86%	1.41%
1999	$16,573	$7,159	39,322	1.41%	1.71%	0.80%
1990–1999	**$21,795**	**$9,900**	**321,913**	**1.44%**	**1.56%**	**1.16%**
2000	$14,402	$7,185	12,932	0.44%	0.48%	0.36%
2001	$34,986	$20,714	38,631	1.32%	1.05%	1.88%
2002	$19,040	$8,348	21,442	0.70%	0.72%	0.66%
2003	$21,434	$10,155	31,864	1.05%	1.25%	0.65%
2004	$38,092	$12,559	44,009	1.43%	1.60%	1.08%
2005	$91,911	$72,887	177,100	5.21%	6.16%	3.31%
2006	$23,117	$11,840	20,179	0.57%	0.58%	0.56%
2007	$22,499	$10,902	18,270	0.49%	0.55%	0.40%
2008	$42,895	$18,883	65,244	1.69%	2.12%	1.10%
2009	$22,940	$10,339	26,584	0.68%	0.72%	0.64%
2000–2009	**$54,506**	**$21,740**	**456,255**	**1.36%**	**1.52%**	**1.06%**
2010	$20,994	$8,552	23,832	0.62%	0.70%	0.52%
2011	$25,830	$12,121	63,565	1.65%	2.25%	0.91%
2012	$34,080	$20,000	105,434	2.15%	3.02%	1.09%
1980–2012	**$34,478**	**$12,555**	**1,199,274**	**1.45%**	**1.55%**	**1.27%**

Source: Authors. Data from FEMA, U.S. Department of Homeland Security. *Note*: The summary years are in boldface.

of claims are less than $13,200 and 75 percent are less than $41,000. The 99th percentile, however, is $310,240.

Column (5) in Table 2 shows the percentage of all single-family policies-in-force in a given year with a paid claim. This was compiled by using aggregate data from FEMA on policies-in-force by year for different types of policyholders and combining it with our claims data set. This percentage ranges substantially, from a low 0.34 percent to a high 5.21 percent. It has been declining over the decades, but with an average of 1.45 percent over all years. Columns (6) and (7) examine the rate of paid claims in the SFHA and outside the SFHA. We use this to test H1a (higher claim rate in SFHA than in non-SFHA zones).

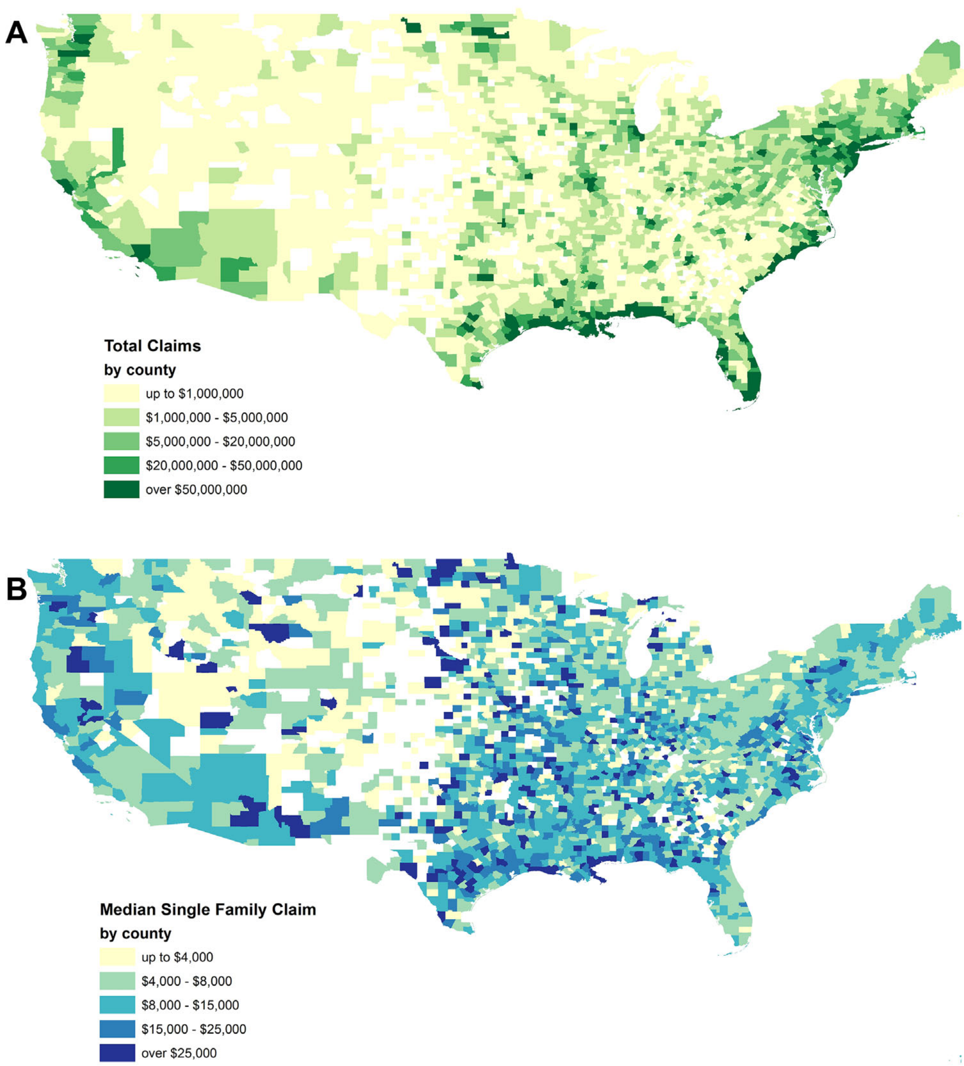
We find that on average the claim rate is higher than the 1 percent level FEMA uses in both SFHAs and non-SFHAs. The claim rate is not always higher in SFHAs than in non-SFHAs. The average across all years is 1.55 percent per year for residences in SFHAs and 1.27 percent for those outside of the SFHAs. Interestingly, we find that there is no statistically significant difference in these rates across the two groups for any decade or for the entire time period. This might be due to a couple factors. FEMA maps may not be fully accurate or up to date. There could also be an adverse selection problem; outside the SFHA purchase is voluntary for all properties and it is likely that only the riskiest properties outside the SFHA choose to insure. We thus find that H1 does not hold, contrary to what would be presumed based on the definition of the flood zones.

