How do households respond to social program reforms? Evidence from the U.S. National Flood Insurance Program*

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Abstract

How households will respond to reforms of public insurance programs is unclear given recent behavioral findings on consumers' insurance choices. We examine the insurance decisions of an extremely vulnerable group in the U.S. National Flood Insurance Program. Severe repetitive loss (SRL) properties account for only 1% of policies but 25–30% of flood claims. Congress passed a reform that phases out the premium subsidies offered to this group over several years such that their premiums will eventually equal their contract's actuarially fair rate. We measure the effect of the reform using difference-in-differences estimation on a panel of over two million policy-year observations. We find that about one fourth of SRL property owners decided to stop insuring in response to the reform. The reform did not meaningfully affect the coverage limit choices of households that continued to insure. Curiously, the observed effect on non-renewal begins after the law was ratified but before it was implemented. Our findings thus seem in contrast to canonical and most common behavioral theories of insurance demand. We discuss potential alternative decision-making explanations of our results and are able to rule out some of them. Our findings add to research on public policy design and behavioral insights into insurance demand.

Keywords: Social Programs · Public Policy Design · Insurance Choices

JEL Classifications: D81 · G22 · H31 · H53

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1 Introduction

Policymakers occasionally decide to reform the social programs on which vulnerable groups rely. For example, recent reforms have affected programs covering the health risks of diabetics, the flood risks of residents in coastal communities, and the longevity risks of low-skilled workers. Neoclassical models provide specific predictions of how households will be affected by these reforms. For example, consider a social program offering subsidized insurance. As long as premiums remain below the actuarially fair rate, classic models predict that reducing subsidies would not meaningful affect households' insurance coverage (Mossin, 1968; Schlesinger, 2013). Thus, carefully designed reforms might reduce the generosity of public programs without undermining the policy goal of protecting the vulnerable. However, empirical research on consumers' insurance decisions shows that the predictions of classic models do not always hold (Bhargava et al., 2017; Browne et al., 2015; Kunreuther, 1976). It has been shown for financial decisions of households in general (e.g., Chetty et al., 2013) and insurance decisions in particular (e.g., Brot-Goldberg et al., 2017; Handel, 2013) that behavioral motives can dictate the consumers' reactions to a change in their available options. Hence, how households respond to reforms in social programs *in practice* is unclear and has important implications for designing effective policies.

We examine the insurance decisions of an extremely vulnerable group in the U.S. National Flood Insurance Program (NFIP) and a reform that reduces the premium subsidies offered to this group. The NFIP is the provider of almost all residential flood insurance in the U.S. and has a policy goal that at-risk populations are covered against severe losses.[1] Toward this goal, the NFIP frequently subsidizes insurance for older and riskier properties. The largest subsidies accrue to "severe repetitive loss properties" (SRL properties), a set of homes which account for only 1% of policies but make up 25–30% of total claims payments in the NFIP (GAO, 2010). Before the reform, SRL properties properties paid, at most, 35–40% of the actuarially fair premium for their insurance (GAO, 2008). The NFIP has operated at an increasingly worsening deficit since Hurricane Katrina and currently has an outstanding debt of $20.5bn (FEMA, 2018b). Out of concern that the NFIP had become too generous, Congress passed the Biggert-Waters Flood Insurance Reform Act of 2012 (Biggert-Waters), which authorizes rate increases on some NFIP policyholders to "ensure the fiscal soundness of the program" (FEMA, 2019). Beginning 1 October 2013, Biggert-Waters increased the premiums of SRL properties by 25% each year until the actuarially fair premium for

[1] Households are pervasively underinsured against catastrophes: over 70% of disaster losses in the last decade were uninsured (Swiss Re, 2018). The U.S. Federal Emergency Management Agency (FEMA), which manages the NFIP, describes this policy goal as follows: "FEMA is committed to closing the insurance gap across the nation...One of [its strategic] goals is creating a culture of preparedness, which includes an ambitious 'moonshot' to double the number of properties covered by flood insurance by 2022. Plain and simple, we need more insured survivors." (FEMA, 2018a).

the SRL property is reached.

From the perspective of the canonical insurance demand model using standard assumptions (e.g., fully informed, risk averse households), Biggert-Waters would not be expected to affect the insurance coverage on SRL properties. In the near term, these policyholders will continue to be offered insurance contracts on which they will earn money in expectation, until their premiums eventually converge to the actuarially fair rate. Moreover, if the program inadvertently overcharged SRL properties so that they paid premiums above the actuarially fair rate, classic theory predicts that households would adjust on the intensive margin, partially insuring but continuing to insure against severe losses (Mossin, 1968). Using detailed policy-level data, we examine whether Biggert-Waters nevertheless affected the insurance demand of SRL property owners. Our data include both SRL and non-SRL properties, and have more than 1 million policy-year observations from 2010 to 2018. Before the reform, a group of non-SRL properties was charged identical premium rates as a group of SRL properties, but their rates diverge after the reform. We employ difference-in-differences estimations using the group of non-SRL properties as a control group.

We find that about one fourth of SRL property owners decided to stop insuring in response to the Biggert-Waters reform in the two years after its passage. Interestingly, this decrease began after the law was passed, but before SRL and non-SRL properties were charged different prices. On the intensive margin, almost no differential behavior between the SRL properties and the reference group can be observed. Thus, SRL property owners responded in three ways that are difficult to reconcile with classic models: (1) a large group of households was unwilling to pay premiums below actuarially fair rates for insurance, (2) these households preferred not to insure rather than adjust on the intensive margin, and (3) these households stopped insuring before the SRL-specific rate increases took effect. Using a second set of data, we observe that many of the non-renewed properties remain uninsured after dropping the NFIP coverage. Five years after the reform, only 50% of SRL properties still have coverage. The data also indicate whether the property has been altered to mitigate its risk or the owner has resettled and left the properties uninhabited, and 36% of all SRL properties remain unmitigated and inhabited but without flood insurance coverage.

Our paper contributes to the literature in several ways. First, our findings add to research on public policy design. A recent strand in this literature considers how to design public policy for settings in which behavioral factors may guide households' choices (see Chetty, 2015; Handel and Schwartzstein, 2018), and our research fits in this vein. To our knowledge, our setting is novel in that we examine how consumers respond to a plausibly exogenous change in the subsidy rate of their below-actually-fair insurance. Our findings suggest a tradeoff in policy goals that neoclassical models do not anticipate. From the perspective of increasing the financial sustainability of

a public program, Biggert-Waters appears to be a success: it reduced the subsidy rate of participants in the NFIP's risk pool. However, a longstanding, fundamental goal of disaster policy is that vulnerable populations are insured. According to FEMA, insurance allows households to recover more quickly and fully from a shock and reduces government spending on relief (FEMA, 2018a; FEMA, 2013).[2] Thus, households' tendency to drop their insurance in response to the reform appears to exacerbate a larger public policy problem, that many households do not insure against catastrophes, which may outweigh the benefits of the reform.

Second, our paper adds a puzzle to recent contributions in the literature on insurance demand. Several papers have studied the decisions of consumers who are offered insurance with premiums above the actuarially fair rate (e.g., Abito and Salant, 2018; Barseghyan et al., 2013; Collier et al., 2017; Sydnor, 2010). Each of these papers concludes that models incorporating over-weighting of small probabilities or loss aversion help explain consumers' insurance choices better than classic models of risk aversion. Yet, neither expected utility nor over-weighting of small probabilities nor loss aversion in the way it has typically been applied to insurance demand would appear to explain the decision of SRL property owners to stop purchasing subsidized insurance. Particularly puzzling is that SRL property owners responded in *anticipation* of the reform's price increases, renewing at a lower rate than the control group in the interim between the passage of the law and when its price increases took effect.

Some recent findings, however, offer at least partial potential explanations for this response. First, models including reference points (Baucells et al., 2011; Kőszegi and Rabin, 2007) would seem to predict that consumers are likely to view the changes in prices negatively, evaluating them relative to pre-reform prices. Second, SRL property owners might have canceled their policies because of liquidity constraints as has been proposed theoretically (Ericson and Sydnor, 2018; Rampini and Viswanathan, 2019) and documented in developing country contexts (Casaburi and Willis, 2018). This explanation requires, however, that liquidity became binding for a large group of households at the moment that reform passed, and would not explain why households did not adjust on the intensive margin rather than dropping their insurance. Third, consumers may instead use heuristics or simplifying decision rules. For example, simple decision rules based on linear reactions to insurance prices have been shown in lab settings to perform better than expected utility theory or more modern behavioral models when predicting insurance demand (Jaspersen et al., 2019). Finally consumers might simply be misinformed about their expected losses or the structure of Biggert-Waters. Such information frictions are not uncommon in insurance settings (Handel and Kolstad, 2015) and could in particular explain the premature cancellation of insur-

[2]Households can apply for federal disaster grants to receive up to $34,000 in 2018 dollars for uninsured losses, though the average grant is around $5,000. FEMA also provides in-kind relief such as temporary shelter.

ance coverage before the Biggert-Waters reform came into effect.

Third, we contribute through our evaluation of a social insurance reform in a setting that provides greater insight into consumers' preferences than is typical for social programs. The NFIP is one of several government-subsidized insurance programs in which participation is voluntary (others include Medicare Advantage and U.S. crop insurance); however, participation in many forms of social insurance is compulsory (e.g., social security, unemployment insurance). Our finding that consumers in a voluntary setting are willing to pay much less for flood insurance than classical demand models predict motivates some caution in evaluating reforms to compulsory social insurance programs through a neoclassical lens.

In the following, we first summarize the institutional background of the NFIP and the Biggert-Waters reforms. We then give an overview of the data used in this study. The third section reports the results. The paper concludes with a discussion of the results and their implications in section four.

2 Background

2.1 Institutional Details

Congress established the NFIP in 1968 due to a lack of flood insurance offerings in the private insurance market (Michel-Kerjan, 2010). Today, standard homeowners insurance continues to exclude flood risk and the NFIP provides 95% of residential flood insurance in the U.S., insuring over 4 million households a year (Kousky et al., 2018).

The NFIP designs its insurance contracts, determines premium rates, and bears the claims risk. The Federal Emergency Management Agency (FEMA) administers the NFIP and develops and maintains flood insurance rate maps (FIRM), which identify flood zones. These flood maps influence building codes. For example, codes require new homes that are built in flood zones to be elevated. Homes built before local flood maps were developed (pre-FIRM homes) tend to be at greater risk as they often were not constructed with flooding in mind. The program has tended to offer preferential rates to pre-FIRM homes. Moreover, it calculates premium rates for pre-FIRM properties using methods that are less risk sensitive than the rating used for newer (post-FIRM) homes. For example, a property's elevation significantly influences the premiums of post-FIRM homes but not pre-FIRM homes.

SRL properties are a specially designated group of properties that flood frequently. Using

claims records beginning in 1978, the NFIP defines SRL properties as those with four or more claims payments of more than $5,000 each within a ten-year period. In 2012, the Biggert-Waters Flood Insurance Reform Act began phasing out premium subsidies for pre-FIRM, SRL properties. The reform increased the premium rates on these properties by 25% each year independent of a loss occurrence until the actuarially fair premium is reached.[3]

2.2 Data

2.2.1 Overview of Databases

We use two databases in our analyses, both collected and maintained by the NFIP. The first database is policy-level panel data that includes both SRL and non-SRL properties, from 2009 to 2018. It shows the insurance choices of each policyholder by year (e.g., the selected coverage limit). We compare policyholders' insurance choices across time and groups in this database to understand the effects of the reform.

The second describes each SRL property as of 2018. It is cross-sectional, showing the current status of the property such as whether the home has been demolished but not when any changes to the property occurred. These data represent an end-line in our policy analysis, describing SRL properties about five years after the October 2013 implementation of Biggert-Waters.

2.2.2 Policy-Level, Panel Data

Our panel data include residential flood insurance policies on privately-owned properties in the NFIP's Regular Program.[4] These data provide policyholders' coverage limit and deductible choices, home characteristics (e.g., number of floors, whether the home has an elevation certificate, obstruction, etc.), location characteristics (zip code, community, etc.) and other pricing relevant variables. Additionally, the data include both SRL and non-SRL properties and an indicator designating SRL

[3] This Reform Act also removed subsidies for other properties. For example, before Biggert-Waters, in the case of rate map changes policyholders could under certain circumstances keep the rating based on their old flood zone if more favorable to them. The Reform Act of 2012 phased out these so called "grandfathered" rates. The Consolidated Appropriations Act of 2014 and the Homeowner Flood Insurance Affordability Act of 2014 repealed and modified parts of Biggert-Waters. In our sample, however, neither were non-SRL properties affected by Biggert-Waters nor were SRL properties affected by the repeals.

[4] In addition to insuring privately-owned residential properties, the NFIP insures nonresidential properties (e.g., businesses) and publicly owned residential properties (e.g., public housing), which are not part of our study. In addition to the Regular Program, the NFIP manages an Emergency Program, which is the initial phase of a community's participation in the NFIP. After completion of certain requirements the communities can join the Regular Program (NFIP, 2014). The Emergency Program represents a small number of policies in the NFIP in 2009.

properties.

For our primary analyses we examine the renewal and coverage choices of policies that were in force in 2009, the year our data begin, and track these policies over time. For example, these analyses do not include new policies that enter the program in 2010.[5]

The data include over 5 million policies in 2009. Table 1 provides the steps to restrict the data to the group of SRL and non-SRL properties that were charged identical premium rates before Biggert-Waters but different rates afterward. We call properties in this subset the "Restricted Sample." The Restricted Sample is properties that are single-family homes that serve as a primary residence, are located in A flood zones, and have a pre-FIRM rating. Properties located in A flood zones (A, AE, A1–A30, AO, AH) lie in the non-coastal areas, which are not vulnerable to wave damage from storm surge, but are estimated to have at least a one percent annual probability of flooding.

In total, the Restricted Sample include 476,631 unique policies, 2,050 of which are designated SRL. We follow this 2009 cohort of policies until 2018, which provides us with more than 2 million policy-year observations to analyze their insurance choices.

Table 1: Data Selection Process

Step	**Description**	**Policies**
0	All policies in 2009	5,002,696
1	Keep if single family home	4,245,726
2	Keep if primary residence	3,586,375
3	Keep if flood zone is A, AE, A1–A30, AO, AH	1,936,661
4	Keep if rated as a pre-FIRM property	476,631
Restricted Sample		**476,631**

Notes: The table describes the steps of the data selection process and provides the number of policies in the remaining sample after the respective step has been applied.

2.2.3 Effect of Biggert-Waters on Premium Ratings

Homeowners can separately choose building coverage $c^{(b)}$ and contents coverage $c^{(c)}$ up to a limit of \$250,000 for buildings and \$100,000 for contents in our data. The premium p for NFIP's flood

[5] As a robustness check we similarly analyze the 2010 cohort (see Table 10 and Table 11 in Appendix B).

insurance policy depends on these insurance choices and is calculated as follows:

$$\text{Building:} \quad p^{(b)} = \min\left(c^{(b)}, 60000\right) \cdot r_b^{(b)} + \max\left(c^{(b)} - 60000, 0\right) \cdot r_a^{(b)} \tag{1}$$

$$\text{Contents:} \quad p^{(c)} = \min\left(c^{(c)}, 25000\right) \cdot r_b^{(c)} + \max\left(c^{(c)} - 25000, 0\right) \cdot r_a^{(c)} \tag{2}$$

$$\text{Total:} \quad p = \left(\left(p^{(b)} + p^{(c)}\right) \cdot \delta + icc\right) \cdot crs + f \tag{3}$$

In the above formula $r_b^{(b)}$ denotes the premium rate for building coverage limits up to \$60,000, called "basic building coverage", and $r_a^{(b)}$ designates the premium rate for the additional coverage exceeding \$60,000. Similarly, $r_b^{(c)}$ denotes the premium rate for basic contents coverage until \$25,000 and $r_a^{(c)}$ for additional coverage exceeding \$25,000.

The sum of the premium for building $p^{(b)}$ and contents coverage $p^{(c)}$ is multiplied by a deductible factor δ. NFIP's rating manual provides these deductible factors. For example in January 2012, the minimum deductible option of \$1,000 had a $\delta = 1.1$ while the maximum deductible option of \$5,000 had a $\delta = 0.81$. The policy's premium further comprises a Community Rating System (crs) discount for the respective communities' engagement in mitigation measures, an administrative fee f, and a fee icc as a contribution to the increased cost of compliance program that helps policyholders bring their properties to current building standards after a loss occurrence. In 2010, the median crs discount, administrative fee f, and icc fee are 0.9, \$40, \$64 for the non-SRL properties and 1, \$40, \$64 for the SRL properties in the Restricted Sample. The difference between SRL and non-SRL properties in the median crs discount is due to differences in community affiliations.