Figure 2 shows total claims and median single-family claims by county across all years in our data. The map of total claims (Panel A) demonstrates that claims are concentrated in areas where there are a high number of policies-in-force, such as the Gulf and Atlantic coasts, as well as where major flood events have occurred, such as around Louisiana, Florida, and the New York/New Jersey region. Looking at all paid claims in our database, the largest percentage, at 21.5 percent, are in Louisiana, due to the 2005 storms. Next is Texas at 12.5 percent of claims and Florida at 10 percent. So while Florida has the most policies-in-force, with Texas second and Louisiana third, the location of the landfall of large storms has driven claims. Median claims, on the other hand, are much more scattered around the country, demonstrating that severe local flooding is not just a coastal phenomenon (Panel B).

For our regressions, we define a set of explanatory variables related to the property, its flood risk, and any mitigation undertaken. We focus on building claims and examine three different dependent variables: the building claim over building value, the total building claim, and the total building claim over NFIP insurance coverage. We drop from our regressions any claims that were for contents only or closed without payment, leaving us with over 1 million claims.

We define dummy variables for whether the property associated with the claim is in an A zone, V zone, or B zone (this is the 500-year floodplain, exclusive of the SFHA); whether the property is pre-FIRM; whether it has now been tagged as a repetitive loss property; whether it is elevated; whether it has more than one floor; whether it has a basement; and whether the claim was attributable to flooding from storm surge.

FIGURE 2
NFIP Claims Across the United States (1978–2012)



Note: Panel A in Figure 2 shows the total NFIP flood insurance single-family residential claims by county over the period 1978–2012 (in 2012 prices); coastal counties top the ranking (dark color), which results from a combination of more policies-in-force there and high coastal flood risk. Panel B takes an individual view of flood risk and shows the median single-family claim over the same period (in 2012 prices), demonstrating that the individual risk is actually spread widely across the country.

Finally, for the years 1998–2012, we are able to identify the CRS scores of each NFIP community. This was one of the aggregate data sets obtained from FEMA and we match each community and year from the individual claims database to the CRS data set (CRS data before 1998 were not consistently collected). In some regression

TABLE 3
Summary Statistics for Regression Variables

Variable	Min	Mean or Percentage	Max
Dependent variables			
Total paid building claim (in nominal $)	.01	21,723	250,000
Building claim/value	4.62e-09	0.2483	1
Building claim/coverage	5.41e-08	0.2724	1
Independent variables			
A Zone dummy	0	0.6591	1
V Zone dummy	0	0.03241	1
B Zone dummy	0	0.05137	1
Pre-FIRM dummy	0	0.7757	1
Repetitive Loss dummy	0	0.01521	1
Elevated dummy	0	0.1653	1
More than one floor dummy	0	0.4595	1
Basement dummy	0	0.2568	1
Surge dummy	0	0.27	1
Katrina dummy	0	0.1057	1
CRS class 8 or 9	0	0.3167	1
CRS class 6 or 7	0	0.1519	1
CRS class 5 and better	0	0.0168	1
Total CRS points (in 100s)	0	6.364	48.46

specfications we will also introduce a dummy for whether the claim was from Hurricane Katrina. Summary statistics for these variables appear in Table 3.

The mean total paid building claim, in nominal dollars, is $21,700 and the maximum is the cap on building coverage of $250,000. Less than 1 percent of claims over all years are actually at the NFIP cap and roughly 78 percent of these occurred in 2005. The average building claim as a percent of value is almost 25 percent and the average building claim as a percent of coverage is just over 27 percent. Looking at the overall distribution of our main dependent variable—building claim as a percent of value—we find that half of claims are for less than 10 percent of the value of the building, roughly 15 percent of claims exceed 50 percent of the building's value, and approximately 7 percent exceed 75 percent of building value.[7] Most claims are in A zones (66 percent) and only just over 3 percent are in V zones. Roughly 30 percent of the over 1 million claims in our regression data set are outside an SFHA, demonstrating the importance of looking beyond the A and V zones described by FEMA as high risks.

A large majority of claims (77 percent) are from structures indicated as pre-FIRM. Only a small percent (1.5 percent) are tagged as being repetitive loss. This is because in our individual claims database, this indicator is only for claims on properties *once they*

[7]When we exclude 2005 data, roughly 10 percent of claims exceed 50 percent of the building's value and only slightly more than 3 percent of claims exceed 75 percent of the building's value.

have met the criteria, not claims on properties that will eventually meet the criteria.[8] Only 16 percent of claims are from homes that are elevated, around 46 percent have more than one floor, and just over 25 percent have a basement. As stated, we have the CRS information for claims since 1998 only, so those statisitcs are limited to those years. Just over half of claims come from non-CRS communities (or those coded as class 10). This suggests that CRS communities may indeed be successful in reducing claim rates since roughly two-thirds of policies are located in CRS communities.

METHODS

To examine the determinants of flood insurance claims, we use a series of community fixed effects specifications. Each observation is an individual flood claim. We regress our measure of the claim—in the base specifications, this is the building claim as a percent of the building's value[9]—on a series of explanatory variables and spatial and time fixed effects. This takes the form of Equation (1), for claim i in community c in year t:

$$claim_{i,c,t} = \alpha_c + \lambda_t + \gamma_s + X_{ict}\beta_j + u_{it}. \tag{1}$$

NFIP community fixed effects, given by α_c in Equation (1), control for any time-invariant aspects of the community in which the claim occurred. Year fixed effects, given by λ_t, control for shocks and changes that are common to all communities within a given year. We are thus examining the impact of various determinants on the variation in claims within a given community and year.[10] We also include state-level fixed effects given by γ_s. Our vector of claim determinants discussed in the preceding section is given by $\boldsymbol{X_{ict}}$. This includes the flood zone and indicators for whether the house is pre-FIRM, repetitive loss, elevated, has more than one floor, or is a claim from storm surge. The specification also includes a year time trend and a random error term. A subset of specifications, as reported in the next section, also include a fixed effect for the catastrophe number of the associated flood event assigned by FEMA.