The Biggert-Waters Reform Act increased the premiums of the SRL property owners in the Restricted Sample. Specifically, Biggert-Waters increased the building and contents coverage rates, $\{r_b^{(b)}, r_a^{(b)}, r_b^{(c)}, r_a^{(c)}\}$. Table 2 shows the development of building premium rates, $r_b^{(b)}$ and $r_a^{(b)}$ over time for properties without a basement, which represents 75% of both SRL and non-SRL properties in the Restricted Sample. SRL properties with basements experienced similar rate increases due to Biggert-Waters (shown in Appendix A, Table 9). For example in January 2013, prior to the implementation of Biggert-Waters in October, policyholders in the Restricted Sample with no basement paid $r_b^{(b)} = 0.76$ and $r_a^{(b)} = 0.77$. Following Biggert-Waters, premium rates increased for SRL properties to $r_b^{(b)} = 0.91$ and $r_a^{(b)} = 0.92$ versus $r_b^{(b)} = 0.91$ and $r_a^{(b)} = 0.77$ for non-SRL properties. Thus, both SRL and non-SRL properties experienced a premium rate increase for the basic building coverage until \$60,000 but only SRL properties faced an increase for the additional building coverage above \$60,000. In subsequent years, due to Biggert-Waters, SRL properties experienced additional increases, approximately tripling their pre-reform rates, while rates for

Table 2: Development of Building Rates in the Restricted Sample Over Time

Effective date	**SRL properties**		**Non-SRL properties**	
	$r_b^{(b)}$	$r_a^{(b)}$	$r_b^{(b)}$	$r_a^{(b)}$
2008-10-01	0.76	0.54	0.76	0.54
2009-10-01	0.76	0.57	0.76	0.57
2010-05-01	0.76	0.56	0.76	0.56
2010-10-01	0.76	0.60	0.76	0.60
2011-10-01	0.76	0.66	0.76	0.66
2012-10-01	0.76	0.77	0.76	0.77
Implementation of Biggert-Waters for SRL properties				
2013-10-01	0.91	0.92	0.91	0.77
2014-10-01	0.91	0.92	0.85	0.78
2015-04-01	1.03	1.05	0.89	0.81
2016-04-01	1.29	1.31	0.94	0.85
2017-04-01	1.61	1.64	0.99	0.90
2018-04-01	2.01	2.05	1.04	0.95

Notes: The table displays the development of building rates in the Restricted Sample for properties without a basement. It shows the rate $r_b^{(b)}$ for basic building coverage until \$60,000 and the rate $r_a^{(b)}$ for additional building coverage above \$60,000 for both SRL and non-SRL properties between October 2008 and December 2018.

non-SRL properties changed only moderately, by comparison.

Table 3 shows summary statistics for SRL and non-SRL properties in 2009 and at the end of our sample, 2018. In 2009, SRL and non-SRL properties exhibit similar building coverage, home age, and policy age. SRL property owners are more likely to purchase contents coverage. While the underlying premium rate tables (e.g., Table 2) did not differ in 2009, the median premium for SRL properties is about 25% more than the median premium for non-SRL properties, \$1,029 versus \$807. This difference is due in part to their different contents coverage choices, but also differences in CRS discounts and deductible choices.[6] The statistics from 2018 are for the subset of 2009 properties that continued to insure at the end of the panel dataset. Comparing the statistics in 2009 and 2018 shows that both the median SRL and median non-SRL policyholder did not notably change their insurance coverage. In 2018, the median premium for SRL property was \$3,284, about 75% more than the median premium for non-SRL properties.

[6] The NFIP provides default deductibles. The policyholder can choose a deductible equal, below or above this default deductible. In 2009, the default deductible in the Restricted Sample was \$1000. In 2018, the default deductible in the Restricted Sample was \$2000.

Table 3: Summary Statistics: Restricted Sample in 2009 and 2018

2009

	SRL properties			Non-SRL properties		
	Mean	St. Dev.	Median	Mean	St. Dev.	Median
Building Coverage	140,373	76,796	130,500	142,840	77,843	135,700
Contents Coverage	31,076	28,282	23,500	20,331	30,715	0
Premium	1,154	648	1,029	937	564	807
CRS Score	0.086	0.077	0.100	0.075	0.050	0.086
Home Age	46	15	41	49	18	45
Policy Age	4	3	3	6	5	4
Deductible Below Default Deductible			0.19			0.20
Default Deductible ($1000)			0.66			0.54
Deductible Above Default Deductible			0.15			0.26
Has Contents Coverage			0.83			0.42

2018

	SRL properties			Non-SRL properties		
	Mean	St. Dev.	Median	Mean	St. Dev.	Median
Building Coverage	150,233	74,629	139,200	158,615	79,069	158,700
Contents Coverage	30,133	28,190	22,800	19,393	29,250	0
Premium	3,719	2,208	3,284	2,003	1,055	1,878
CRS Score	0.117	0.092	0.150	0.095	0.101	0.100
Home Age	55	16	51	60	18	56
Policy Age	11	4	11	11	7	9
Deductible Below Default Deductible			0.11			0.09
Default Deductible ($2000)			0.69			0.65
Deductible Above Default Deductible			0.20			0.26
Has Contents Coverage			0.78			0.43

Notes: The table displays summary statistics for SRL and non-SRL properties in the Restricted Sample in 2009 and 2018.

2.2.4 Severe Repetitive Loss Property Database

The SRL Property Database includes all SRL properties up to 2018, a total of 36,774 homes. Table 4 describes these properties. The left panel of the table provides summary statistics for the full database. The properties are primarily single-family dwellings (82%) that were constructed pre-FIRM (86%).

These properties lie mainly in the A flood zones (75%). Interestingly, almost all of the remaining SRL properties (19%) are located in "low-risk" zones (A99, B, C, X), which FEMA estimates have an annual probability for flooding that is less than 1%. 4% of SRL properties are located in the V flood zones, which denote coastal areas subject to wave damage.

Table 4: Descriptive Statistics of Severe Repetitive Loss Properties as of 2018

	Unrestricted Sample (36,774)			Restricted Sample (20,430)		
Occupancy						
Single family			0.82			1
2-4 family			0.04			0
Other residential			0.02			0
Non residential			0.10			0
Unknown			0.01			0
Pre-FIRM Construction						
Yes			0.86			1
No			0.14			0
Flood Zone						
A, AE, A1-A30, AO, AH			0.75			1
V, VE, V1-V30			0.04			0
A99, B, C, X			0.19			0
Unknown			0.02			0
Claims Statistics	Claims Payments	Tot. Payment	Tot. No. Losses	Claims Payments	Tot. Payment	Tot. No. Losses
Mean	39,095	200,382	5	33,409	168,876	5
St. Dev.	89,901	282,048	3	47,072	141,295	3
Pctl(1)	1,207	14,035	2	1,194	14,398	2
Pctl(25)	7,480	82,361	4	7,286	80,385	4
Median	17,226	141,511	5	16,570	135,521	5
Pctl(75)	41,640	234,052	6	38,809	213,690	6
Pctl(99)	305,119	1,154,304	15	245,004	659,395	15
Type of Mitigation						
Building acquired and demolished as part of a program			0.08			0.10
Building elevated to or above BFE			0.07			0.09
Building demolished but not acquired through a federal program			0.06			0.07
Building replaced by a new elevated/floodproofed building			0.03			0.03
Building protected by a flood control/stormwater management project			0.01			0.01
Unknown			0.02			0.01
None			0.73			0.69
Insurance/Mitigation	Mitigated	Unmitigated	Σ	Mitigated	Unmitigated	Σ
Insured	0.08	0.42	0.5	0.09	0.40	0.49
Uninsured	0.05	0.31	0.36	0.06	0.29	0.35
No building on property	0.14	0	0.14	0.16	0	0.16
Σ	0.27	0.73	1	0.31	0.69	1

Notes: The table displays summary statistics about SRL properties regarding characteristics, claims, insurance, and mitigation based on NFIP's SRL Property Database.