We undertake several extensions and robustness checks. In terms of extensions, we examine alternate dependent variables, including the absolute amount of the individual building claim and the claim as a percentage of the insured coverage level. These let us examine slightly different aspects of the claims to provide greater insight. We also examine the role of the CRS by limiting our sample to the years for which we have data on CRS participation and re-estimating Equation (1) with independent variables on the CRS class (or points, depending on the specification) of the community in which the claim occurred.

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[8]The statistics from the GAO report are on all claims for repetitive loss properties, including their first two claims. We will examine data on all those repetitive loss claims later in the paper but we have such data only at a state level from FEMA.

[9]Note, some claims were missing data on one or more of the variables in the regressions; building value was the most often missing so the sample in regressions using that as the dependent variable is smaller than for the other dependent variables.

[10]We also ran our models with county fixed effects instead of community fixed effects and got very similar results but a slightly less good model fit.

Table 4
Determinants of NFIP Claims as a Percent of Building Value, Years 1978–2012

Dependent Variable: ln(bldg claim/bldg value)	(1)	(2)	(3)
	Community Fixed Effects Models		
A Zone	0.2011***	0.2495***	0.2444***
	(0.0271)	(0.0343)	(0.0327)
V Zone	0.3469***	0.3527***	0.3594***
	(0.0491)	(0.0514)	(0.0532)
B Zone	0.1254	0.1551***	0.1662***
	(0.0426)	(0.0541)	(0.0555)
Pre-FIRM	0.4509***	0.4242***	0.4392***
	(0.0482)	(0.0476)	(0.0481)
Repetitive Loss	0.2028***	0.0497	0.0981***
	(0.0273)	(0.0314)	(0.0277)
Elevated	−0.1583***	−0.1792***	−0.1629***
	(0.0271)	(0.0302)	(0.0287)
More than one floor	−0.2918***	−0.2989***	−0.2860***
	(0.0112)	(0.0153)	(0.0133)
Has a basement	−0.2030***	−0.2161***	−0.2071***
	(0.0165)	(0.0190)	(0.0187)
Storm surge claim	0.0809***	0.2057***	0.1704***
	(0.0086)	(0.0149)	(0.0166)
Annual trend	−0.0066***	0.0046	0.0027
	(0.0020)	(0.0052)	(0.0051)
Katrina claim			1.4822***
			(0.2120)
State and year FE	Y	Y	Y
Catastrophe FE	Y	N	N
Observations	1,106,608	1,106,608	1,106,608
R^2	0.3094	0.2581	0.2706

Note: Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

We also perform robustness checks on the functional form assumed in Equation (1). First, we break our data into two time periods to examine whether the influence of any of our variables on claims is drastically different in the early years of the program as compared to later years. Second, since our main dependent variable is a ratio bounded between 0 and 1, we estimate a fractional response model: a generalized linear model with a logit link function and the binomial family estimated by quasi-maximum likelihood, often referred to as a fractional logit model (Papke and Wooldridge, 1996).[11] We include the same fixed effects. Our findings are robust to this alternative specification.

[11] A Tobit model, which also could be used for this purpose, is not appropriate for our data since it is a censored regression model and our dependent variable is not censored at some value, but truly bounded as a ratio.

RESULTS

Main Results

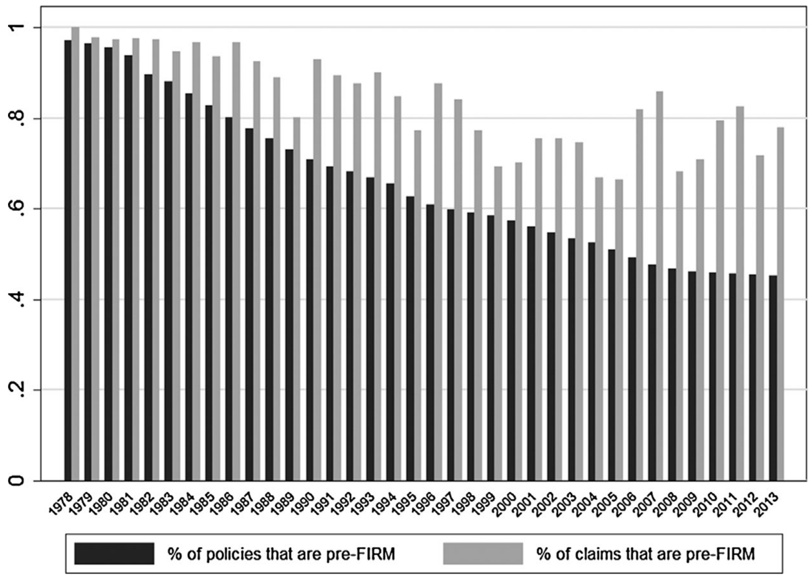
This section presents our results; the discussion of policy implications follows in the next section. The regression results are for individual-level claims. In our base models, the dependent variable is building claim as a percent of building value. Table 4 shows the results of several specifications, all with NFIP community fixed effects. All specifications include the explanatory variables discussed earlier. Specification (1) includes fixed effects for different flood events ("catastrophe FE"), as given by the NFIP to code large events. Specification (3) does not include these fixed effects, but does include a dummy for whether the claim was associated with Hurricane Katrina, letting us examine how this event was an outlier in claims experience for the NFIP.

First, in order to test H1b, we look at the impact of being in an A zone or V zone (both SFHAs) compared to claims outside these zones. The risk of flooding is an obvious source of heterogeneity in flood claims. As expected, we find that A zone claims are higher than outside the SFHA and 500-year floodplain, by roughly 20 to 25 percent. V zone claims are even higher compared to claims outside the SFHA and 500-year floodplain by 35 to 36 percent. A Wald test finds that the coefficients on A and V zones are indeed statistically different from one another (p-value for specification (1) is .0004). B zone claims (500-year floodplain exclusive of SFHA) are higher than outside the 100- and 500-year floodplains by 12.5 to 16.6 percent. Claims in the A zone are statistically different from B zone claims (although the p-value is lower at 0.0723). For reference, in the sample of claims in our regressions in Table 3, there are just over 741,000 claims from A zones and just over 37,700 claims from V zones. V zones have a small number of claims because they occur only in a small band along some coasts. The lower number of claims from non-SFHAs reflects the lower take-up rate for flood insurance outside 100-year floodplains, as mentioned earlier. We thus find confirming evidence for H1b.