The median SRL property has received $141,511 in total payments, the sum of all building and contents payments for this property since 1978. The median payment is $17,226. The median property incurred 5 insured losses between 1978 and 2018; however, 20 properties faced 30 losses or more. One property located in Louisiana filed 40 claims, which correspond to approximately one loss per year. Another property, also located in Louisiana, filed 21 claims since 1978. Between 2009 and 2012 for example, this property worth $190,051 in building value faced five losses. For these losses NFIP paid the policyholder $98,628 in total payments which correspond to an average of $24,657 each year. In contrast, the property faced an average premium equal to $940 in this

period.

Furthermore, the database gives information on whether the risk of the property has been reduced through mitigation and whether the property is currently insured. We find that the risk had been reduced on 27% of SRL properties. About 10% of properties were either elevated or replaced with a new property that was elevated. About 14% were demolished. Typically, these properties were acquired by a government "buy-out" program. About half of these demolished properties were acquired through a federal program. A flood water management program reduced the risk of 1% of SRL properties. Regarding insurance, we find that 42% of SRL properties with *existing* homes in 2018 are uninsured ($0.419 = 0.36/(0.5 + 0.36)$). Because the mitigation actions above may reduce the need to insure, we also examine whether uninsured properties are mitigated. We find that 31% of SRL properties are both unmitigated and uninsured.

The right panel shows the same statistics for the Restricted Sample, which total 20,430 homes. As Section 2.2.2 describes in more detail, these properties are single family homes, constructed pre-FIRM, and located in flood zones A, AE, A1-A30, AO, AH and so represent the typical SRL property in the Restricted Sample.[7] The Restricted Sample also appears similar regarding its claims statistics, though the amounts are a little lower. While properties have also flooded a median of 5 times in the Restricted Sample, the median total payment is $135,521 versus $141,511 for the Unrestricted Sample. These differences may result from the Unrestricted Sample including some larger value properties, apartment buildings and small business buildings. The mitigation and insurance statuses look very similar. For example, 29% of properties in the Restricted Sample are both unmitigated and uninsured (versus 31% for the Unrestricted Sample).

In summary, the SRL Property Database shows that, approximately five years after Biggert-Waters, most properties remained unmitigated (73%), and many existing properties were uninsured (42%). The 31% of properties that are both uninsured and unmitigated represent an especially concerning group. Our data are limited in their ability to explain mitigation choices. Mitigation decisions depend on a complicated mix of unobserved variation in mitigation costs across homes, access to public funding (which can vary by municipality and state), access to private funds (e.g., access to credit), and the private value of mitigation (e.g., some homeowners may be unwilling or unable to live in a home that is elevated on stilts). Instead, we examine households' insurance decisions in depth using policy-level panel data.

[7] The SRL Property Database does not give information on whether the property is rated pre-FIRM or post-FIRM but only if it was constructed pre-FIRM. Owners of pre-FIRM constructed properties may decide to switch the utilized rating system to post-FIRM if they believe that it would lead to more favorable insurance premiums. Thus, the data given in Section 2.2.2 is a subset of the properties that we here call the "Restricted Sample".

3 Insurance Decisions

3.1 Overview of Analysis

We examine the effect of the Biggert-Waters Flood Insurance Reform Act on the insurance choices of SRL property owners. The large number of uninsured properties in the 2018 SRL property database raises the question of to what extent the reform led policyholders to stop insuring. Alternatively, consumers might change their insurance on the intensive margin such as by reducing their coverage limits. Thus, we examine how Biggert-Waters affected (1) policyholders' decisions to renew their insurance contract and (2) what coverage limit to select.

3.2 Renewal Decisions

3.2.1 Graphical Illustration

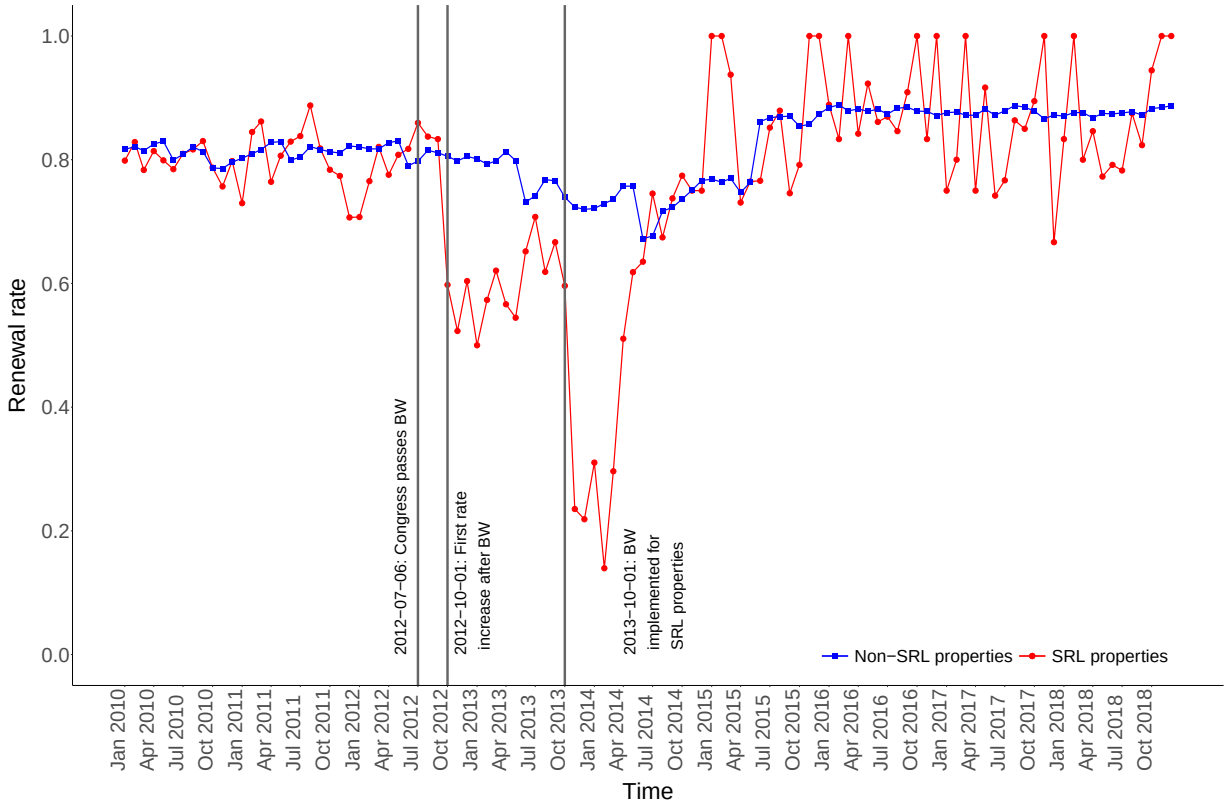
In this section, we analyze the effect of Biggert-Waters on renewal decisions of SRL properties using data from 2010 and 2018 including over 2 million policy-year observations.[8]

Figure 1 shows the renewal rate for both SRL properties and non-SRL properties between January 2010 and December 2018 in our Restricted Sample. For both SRL and non-SRL properties we calculate the renewal rate at time t by dividing the number of policies that were renewed at time t by the number of policies that were in force one year before. For example, about 80% of both SRL and non-SRL properties that were active in September 2011 were renewed in September 2012. The renewal rates of SRL and non-SRL properties exhibit parallel trends before the ratification of Biggert-Waters on July 6, 2012. The larger month-to-month variation in renewals for SRL properties occurs because the sample of SRL properties is much smaller than that of non-SRL properties. In 2010, for example, we observe renewal decisions of 2,050 SRL property owners and 476,631 non-SRL property owners.

The NFIP implemented a premium increase on 1 October 2012 – after the law was passed, but before SRL and non-SRL properties were charged different prices. Even though this October 2012 premium increase affected SRL and non-SRL properties similarly, SRL properties dropped from a renewal rate of 80% in September 2012 to a rate of 60% in October 2012. Following October 2012 and until October 2013, SRL property owners continued to renew their policies at rates around 60%. In contrast, non-SRL property owners' renewal rates remained effectively constant during this period.

[8] Our data allows us to observe policies dropping insurance coverage for the first time in 2010.

Figure 1: Renewal Rates of the 2009 Policy Cohort Between 2010 and 2018



Notes: The figure displays the renewal rates of the 2009 policy cohort between January 2010 and December 2018. For both SRL and non-SRL properties we calculate renewal rates at time t by dividing the number of policies that were renewed at time t by the number of policies that were in force one year before.