Another related potential source of variation in flood claims is whether the flooding is storm surge related or not. This is partially captured by the zone, since the V zone areas are subject to storm surge. That said, it is possible that V zone claims are not all from surge. We thus explicitly control for whether the claim is a result of storm surge. Note, the correlation between the surge variable and our V zone variable is positive but small at 0.1143. We find surge claims are an extra 8 to 20.5 percent higher than nonsurge claims, likely due to the extra force of the water. The range in this coefficient across specifications is due to the inclusion or not of the catastrophe code fixed effects. These codes are for very localized events and so are likely picking up much of the difference in surge and non-surge claims when included, lowering the coefficient on the surge variable.

Next we consider the difference between pre-FIRM and post-FIRM properties. In Table 4, we examine claims as a percent of building value; this ratio allows us to control for any possible effect of lower building value among pre-FIRM properties. We find that this ratio is on average 42 to 45 percent higher for pre-FIRM properties than post-FIRM ones, highlighting their heightened susceptibility to damage and confirming H2a. Of note, there are many more pre-FIRM claims in the database, since

FIGURE 3
Percent of NFIP Policies and Claims That Are Pre-FIRM



early in the program, almost all properties were pre-FIRM.[12] This includes all properties built before their community was mapped, regardless of whether they are actually receiving a premium discount that FEMA offers to such properties. Thus, some, while being built before flood maps were available, may not be as risky as others. When a property is substantially damaged or expanded, it must come into compliance with current maps and is no longer pre-FIRM.

This pattern is shown in Figure 3, which compares the percent of pre-FIRM policies with the percent of pre-FIRM claims, by year. While the percent of policies that are from pre-FIRM properties has been steadily declining since the late 1970s, the percent of claims that are pre-FIRM has not be declining as quickly and still remains at over 60 percent of building claims.

Next, we examine repetitive loss properties. Note, as stated earlier, the claims in our database that are identified as repetitive loss are only those claims that occur on a property after it has met the definition of repetitive loss (two claims of more than $1,000 over a 10 year period); it does not include claims on that same property before meeting the criteria. While we would expect repetitive loss properties to have more frequent claims, it was not clear they would necessarily be higher in magnitude. We

[12]From 1978 to 1990 there were approximately 267,500 pre-FIRM, single-family claims and only roughly 16,500 post-FIRM, single-family claims. For 1991–2000, there were roughly 256,700 pre-FIRM, single-family claims and about 58,300 post-FIRM, single-family claims. For 2001–2012, there were over 431,000 pre-FIRM, single-family claims and over 168,900 post-FIRM, single-family claims. Thus, most post-FIRM claims have occurred in recent years, but pre-FIRM claims make up a large majority of the claims.

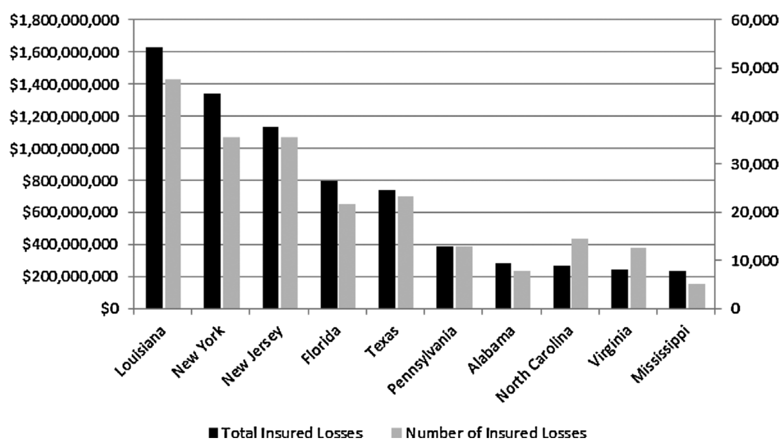
find, however, that the magnitude of these building claims as a percent of building value is higher than nonrepetitive loss properties by roughly 5 to 20 percent depending on the specification. This large variation in range stems from whether we include fixed effects for catastrophes in the specifications. It appears that the difference in repetitive versus nonrepetitive loss claims are higher, once we control for the individual disaster event. We thus find that H3 is confirmed. This can be seen just by examining the raw means. The average paid building claim for a repetitive loss claim is $36,200 in 2012 dollars, compared to about $27,800 for the sample overall.

Of those claims tagged as repetitive loss in our database for the regressions, 74 percent of them are from A zones, close to 4 percent are from V zones, and the rest are from outside of SFHAs. This is very similar to the distribution of claims for nonrepetitive loss properties (which is just under 71 percent in the A zone, almost 4 percent in the V zone). Repetitive loss claims do seem to happen less from storm surge, perhaps because repetitive loss properties are less concentrated on the coast. Of repetitive loss claims, 13.5 percent are from surge, and of nonrepetitive loss claims, over 27 percent are from surge.

We also obtained from FEMA aggregate state data on all repetitive loss claims from 1978 through September 2014. Unlike our claims database used in the regressions, this aggregate data set includes all claims ever paid to repetitive loss properties' owners, both before and after they were identified as meeting repetitive loss criteria. Figure 4 shows the top 10 states with the highest insured losses from repetitive loss properties (black bars with the y-axis on the left side)—a total of over $7 billion in insurance reimbursement over this period. For these top 10 states, we also show the total number of repetitive loss claims to date (gray bars with the y-axis on the right side).

Turning back to our regression results, we examine several characteristics of the property. We have a dummy variable for whether the building is elevated.

Figure 4
Top 10 States for NFIP Claims From Repetitive Loss Properties (1978–2014)



Sources: Authors with statewide data on repetitive loss properties from FEMA.