An additional drop in renewal rates begins on 1 October 2013, the point at which Biggert-Waters price increases for SRL properties were implemented. Only 20% of policies that were in force in November 2012 were renewed in November 2013. Finally, after October 2014 renewal rates of SRL policies matched almost those of non-SRL policies and reached levels of about 80% again. The renewal rate appears slightly higher at the end of the time series than at the beginning. One explanation for this pattern is that the subset of the cohort that remains insured throughout the time series is especially likely to renew.

3.2.2 Identification and Estimation

We consider the implementation of Biggert-Waters a natural experiment as it created a plausibly exogenous source of variation in insurance prices by increasing insurance premiums for pre-FIRM SRL property owners (treatment group) but not pre-FIRM non-SRL property owners (con-

trol group).[9] We study the effect of the policy change with a difference-in-differences estimation. This estimation strategy leverages the panel structure of our data. First, we observe the insurance choices of each policyholder across years and so can leverage time series variation. Second, we observe both treatment and control groups and so can leverage cross-sectional variation. The combination allows us to construct a counterfactual regarding what insurance choices SRL property owners would make had the reform not occurred.

Using this counterfactual to estimate the treatment effect relies on two assumptions. First, we assume that, after the inclusion of controls, the responses of non-SRL properties capture common trends in the data. This first assumption indicates that if the reform had not occurred, the average change in renewal rates for the SRL properties following the reform would have been the same as the average change in renewal rates for non-SRL properties, after accounting for model controls. For example, if a macroeconomic downturn caused non-SRL properties not to renew following the reform, SRL properties would have similarly decided not to renew. Figure 1 in Section 3.2.1 shows the pre-reform renewal rates of the SRL and non-SRL properties and suggests support for the parallel trends assumption.[10] Second, we assume that Biggert-Waters did not coincide with an additional change that might account for differences between SRL and non-SRL properties. We have been unable to identify changes concurrent with Biggert-Waters that affected only SRL properties or only non-SRL properties.

The empirical test for the effect of the reform on renewal decisions is a regression model of whether policyholder i renews her policy at time t as a function of the treatment group indicator ($\mathbb{1}_{(SRL_i)}$), four structural break indicators $\mathbb{1}_{(Oct\_12 \leq t < Oct\_13)}$, $\mathbb{1}_{(Oct\_13 \leq t < Oct\_14)}$, $\mathbb{1}_{(Oct\_14 \leq t < Oct\_15)}$,

[9] Biggert-Waters appears to be a good candidate for such a natural experiment. It was enacted in July 2012, a relatively quiet period in terms of flood claims, which was roughly 3 months before Hurricane Sandy occurred. The part of the law pertaining to SRL properties was but one element of a large law that affected NFIP policyholders outside of our study. Thus, its passages does not appear to have been precipitated by underlying changes to SRL properties that might interfere with our estimation of the reform's effect.

[10] While difference-in-differences estimation requires a common trend between treatment and controls, it does not require that the treatment and control groups are identical pre-treatment (Angrist and Pischke, 2008, Chapter 5), and we have reason to believe that SRL and non-SRL properties were not as the SRL properties had been previously identified as a vulnerable group by the NFIP.

$\mathbb{1}_{(t \geq Oct\_15)}$, and their interactions.

$$
\begin{aligned}
\mathbb{1}_{(Renew_{it})} = \beta_1 \cdot \mathbb{1}_{(SRL_i)} & \\
&+ \beta_2 \cdot \mathbb{1}_{(Oct\_12 \leq t < Oct\_13)} + \beta_3 \cdot \mathbb{1}_{(Oct\_12 \leq t < Oct\_13)} \cdot \mathbb{1}_{(SRL_i)} \\
&+ \beta_4 \cdot \mathbb{1}_{(Oct\_13 \leq t < Oct\_14)} + \beta_5 \cdot \mathbb{1}_{(Oct\_13 \leq t < Oct\_14)} \cdot \mathbb{1}_{(SRL_i)} \\
&+ \beta_6 \cdot \mathbb{1}_{(Oct\_14 \leq t < Oct\_15)} + \beta_7 \cdot \mathbb{1}_{(Oct\_14 \leq t < Oct\_15)} \cdot \mathbb{1}_{(SRL_i)} \\
&+ \beta_8 \cdot \mathbb{1}_{(t \geq Oct\_15)} + \beta_9 \cdot \mathbb{1}_{(t \geq Oct\_15)} \cdot \mathbb{1}_{(SRL_i)} \\
&+ \gamma \cdot controls_{it} + \alpha_i + \delta_s + \mu_k + \varepsilon_{it}.
\end{aligned} \tag{4}
$$

The indicators $\mathbb{1}_{(Oct\_12 \leq t < Oct\_13)}$, $\mathbb{1}_{(Oct\_13 \leq t < Oct\_14)}$, and $\mathbb{1}_{(Oct\_14 \leq t < Oct\_15)}$ model the first, second, and third renewal decision after the ratification of Biggert-Waters. The variable $\mathbb{1}_{(t \geq Oct\_15)}$ captures effects of Biggert-Waters on renewal decisions in the long-run. The model additionally includes control variables ($controls_{it}$), which account for characteristics of the home such as its elevation relative to the flood plain, the number of floors, whether it is a mobile home, the age of the home, the age of the policy, and the NFIP's rating of the actions that the community has taken to reduce its flood risk (see Table 5 for a description of each control variable).

Our preferred model estimates a linear probability model and includes individual fixed effects α_i, year fixed effects δ_s, and month (January, February, etc.) fixed effects μ_k to respectively capture unobserved characteristics of the individual policyholder or time of year that may affect households' renewal decisions. In alternative specifications of the model, we replace individual fixed effects with ZIP fixed effects and change the structure to capture time effects.

3.2.3 Estimation Results

We estimate several specification of the renewal decision model (Equation (4)), reported in Table 6. Column (3) describes the results of our preferred model, which allows comparisons at the individual level. As the individual fixed effects in column (3) are often specified with only a few (2–3) observations, we present in column (2) and column (1) models that replace individual fixed effects with ZIP fixed effects as robustness checks. Column (2) and column (1) differ in how they capture time effects. The first specification (column 1) controls for time effects by including month fixed effects as well as a quadratic monthly time trend, in which the time variable takes values between 1 (for January 2010) and 108 (for December 2018). Column (2) modifies the model in column (1) by omitting the quadratic time trend and instead including year fixed effects.

The first row in column (3) shows the interaction between the SRL indicator (SRL) and policy-

Table 5: Home and Policy Characteristics

Variable	Description
CRS Score	The community's score on the Community Rating System (CRS). The CRS is a voluntary program that rewards communities for taking actions to mitigate flood risk beyond minimum NFIP requirements. Community actions reduce policyholder premiums by up to 45%. The CRS score is the associated premium reduction, ranging from 0 (no mitigation) to 45 (maximum mitigation).
Elevation Certificate	Home elevation is sometimes estimated by communities; however, homeowners can also contract an engineer or surveyor to evaluate their homes. This variable can take 12 values depending on who assessed the elevation and when.
Elevation Indicator	A building that has no basement and that has its lowest elevated floor raised above ground level by foundation walls, shear walls, posts, piers, pilings, or columns.
Floors	Number of floors in the home, taking four possible values: 1, 2, 3 or more, or split-level.
Home Age	Age of the home, in years.
Mobile	Indicates whether the structure is a manufactured/mobile home.
Obstruction	Description for elevated buildings regarding the area and machinery attached to the building below the lowest floor. It takes 13 values, depending on the size of the area, whether it has permanent walls, and the presence/location of machinery (e.g., if it is elevated). We include dummy variables for these in our models.
Policy Age	Age of the insurance policy with respect to original new business year.

Notes: NFIP (2014) provides additional information on these variables. Each of these variables occurs as control variable in our regression models in Section 3.2 and 3.3.

holders' renewal decision between 1 October 2012 and 30 September 2013 (Oct_12_13). It shows that SRL property owners reduced their renewal probability by 16 percentage points during this period. This decline is noteworthy because it occurs after the ratification but before the implementation of Biggert-Waters (see also Figure 1). It coincides with the first premium rate increase after the ratification of the reform. That rate increase applied similarly to SRL and non-SRL properties (see Table 2), but we find that it affected their renewal decisions differently. While we observe a 16 percentage reduction in SRL policyholders' renewal probability, non-SRL policyholders' renewal probability did not change during this period (see the coefficient of Oct_12_13).