Unfortunately, FEMA does not have data on the amount of elevation of all insured single-family residences (buildings are considered elevated if their first floor is above the base-flood elevation, i.e., the 100-year return period flood) but does have a variable that is a simple binary variable on whether any elevation has occurred. Using this variable, we find that on average across all buildings that are known to be elevated, claims as a percent of building value are roughly 16 to 18 percent less than for nonelevated buildings. We also find that buildings with more than one floor have 29 to 30 percent lower claims as a percent of building value, which is intuitive, and those with a basement also have 20 to 22 percent lower claims. The negative coefficient on the basement is likely because homes with basements will often only have flooding in the basement and NFIP coverage is quite limited for basements. This confirms H4. Note, we suppress state, county, year, and catastrophe number fixed effects in the table. As predicted, some of these fixed effects are highly significant. Specification (3) in Table 4 replaces the catastrophe number fixed effects with a simple dummy to control for Katrina claims and demonstrates that claims were dramatically higher from that storm; this is also seen above in Table 2.

Extensions

Our first extension consists of a closer examination of how being in a CRS community may affect individual flood insurance claims. As discussed earlier, we hypothesize that a higher number of CRS points, leading to a better score (i.e., moving up from a class 10 to a higher class, up to class 1) will reduce claims, but not necessary for communities with a low CRS participation level since this might be reached by undertaking activities that might not directly lower exposure to flood risk (such as outreach and communication activities). We thus assign to every claim in our data set the CRS class and total point score for the given year of the community in which it was located. We then run specification (1) again, including these new variables. Note, as already mentioned, this is only for the years that FEMA has good quality CRS data over the period we study, namely, 1998 to 2012. The regression results are shown in Table 5.

Consistent with H5, claims in communities that participate in the CRS (i.e., class 9 and better) are lower. More specifically, we find that individual claims in class 9 (entry level) and class 8 communities are 13.5 percent lower than in non-participating communities. As such, while we were cautious about H5 not holding for low-score communities, it seems that even communities that undertake minimal effort to be in the CRS do see a reduction in claim amounts, all things being equal. This is very encouraging and has important policy implications on the benefits of even minimal participation in the CRS.

Claims in higher classes are lower as well, but statistically insignificant, although this could be due to a lack of power since the number of communities in those classes is small. Only 1.5 percent of our claims are from communities in class 5 or better, 3 percent are in class 6, and 11 percent are in class 7.

We can also measure the impact of gaining 100 points in the CRS program. A 100-point increase in CRS class reduces claims by slightly less than 2.5 percent. Points likely influence claims nonlinearly, so we included a squared term, although it is not

TABLE 5
Impact of CRS on Claims as a Percent of Building Value, Years 1998–2012

Dependent Variable: ln(bldg claim/bldg value)	(1)	(2)
A Zone	0.2181***	0.2141***
	(0.0315)	(0.0330)
V Zone	0.3302***	0.3273***
	(0.0692)	(0.0714)
B Zone	0.3302***	0.3273***
	(0.0692)	(0.0455)
Pre-FIRM	0.4827***	0.4710***
	(0.0609)	(0.0652)
Repetitive Loss	0.2367***	0.2325***
	(0.0294)	(0.0308)
Elevated	−0.2276***	−0.2148***
	(0.0310)	(0.0325)
More than one floor	−0.2662***	−0.2588***
	(0.0173)	(0.0178)
Has a basement	−0.1989***	−0.2037***
	(0.0227)	(0.0237)
Storm surge claim	0.0919***	0.0817***
	(0.0145)	(0.0148)
Annual trend	0.0682	−0.0066
	(0.0760)	(0.0449)
CRS class 8 or 9	−0.1351*	
	(0.0773)	
CRS class 6 or 7	−0.1416	
	(0.0940)	
CRS class 5 and better	−0.0630	
	(0.1130)	
Total CRS points (in 100s)		−0.0244***
		(0.0084)
Total CRS points (in 100s) squared		0.0004
		(0.0004)
State and year FE	Y	Y
Catastrophe FE	Y	Y
Observations	632,381	595,567
R^2	0.3427	0.3487

Note: Standard errors in parentheses. $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.

statistically significant. Some actions will have a much greater influence on flood damage, but we do not have information on the specific activities.[13]

As the next extension, we examine the impact of our independent variables on two alternate dependent variables: the natural logarithm of the total building claim and the natural logarithm of the total building claim divided by the total building coverage. For

[13]FEMA is currently undertaking an analysis of the effectiveness of the CRS at reducing flood insurance claims.

TABLE 6
Alternative Dependent Variables, Community Fixed Effects Model

	(1) ln(total bldg claim)	(2) ln(bldg claim/ bldg coverage)	(3) ln(bldg claim/bldg value) (as in Table 4)
A Zone	0.1684***	0.2328***	0.2011***
	(0.0236)	(0.0329)	(0.0271)
V Zone	0.3670***	0.3660***	0.3469***
	(0.0493)	(0.0594)	(0.0491)
B Zone	0.0736**	0.0089	0.1254***
	(0.0366)	(0.0463)	(0.0426)
Pre-FIRM	0.2427***	0.4406***	0.4509***
	(0.0380)	(0.0464)	(0.0482)
Repetitive Loss	0.1443***	0.1614***	0.2028***
	(0.0250)	(0.0274)	(0.0273)
Elevated	−0.2131***	−0.2097***	−0.1583***
	(0.0264)	(0.0280)	(0.0271)
More than one floor	−0.0020	−0.2563***	−0.2918***
	(0.0135)	(0.0140)	(0.0112)
Has a basement	−0.2248***	−0.1228***	−0.2030***
	(0.0141)	(0.0157)	(0.0165)
Storm surge claim	0.0646***	0.0202**	0.0809***
	(0.0083)	(0.0096)	(0.0086)
Annual trend	0.0072***	−0.0224***	−0.0066***
	(0.0018)	(0.0030)	(0.0020)
State and year FE	Y	Y	Y
Catastrophe FE	Y	Y	Y
Observations	1,151,549	1,151,471	1,106,608
R^2	0.3640	0.3483	0.3094

Note: Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

the total building claim, we adjust claims to 2012 dollars using the U.S. Consumer Price Index. These are shown as columns (1) and (2) in Table 6. Column (3) replicates column (1) from Table 4 for comparison. Findings are actually fairly similar across these alternative dependent variables. A few things stand out as noteworthy. Being a pre-FIRM property has less of an impact on the size of the total claim—although it is still positive, confirming H2b—as it does on the claim as a percent of building value or coverage levels. Being in a B zone is not statistically different from being outside both 100-year and 500-year floodplains on claims as a percent of coverage. As would be expected, having more than one floor has no influence on the total size of the claim, but negatively influences the claim as corrected for value or coverage.