Similarly, the interaction between the SRL indicator (SRL) and the indicator (Oct_13_14) cap-

Table 6: Regression Results: Renewal Decisions of the 2009 Policy Cohort Between 2010 and 2018

	Dependent variable:		
	renewal indicator		
	(1)	(2)	(3)
SRL:Oct_12_Oct_13	-0.1605^{***}	-0.1582^{***}	-0.1653^{***}
	(0.0233)	(0.0236)	(0.0298)
SRL:Oct_13_Oct_14	-0.1657^{***}	-0.1641^{***}	-0.2117^{***}
	(0.0402)	(0.0403)	(0.0440)
SRL:Oct_14_Oct_15	0.0412^{**}	0.0355^{**}	-0.0554^{**}
	(0.0178)	(0.0170)	(0.0236)
SRL:after_Oct_15	0.0073	0.0069	-0.0797^{***}
	(0.0125)	(0.0126)	(0.0189)
Oct_12_Oct_13	-0.0252^{**}	0.0002	-0.0063
	(0.0103)	(0.0049)	(0.0044)
Oct_13_Oct_14	-0.0890^{***}	-0.0401^{**}	-0.0594^{***}
	(0.0250)	(0.0174)	(0.0179)
Oct_14_Oct_15	-0.0298^{**}	-0.0057	-0.0428^{***}
	(0.0134)	(0.0123)	(0.0127)
after_Oct_15	0.0484^{***}	0.0600^{***}	0.0071
	(0.0098)	(0.0122)	(0.0126)
SRL	-0.0330^{***}	-0.0330^{***}	
	(0.0085)	(0.0085)	
monthly_time_trend	-0.0013^{***}		
	(0.0002)		
monthly_time_trend_squared	0.00001^{***}		
	(0.000002)		
Controls	Yes	Yes	Yes
ZIP FE	Yes	Yes	No
Month FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Individual FE	No	No	Yes
Clustered SE	State	State	State
Observations	2,088,595	2,088,595	2,088,595
R^2	0.0545	0.0548	0.4650
Adjusted R^2	0.0464	0.0467	0.2991
Residual Std. Error	0.3838	0.3837	0.3291

Notes: Dependent variable is the renewal indicator variable. Column (1) gives the results of a linear probability model including ZIP and month fixed effects as well as a quadratic monthly time trend. Column (2) modifies the model given in column (1) and uses year fixed effects instead of a quadratic time trend. Finally, column (3) extends column (2) in replacing ZIP fixed effects with individual fixed effects. All models include home and policy characteristics as control variables.

tures the drop in renewal rates in the year immediately following the implementation of Biggert-Waters, when the treatment and control groups first experienced different premium ratings. Between October 2013 and October 2014, SRL property owners reduced their renewal probability by 21 percentage points in response to the implementation of the reform. Non-SRL property owners were 6 percentage points less likely to renew during this time (see the coefficient of Oct_13_14), which may be in response to a premium increase for basic building coverage that affected both non-SRL and SRL properties. The 21 percentage point decline of SRL properties during this time should be understood as incremental to the 6 percentage point decline observed for SRL properties. Overall, about one fourth of SRL property owners decided to stop insuring in response to the reform in the two years after its passage.[11]

Finally, the SRL interaction terms including the third year indicator (Oct_14_15) and longer term indicator ($after\_Oct\_15$) both also show slightly smaller effects of the reform, around 6 and 8 percentage points respectively. This return to pre-event renewal probabilities can be explained by a selection issue: property owners that renew their policy despite the previous rate increases may be especially likely to renew despite future rate increases. The significance and sign of the third year and longer term interaction terms are inconsistent across the different specifications and so warrant some caution in interpretation.

Otherwise, our results appear robust to different specifications of the model, as shown in columns (1) to (3). We also estimate these regressions using the 2010 cohort, instead of the 2009 cohort, and find similar results (Table 10 in Appendix B).

3.2.4 Loss History and Mitigation Status

Our end-line data, the SRL Property Database, may offer some insights regarding whether certain types of SRL property owners were less likely to renew. We are able to match 701 out of 2,050 SRL properties from the 2009 cohort in the policy level, panel data with the SRL Property Database.[12] For these properties, we compare policyholders who were uninsured after October 2014 – one year after the implementation of Biggert-Waters pricing – to those that continued to insure after this date.

[11] We calculate this 25% effect as follows. We assume that SRL properties would have renewed at the rate of non-SRL properties if not for the reform. Let p_{12_13} and p_{13_14} represent the renewal rates of non-SRL properties from October 2012 to October 2013 and October 2013 to October 2014, respectively. Also let bw_{12_13} and bw_{13_14} represent the estimated effect of Biggert-Waters on SRL properties in Column 3 of Table 6. Then, we calculate the total effect of the reform on SRL property renewals as a reduction of $p_{12\_13} \cdot p_{13\_14} - (p_{12\_13} - bw_{12\_13}) \cdot (p_{13\_14} - bw_{13\_14}) = 0.81 \cdot 0.77 - (0.81 - 0.16) \cdot (0.77 - 0.21) = 0.26$.

[12] Both databases include a unique property location indicator, which we use to merge the data.

Table 7: Statistics about SRL Properties in Dependence of Their Insurance Status

	Properties uninsured after October 2014			Properties insured after October 2014		
Claims Statistics	Claims Payments	Tot. Payment	Tot. No. Losses	Claims Payments	Tot. Payment	Tot. No. Losses
Mean	31,028	215,171	7	32,531	205,491	7
St. Dev.	78,350	314,135	4	67,163	241,347	4
Pctl(1)	1,112	15,305	2	1,175	33,876	2
Pctl(25)	5,977	75,673	5	5,568	77,387	5
Median	13,112	141,818	6	12,804	131,978	6
Pctl(75)	30,592	246,974	9	30,476	240,995	8
Pctl(99)	276,364	1,533,814	25	306,836	1,340,589	16
Type of Mitigation as of May 2018						
Building acquired and demolished as part of a program			0.13			0.10
Building elevated to or above BFE			0.05			0.06
Building demolished but not acquired through a federal program			0.06			0.04
Building replaced by a new elevated/floodproofed building			0.04			0.04
Building protected by a flood control/stormwater management project			0.03			0.04
None			0.69			0.72

Notes: The table displays summary statistics about SRL properties from the 2009 cohort in terms of claims and mitigation. It compares statistics on claims and mitigation for properties that are in force as of October 2014 with properties that dropped insurance before October 2014.

We consider two possibilities. First, we examine whether SRL property owners who stopped insuring were more likely to have mitigated their flood risks than those who continued to insure. Mitigation is a partial substitute for insurance and so higher insurance costs might have encouraged some SRL property owners to adopt mitigation strategies. The SRL property database includes information on whether the properties were mitigated through home improvements such as elevation. It also indicates whether the risk was "mitigated" through relocation and destruction of the home. Table 7 compares the mitigation status of the SRL properties that were insured versus those that were uninsured. While we observe small differences across specific types of mitigation, overall, mitigation does not appear to explain why some SRL properties decided not to renew – 69% of uninsured properties are unmitigated, versus 72% of insured properties.

Second, we examine whether a policyholder's loss experience affected her decision to renew. Previous research finds that consumers' flood experiences affect their decision to insure against flood (Browne and Hoyt, 2000; Michel-Kerjan and Kousky, 2010; Gallagher, 2014). We compare the insured and uninsured based on their claims history. The median claims payments and median total payments per property are slightly higher for uninsured properties than insured properties; however, these differences are not statistically significant due to the large standard deviations in these measures. In summary, the SRL properties that were no longer insured following Biggert-Waters do not appear different, in mitigation and claims payments, than the SRL properties that continued to insure after the reform.

3.3 Coverage Choices

3.3.1 Graphical Illustration

We also examine the effect of Biggert-Waters on coverage choices of SRL and non-SRL properties. Tracking a cohort over time creates a selected sample if property owners decide not to renew. Thus, home and policy characteristics at the beginning of our observation period can differ from those at the end of of our observation period. We want to avoid this selection process and thus examine the coverage limit choices of policyholders who renewed each year between 2010 and 2018. This leads to a balanced panel with more than 700,000 policy-year observations.[13]

Figure 2 shows the evolution of coverage choices from January 2010 to December 2018. For both SRL and non-SRL properties we measure coverage choices at time t by dividing the chosen building coverage at time t by the building coverage chosen in 2009. In contrast to extensive margin decisions, on the intensive margin, almost no differential behavior between the SRL properties and the reference group can be observed at the first renewal decisions after the ratification of Biggert-Waters on July 6, 2012. However, the figure indicates that SRL property owners react on the intensive margin and reduce their building coverage in the long-run.

3.3.2 Empirical Estimation and Results

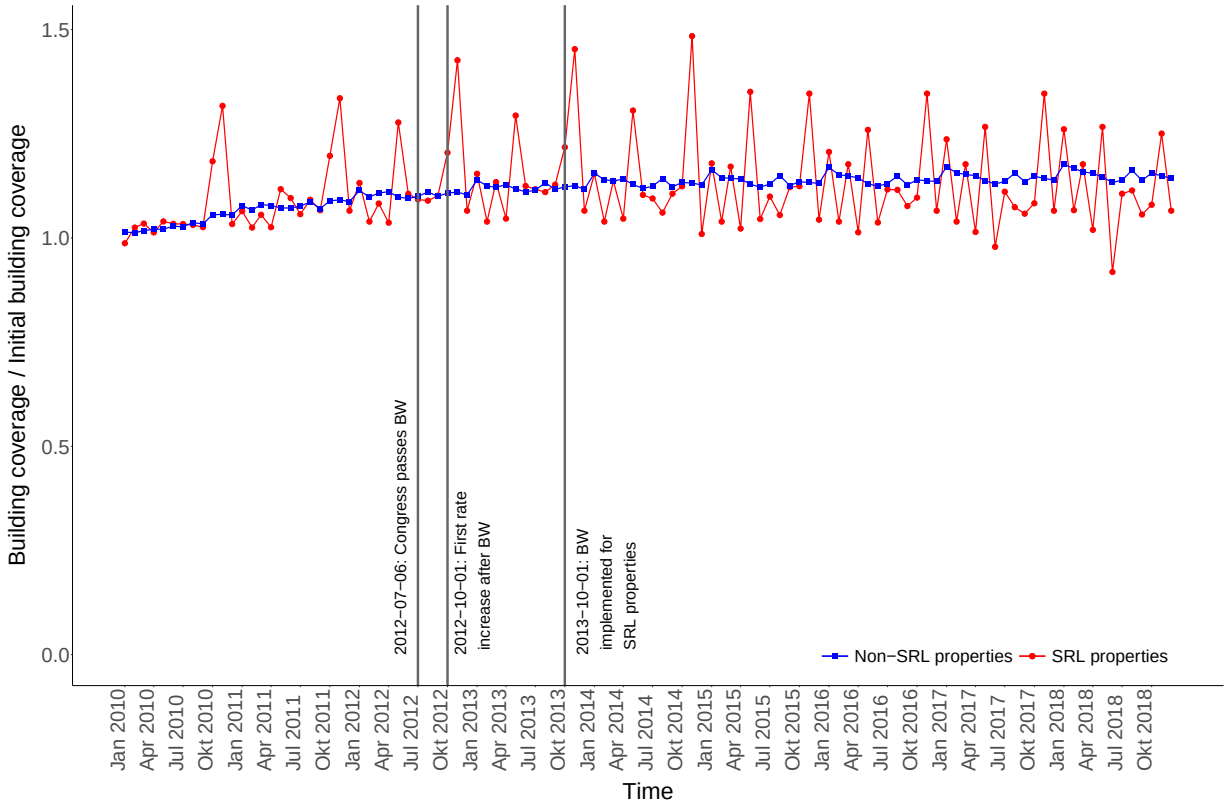
The empirical test for the effect of Biggert-Waters on coverage choices is, with the exception of the dependent variable, identical to the regression model for the renewal decisions. The dependent variable is defined as ratio of building coverage and building coverage chosen in 2009.

$$coverageChoice_{it} := \frac{buildingCoverage_{it}}{buildingCoverage_{i,2009}}, \tag{5}$$

$$\begin{aligned} coverageChoice_{it} = {} & \beta_1 \cdot \mathbb{1}_{(SRL_i)} \\ & + \beta_2 \cdot \mathbb{1}_{(Oct\_12 \leq t < Oct\_13)} + \beta_3 \cdot \mathbb{1}_{(Oct\_12 \leq t < Oct\_13)} \cdot \mathbb{1}_{(SRL_i)} \\ & + \beta_4 \cdot \mathbb{1}_{(Oct\_13 \leq t < Oct\_14)} + \beta_5 \cdot \mathbb{1}_{(Oct\_13 \leq t < Oct\_14)} \cdot \mathbb{1}_{(SRL_i)} \\ & + \beta_6 \cdot \mathbb{1}_{(Oct\_14 \leq t < Oct\_15)} + \beta_7 \cdot \mathbb{1}_{(Oct\_14 \leq t < Oct\_15)} \cdot \mathbb{1}_{(SRL_i)} \\ & + \beta_8 \cdot \mathbb{1}_{(t \geq Oct\_15)} + \beta_9 \cdot \mathbb{1}_{(t \geq Oct\_15)} \cdot \mathbb{1}_{(SRL_i)} \\ & + \gamma \cdot controls_{it} + \alpha_i + \delta_s + \mu_k + \varepsilon_{it}. \end{aligned} \tag{6}$$

[13] As a robustness check we analyze the coverage limits of all policyholders in the 2009 cohort, including those that do not renew (see Table 12 in Appendix B).

Figure 2: Coverage Choices of the 2009 Policy Cohort Renewing in Each Year Between 2010 and 2018



Notes: The figure displays the development of coverage choices of the 2009 policy cohort renewing in each year between 2010 and 2018. For both SRL and non-SRL properties we measure coverage choices at time t by dividing the chosen building coverage at time t by the building coverage chosen in 2009.

We estimate the specifications of the regression model as we did in the previous section. The regression results in Table 8 indicate that the reform did not meaningfully affect SRL property owners' building coverage choices in 2012, 2013, or 2014. We observe a modest, long-run effect in the interaction between the SRL indicator (SRL) and the indicator ($after\_Oct\_15$): SRL properties reduced their coverage limits in the long run by about 6 percentage points in response to the reform. Again, our results are robust to different specifications of the model (see column 1 to column 3).

Additionally in Appendix B, we examine (1) the coverage limits of the 2010 cohort instead of the 2009 cohort (Table 11) and (2) the coverage limits of all policyholders in the 2009 cohort, including those that do not renew (Table 12). Each set of analyses provides similar results to those presented here.

Table 8: Regression Results: Coverage Choices of the 2009 Policy Cohort Renewing in Each Year Between 2010 and 2018

	Dependent variable:		
	coverage choice		
	(1)	(2)	(3)
SRL:Oct_12_Oct_13	0.0103	0.0099	0.0040
	(0.0111)	(0.0110)	(0.0082)
SRL:Oct_13_Oct_14	−0.0161	−0.0169	−0.0203
	(0.0189)	(0.0188)	(0.0179)
SRL:Oct_14_Oct_15	−0.0280	−0.0290	−0.0310*
	(0.0200)	(0.0199)	(0.0185)
SRL:after_Oct_15	−0.0521***	−0.0537***	−0.0606***
	(0.0187)	(0.0186)	(0.0176)
Oct_12_Oct_13	−0.0159***	−0.0040*	−0.0034
	(0.0018)	(0.0024)	(0.0024)
Oct_13_Oct_14	−0.0300***	−0.0122**	−0.0114**
	(0.0037)	(0.0052)	(0.0052)
Oct_14_Oct_15	−0.0448***	−0.0223***	−0.0204***
	(0.0052)	(0.0072)	(0.0072)
after_Oct_15	−0.0582***	−0.0345***	−0.0316***
	(0.0064)	(0.0089)	(0.0086)
SRL	0.0042	0.0050	
	(0.0198)	(0.0199)	
monthly_time_trend	0.0040***		
	(0.0004)		
monthly_time_trend_squared	−0.00002***		
	(0.000002)		
Controls	Yes	Yes	Yes
ZIP FE	Yes	Yes	No
Month FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Individual FE	No	No	Yes
Clustered SE	State	State	State
Observations	715,839	715,839	715,839
R^2	0.1144	0.1143	0.7834
Adjusted R^2	0.1027	0.1026	0.7525
Residual Std. Error	0.4958	0.4959	0.2604

Notes: Dependent variable is the ratio of building coverage and the building coverage chosen in 2009. Column (1) gives the results of a pooled ordinary least squares model including ZIP and month fixed effects as well as a quadratic monthly time trend. Column (2) modifies the model given in column (1) and allows for year fixed effects instead of a quadratic time trend. Finally, column (3) extends column (2) in replacing ZIP fixed effects with individual fixed effects. All models include home and policy characteristics as control variables.