Finally, the annual time trend is positive when examining total building claims, suggesting the absolute value of claims has been increasing at about 0.7 percent per year, while claims corrected for value or coverage have been decreasing, as we hypothesized. H6 is confirmed. This suggests that the claim has been increasing less rapidly than the value of the property and of the limit of insurance purchased (which

TABLE 7
Comparing Time Periods

Dependent Variable: ln(bldg claim/bldg value)	(1) 1978–1994	(2) 1995–2012
A Zone	0.2328***	0.2101***
	(0.0328)	(0.0274)
V Zone	0.4297***	0.3324***
	(0.0480)	(0.0630)
B Zone	0.1412***	0.1236***
	(0.0631)	(0.0393)
Pre-FIRM	0.3564***	0.4848***
	(0.0431)	(0.0556)
Repetitive Loss	−0.4261***	0.2219***
	(0.1204)	(0.0280)
Elevated	0.1462***	−0.2204***
	(0.0343)	(0.0288)
More than one floor	−0.2825***	−0.2817***
	(0.0179)	(0.0151)
Has a basement	−0.2048***	−0.2117***
	(0.0167)	(0.0205)
Storm surge claim	0.0716***	0.0810***
	(0.0095)	(0.0128)
Annual trend	−0.0168***	0.1410**
	(0.0039)	(0.0611)
State and year FE	Y	Y
Catastrophe FE	Y	Y
Observations	362,824	743,784
R^2	0.2690	0.3216

Note: Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

as indicated before, has been increasing over time). All specifications include annual fixed effects, however, which pick up large yearly shocks, such that some of the large claims from years like 2005 and 2012 are not in the annual trend variable.

Robustness Checks

We perform two robustness checks. Our first robustness check divides the data into two time periods to examine whether the impact of any of our determinants of flood claims were changing in their influence over time. This is shown in Table 7, which uses the claim as a percent of building value as the dependent variable and repeats our base specification for the two time periods.[14]

[14]Year fixed effects should account for outlier years in these specifications, such as 2005. Still, to guarantee that the year 2005 was not driving the results in specification (2) we also estimated the same regression but excluding all claims from 2005. While the magnitude of some coefficients does vary slightly, all the findings are robust (results available from authors upon request).

We test whether there is a statistical difference between the coefficients in the different time periods using interaction terms in a pooled model (not shown). Only a few coefficients stand out as being not just statistically different, but substantively different in magnitude, as well. For example, repetitive loss structures switch from being associated with lower claims to higher claims over the time period. The change might be explained by our only capturing such losses when the properties are entered into the NFIP system after two losses, which is more likely to be in the latter half of the data. The impact of elevation also switches signs; it is possible this is due to better elevation data in the later period. Finally, claims as a percent of building value are declining by 1.3 percent a year in the first time period and then increasing in the second half. While we do include annual fixed effects, the annual trend reflects the fact that the largest flood events in terms of claims for the NFIP have all been in the second period of the data.

Finally, we test whether our results are robust to an alternative functional form that accounts for the bounded nature of our dependent variable. We get similar findings using the generalized linear model (GLM) as with our standard fixed effects (results available from authors upon request). We think this similarity in findings is a reassuring robustness check but GLM is not a preferred model for us since it imposes more functional form assumptions and is harder to interpret.

Discussion and Policy Implications

In this article we have examined the determinants of more than three decades of single-family residential flood insurance claims in the United States and explored their temporal and spatial distributions. As the first large-scale analysis of such claims, we believe our findings have implications for both demand for flood insurance by households and the overall structure and exposure of the NFIP. We discuss our findings under these two categories here.

Implications for Insurance Demand

Low take-up rates for voluntary disaster insurance have been observed in the United States and other countries (e.g., Kunreuther, 1978; Palm, 1998). This has generated many studies on the demand for flood insurance. As mentioned in the introduction, some of these studies seek to uncover determinants of flood insurance purchases (e.g., Browne and Hoyt, 2000; Kousky, 2011; Landry and Jahan-Parvar, 2011; Petrolia, Landry, and Coble, 2013; Atreya, Ferreira, and Michel-Kerjan, 2015). Other work focuses on the role of behavioral biases in evaluating risk information as it relates to insurance purchase decisions (e.g., Kunreuther, Pauly, and McMorrow, 2013). For example, flood insurance purchases have been found to increase immediately following disaster events and then decline (Gallagher, 2014). Other work has found that insureds are more likely to stick with default options, rather than make changes from the status quo (Samuelson and Zeckhauser, 1988; Johnson et al., 1993). Some research has found empirical evidence that risk management decisions are often not based on formal beliefs about probabilities (e.g., Magat, Viscusi, and Huber, 1987; Camerer and Kunreuther, 1989; Hogarth and Kunreuther, 1995). In a study by Huber, Wider, and Huber (1997), for example, only 22 percent of subjects sought out probability information when evaluating risk management decisions. There is also evidence that people tend to ignore risks when they view the likelihood of occurrence as falling below some threshold level of concern (e.g., McClelland, Schulze, and Coursey, 1993; Oberholzer-Gee, 1998). Given this, people in a 100-year floodplain (the SFHAs) might deem the risk low enough to ignore.

Our findings suggest yet another plausible explanation for low take-up rates of flood insurance by focusing on the potential loss as opposed to the probability. Since information about flood insurance claims has never been made public, it is not clear whether those living in flood-prone areas are actually knowledgeable about what damage they would suffer after a flood. For decades FEMA has concentrated its communication effort about flood risk on the *probability* component of the risk: all FEMA maps are defined as a return period (100-year, 500-year, etc.). But the literature over the past 40 years has repeatedly shown that individuals have a hard time understanding low-probability events. We argue here that claims data analysis should be more widely discussed with those living in exposed areas. It is time to help residents understand the potential damage they could sustain, as well as the likelihood.

A study on this topic was conducted recently by Petrolia, Landry, and Coble (2013), focusing on individuals residing along the U.S. Gulf Coast and Florida's Atlantic Coast. The authors show through a survey that the likelihood of holding flood insurance was greater for those who anticipated higher damages, something fairly intuitive, but they are also able to measure that there was a marginal effect of 1.6 percent for a 1 percent increase in anticipated damages (as a proportion of structure value). The difference might be explained by preferences. The bigger question then is whether individuals are competent in estimating the magnitude of flood damage (conditional on being flooded). To our knowledge this question has not been analyzed in this context until very recently. Botzen, Kunreuther, and Michel-Kerjan (2015) perform such an analysis, building on a new flood model that two of them had helped developed for the city (Aerts et al., 2014). They show that individuals largely underestimate the damage a flood would cause, despite the survey being conducted the year following massive flooding from Hurricane Sandy in 2012. They show that this underestimation of the damage led to underinsurance, consistent with Petrolia, Landry and Coble (2013).

Our analysis can provide some insight on the estimate of damages in the Petrolia, Landry and Coble (2013) survey. In their paper, the authors ask respondents the following question: "Suppose a Category 3 hurricane (wind speeds of 111–130 mph) directly hit your community. How much damage (expressed as a percentage of total structure value) do you think your home would most likely suffer?" They found that, on average, individuals expected damage from direct strike of a Category 3 storm to be 33.8 percent of structure value (with a range of 0 to 100 percent, illustrating wide misperception in anticipated potential damages). The authors did not have an expert's estimate on what such a disaster would actually do to each respondent's house. We find in our claim data analysis that in 2005, the average claim as a percent of the value of the structure was a much higher 50.5 percent (median of 53.5 percent). Considering the fact that we looked only at flood-related claims, not accounting for wind loss, it is prudent to say that these individuals largely underestimated what such a flood disaster would do to their home.

While we cannot, in this study, uncover what individuals believe about their risk of flooding—probability and damage—we do observe claim rates and magnitudes, which could be communicated to those exposed. We observe that claim rates overall for single-family homes are on average somewhat close, albeit higher, to what one would predict for a 100-year floodplain: 1.45 percent over all years. This ranges from less than half a percent to over 5 percent in high loss years. Outside the SFHA, homeowners might expect claim rates to be much lower, explaining very low take-up in those areas. We find, however, that annual claim rates are not statistically significantly lower than inside the SFHA, and on average higher than 1 percent. This is an important finding since it is not what residents are often told in risk communication efforts (e.g., that non-SFHAs are low risk). Possible inaccuracy of the maps and an adverse selection problem can both explain this result as discussed earlier in the article. Those outside the SFHA voluntarily buying a policy might simply be at much higher risk than the average non-SFHA resident.

Conditional on a claim occurring, we also examine the size of the claim along a number of dimensions. The median claim between 2000 and 2009 is $21,740. Over all years, however, half of claims are for less than roughly $13,000 (although the 99th percentile is over $310,000). This suggests that many claims are for fairly modest amounts, although at times they can be extremely high. Homeowners may perceive that claims tend to be modest and think they do not need to insure. They may also believe that theirs is not the type of property that would sustain a high magnitude claim in the event of a flood.

We shed some light on the types of properties that have higher magnitude claims in our regression analysis, independent of their occurrence rate. We find that conditional on a claim, claim magnitudes as a percent of building value are 20 to 25 percent higher for A zones than outside the SFHA and 35 to 36 percent higher for V zones than outside the SFHA. Claims are lower for elevated properties and higher from storm surge. This is information on damage that could be communicated to those living in flood-prone areas.

Given our findings, and in order to better recognize heterogeneity of individual preferences vis-à-vis flood insurance, we would like to propose two types of policies that may be attractive to different homeowners.

Strategy 1. Purchase insurance coverage for low-loss levels only. Some homeowners may think flood insurance claims are usually low and prefer a policy with a low deductible and low coverage level. They disregard the possibility of a catastrophe and want to see some return on their premium payment and collect as much as possible on their policy should they suffer a loss. This type of policy would indeed cover the vast majority of losses the property is likely to sustain as our study shows. Michel-Kerjan and Kousky (2010) find that in Florida from 2000 to 2005, more than 80 percent of single-family homeowners had selected a deductible of either $500 or $1,000, then the two lowest possible options.

Strategy 2. Purchase tail-loss coverage only. Some individuals might prefer to self-insure for the more frequent and more modest losses but purchase a policy to cover catastrophic damage. Indeed, although flood insurance claims are rare and generally small, there is still some chance of a severe loss from flooding. Specifically, between January 1978 and December 2012, our analysis reveals that 8 percent of claims were above 95 percent of their insured value.[15] Such a "tail insurance policy" would be cheaper than more comprehensive coverage since the probability of suffering a truly catastrophic loss is very low for most; that could make this type of flood insurance much more affordable.

Implications for Program Exposure

Our analysis also has implications for the exposure of the overall flood insurance program. The large debt of the NFIP (currently around $24 billion) has sparked substantial interest in the program's financial standing and whether it could transfer some of the risk it insures to the private sector. Our analysis identifies some particular challenges to achieving a more fiscally sound NFIP. First, while the absolute magnitude of building claims has been increasing each year, claims corrected for the value of the structure have been declining. This suggests that building value has been increasing faster than flood damages and could contribute to more aggregate losses in the future.

The program has very concentrated exposure on the Gulf and Atlantic coasts. Given the high number of policies in these areas and the hurricane risk, it is not surprising that total claims are clustered in these areas. Storms are a correlated risk; with such a high number of policies, when a hurricane makes landfall, many policyholders are impacted simultaneously. Currently, the NFIP is not pricing policies including this risk to its aggregate portfolio. This will continue to leave the program fiscally unprepared for events like Hurricane Katrina and Hurricane Sandy.

Pre-FIRM properties were built before flood risk maps were available and before communities had adopted minimum building regulations for 100-year floodplains. Historically, they were given price discounts to encourage them to participate in the program, as a full risk rate would likely be unaffordable. The burden of these discounted rates was the subject of legislative reform to the program in 2012 and 2014. We find that pre-FIRM properties are indeed a fiscal burden to the NFIP. Their claims as a percent of building value are 43 to 45 percent higher than post-FIRM properties. We also find that while the number of pre-FIRM policies has been declining over time,

[15]The coverage level of these claims ranges from very low to the maximum available. These are, to some extent, a "Katrina effect": close to 63 percent of these observations are from 2005. Another 5.5 percent are from 2008, when Hurricane Ike hit Texas. When we examine the data by state, we find that three-fourths of claims equal to coverage levels over the entire period are from only three states: Louisiana, Mississippi, and Texas. Close to 56 percent of claims equal to coverage levels are from Louisiana and another 11 percent are from Mississippi. After those two states, Texas has the next largest share, at just over 7 percent. However, not all these households are at the NFIP cap: the median insurance purchase for claims equal to the coverage limit is $73,000 and the mean is $93,300.

and is now below 50 percent, a disproportionate share of claims, at over 60 percent, are still pre-FIRM. The 2014 Homeowner Flood Insurance Affordability Act will be slowly raising rates on these properties that are currently receiving a price discount to more closely align the prices with their risk.

Another fiscal challenge for the NFIP are repetitive loss structures. We confirm that these structures flood more frequently, by definition, but also find that they tend to have higher magnitude claims. The NFIP, unlike a private insurance company, cannot choose to decline coverage to these more risky properties. Instead, there has been a program focus on mitigating them or buying them, with several grant funds targeting these structures. We find that most repetitive loss structures are in Louisiana, New York, New Jersey, and Florida—areas with the most policies overall.

We also quantify that across the entire portfolio, elevated structures suffer much lower losses, about 20 percent less, than nonelevated structures, everything else being equal. While this seems to suggest elevation should be encouraged as a mitigation strategy, elevating an existing structure can be extremely costly ($50,000 to $70,000) and cumbersome for the homeowner (e.g., finding living accommodations during the construction process, etc.). Elevating new construction is much cheaper but will still add cost, something the construction industry has been reluctant to do if the homeowner does not see the value of doing so. It is estimated that as many as 1 million structures insured by the NFIP are negatively elevated, hence prone to more frequent floods and a longer duration of flooding, which results in larger claims. These same structures are those that will most likely see the largest flood insurance premium increases when rates are transitioned to being risk-based under the 2014 legislation. The U.S. National Academies of Science is currently working with FEMA and the U.S. Congress on this issue and has proposed alternative ways to handle these structures nationwide (NRC, 2015).

Given the above, one might want to turn to more collective measures to reduce flood exposure and insurance claims. To that end, we tested whether claims were different in communities that participate in the FEMA CRS from those that did not. We find that even low levels of participation in the CRS lead to lower claims, all else equal, and that the reductions in claims becomes greater at higher levels of participation. While this is not an analysis of the particular CRS activities, we find that a 1,000-point increase in the CRS score of a community decreases insurance claims by about 25 percent (expressed as a ratio between dollar amount of the claims over insured value). Our work complements earlier studies on the CRS. For instance, Brody et al. (2007) analyze losses from 383 flood events across 54 counties in Florida from 1997 and 2001 and demonstrate the effectiveness of the CRS program in reducing property damage resulting from floods (an increase of one unit of CRS score reduced flood damage in that community by over $300,000).

Our summary statistics also indicate that flood claims are fat-tailed.[16] One feature of fat-tailed data is that the most extreme events can be a very large share of total losses.

[16]In a companion paper we undertake a detailed analysis of the tail of the NFIP claims data.

For example, our analysis of the sum of all insurance claims paid out by the NFIP for Hurricane Katrina is greater than the sum of all payments made by the program before 2005. With this type of loss distribution, estimating the probability of rare, but large events, takes on even greater importance. This is a difficult challenge for the NFIP. The extreme losses to the program come from the correlation in claims associated with large flood events. As we said earlier, the program is not currently pricing for this risk since it can borrow money from the U.S. Treasury to pay for catastrophe losses. This also poses a problem if one tries to transfer part of the program's exposure to the private sector, as has been proposed (Michel-Kerjan, 2010; GAO, 2014). Unlike the federal government, private reinsurers and institutional investors using dedicated financial instruments such as a catastrophe bond, require a very high cost of capital to cover a fat-tailed portfolio, typically a multiple of the average expected loss of the program. Higher insurance prices would likely mean lower demand, however, and one program goal of the NFIP is to increase take-up rates, creating a trade-off for the program in its pricing. Since the government does not require compensation for the cost of capital, it might be better positioned to cover part of extreme losses if affordability of flood insurance is considered an important policy goal, as the 2014 legislation has shown to be the case. An alternative would be for the government to develop a voucher program to address affordability concerns of low-income homeowners, easing the way for the NFIP to charge risk-based premiums (Kousky and Kunreuther, 2014).

Concluding Remarks

In closing, four final points are worth mentioning. First, our article focuses only on NFIP flood insurance claims and does not include the private flood insurance market. Today, this is a very small portion of the overall residential market, focused on highly valued residences and large commercial clients. Second, we concentrate on single-family houses and do not examine the claims for other types of properties in the program. This is a more homogeneous group, and is also the largest portion of the policies in the NFIP portfolio. Complementary work in the future could undertake similar analyses for other segments of the residential market (condominium units, mobile homes, etc.) as well as small businesses and commercial enterprises. Third, as climate predictions of future flood hazards increase due to stronger storms and sea levels rise in coastal communities the problems we have discussed here will be exacerbated, calling for even more proactive investments in adaptation on local, state, regional, and national scales, that are cost effective and politically feasible (as suggested by Aerts et al., 2014). Finally, although the United States has certainly suffered from large floods in recent years, many other countries have as well. There has been significant flooding in, for example, Australia (2010), Canada (2013), China (2010), Germany (2013), Mexico, (2012), Thailand (2011), and the United Kingdom (2014). All these countries take different approaches to insuring flood risk. Further research comparing flood insurance and insurance claims in these other countries with the U.S. experience would provide a more comprehensive picture of flood claims across market segments and countries.

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