4 Discussion and Conclusion

Social insurance programs are targeted at increasing the financial resilience of the population and, often, contain aspects particularly targeted at protecting vulnerable groups. This protection is usually achieved through premium subsidies (Jaspersen and Richter, 2015). Such premium subsidies can, however, threaten the financial sustainability of the insurance program. The extent of subsidization is thus a commonly discussed policy topic. Arguments against strong subsidization include that rational consumers should purchase subsidized insurance policies no matter how extensive the subsidy is (Schlesinger, 2013). This claim is tested empirically here.

We study the insurance decisions of an especially vulnerable group in the NFIP, SRL property owners. The Biggert-Waters Flood Insurance Reform Act increased the premiums of SRL property owners, and we assess how these rate increases affected their renewal decisions and coverage limit choices. Although SRL properties are still heavily subsidized, Biggert-Waters induced about one fourth of SRL property owners to stop insuring. It had a much smaller effect on coverage limit choices both in the short-run and in the long-run, affecting each by at most 6 percentage points.

Our results are thus in contrast with canonical insurance demand models. Individuals cancel their policies in light of premium increases even if they are still heavily subsidized. Moreover, we observe differential responses to price increases between SRL and non-SRL property owners even before they received differential price increases. The ratification of the Biggert-Waters Act affected insurance choices even before its price increases were implemented. Our results are thus in line with other recent observations on insurance purchasing behavior in that they are hard to reconcile with canonical or even most common behavioral decision theories (Bhargava et al., 2017; Brot-Goldberg et al., 2017; Jaspersen et al., 2019).

While certain institutional effects might possibly explain our results, we find little evidence for them in our data. SRL property owners could, for example, have taken advantage of buyback programs or subsidized mitigation measures and thus rendered insurance coverage either unnecessary or too expensive to maintain. However, renewing and non-renewing SRL properties look virtually identical at the end of our observation period. It thus seems more likely that behavioral aspects in the decision process of individuals explain our results. As an alternative explanation, individuals might have misunderstood the Biggert-Waters Act and thought that their insurance policy was immediately priced above actuarially fair rates after the law was passed. Inaccurate media coverage or peer effects could have potentially exaggerated this effect. Ultimately our analysis is unable to identify the causes of our observations. Doing so is an important direction of further research hopefully allowing the design of effective insurance reforms, both here and in

other settings.

From the perspective of the policymaker it remains unclear whether Biggert-Waters attained its goals. While the premium rate increases contribute to a more financially sustainable NFIP, the tendency of SRL property owners to drop their insurance is a policy concern. When these homes flood again, the financial burden on the household will be greater, as will the federal recovery assistance needed. As stated above the loss of insurance coverage apparently did not lead property owners to adopt alternative risk management measures. In 2018, five years after the reform, 73% of SRL properties were unmitigated, 42% of existing SRL properties uninsured, and 36% of SRL properties both unmitigated and uninsured.

Our findings do not suggest easy policy solutions for insuring vulnerable groups, especially in our setting since flood risks are increasing. They do provide a warning that rate increases may have unintended consequences. Because the federal government pays a portion of uninsured losses through relief, it is not obvious that the reform reduced total public expenditures on these properties. One potential direction for future reforms is to pair premium subsidy reductions with mitigation grants (or loans). However, the effectiveness of such a future reform depends on households' willingness to mitigate. Mitigation decisions are not well understood and so are also an important topic for future research.

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Appendix A Building Rates Development

Table 9: Building Rates in the Restricted Sample in Dependence of Different Basement Options

September 2013	**SRL properties**		**Non-SRL properties**	
	$r_b^{(b)}$	$r_a^{(b)}$	$r_b^{(b)}$	$r_a^{(b)}$
No Basement	0.76	0.77	0.76	0.77
With Basement	0.81	1.14	0.81	1.14
With Enclosure	0.81	1.37	0.81	1.37
Elevated on Crawlspace	0.76	0.77	0.76	0.77
Non-Elevated with Subgrade Crawlspace	0.76	0.77	0.76	0.77
Manufactured (Mobile) Home	0.76	0.77	0.76	0.77
October 2013	**SRL properties**		**Non-SRL properties**	
	$r_b^{(b)}$	$r_a^{(b)}$	$r_b^{(b)}$	$r_a^{(b)}$
No Basement	0.91	0.92	0.91	0.77
With Basement	0.97	1.36	0.97	1.14
With Enclosure	0.97	1.63	0.97	1.37
Elevated on Crawlspace	0.91	0.92	0.91	0.77
Non-Elevated with Subgrade Crawlspace	0.91	0.92	0.91	0.77
Manufactured (Mobile) Home	0.91	0.92	0.91	0.77

Notes: The table displays the rate $r_b^{(b)}$ for basic building coverage until \$60,000 and the rate $r_a^{(b)}$ for additional building coverage above \$60,000 in the Restricted Sample for both SRL and non-SRL properties before (in September 2013) and after (in October 2013) the implementation of Biggert-Waters for SRL properties. These rates are dependent on the characteristics of the home's basement or crawlspace. 75% of both SRL and non-SRL properties in the Restricted Sample fall into the category "no basement". The building rates corresponding to this category are provided in Table 2 for the time period between October 2008 and December 2018.

Appendix B Robustness Checks

Table 10: Regression Results: Renewal Decisions of the 2010 Policy Cohort Between 2011 and 2018

	Dependent variable:		
	renewal indicator		
	(1)	(2)	(3)
SRL:Oct_12_Oct_13	−0.1578***	−0.1560***	−0.1638***
	(0.0233)	(0.0236)	(0.0321)
SRL:Oct_13_Oct_14	−0.1583***	−0.1570***	−0.2211***
	(0.0410)	(0.0412)	(0.0486)
SRL:Oct_14_Oct_15	0.0564***	0.0503***	−0.0679**
	(0.0187)	(0.0180)	(0.0298)
SRL:after_Oct_15	0.0073	0.0072	−0.1055***
	(0.0130)	(0.0130)	(0.0188)
Oct_12_Oct_13	−0.0167**	−0.0051	−0.0072*
	(0.0082)	(0.0047)	(0.0041)
Oct_13_Oct_14	−0.0780***	−0.0520***	−0.0623***
	(0.0219)	(0.0172)	(0.0179)
Oct_14_Oct_15	−0.0201*	−0.0267**	−0.0529***
	(0.0109)	(0.0115)	(0.0129)
after_Oct_15	0.0596***	0.0321***	−0.0081
	(0.0084)	(0.0112)	(0.0128)
SRL	−0.0364***	−0.0364***	
	(0.0081)	(0.0081)	
monthly_time_trend	−0.0020***		
	(0.0003)		
monthly_time_trend_squared	0.00001***		
	(0.000002)		
Controls	Yes	Yes	Yes
ZIP FE	Yes	Yes	No
Month FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Individual FE	No	No	Yes
Clustered SE	State	State	State
Observations	1,831,075	1,831,075	1,831,075
R^2	0.0643	0.0647	0.4880
Adjusted R^2	0.0552	0.0556	0.3154
Residual Std. Error	0.3845	0.3844	0.3273

Notes: Instead of analyzing renewal decisions of the 2009 cohort (see Table 6), here we study renewal decisions of the 2010 cohort. Dependent variable is the renewal indicator variable. Column (1) gives the results of a linear probability model including ZIP and month fixed effects as well as a quadratic monthly time trend. Column (2) modifies the model given in column (1) and uses year fixed effects instead of a quadratic time trend. Finally, column (3) extends column (2) in replacing ZIP fixed effects with individual fixed effects. All models include home and policy characteristics as control variables.

Table 11: Regression Results: Coverage Choices of the 2010 Policy Cohort Renewing in Each Year Between 2011 and 2018

	Dependent variable:		
	coverage choice		
	(1)	(2)	(3)
SRL:Oct_12_Oct_13	−0.0029	−0.0030	−0.0027
	(0.0102)	(0.0101)	(0.0105)
SRL:Oct_13_Oct_14	−0.0188	−0.0191	−0.0159
	(0.0164)	(0.0163)	(0.0187)
SRL:Oct_14_Oct_15	−0.0217	−0.0222	−0.0174
	(0.0164)	(0.0163)	(0.0183)
SRL:after_Oct_15	−0.0515***	−0.0527***	−0.0475***
	(0.0177)	(0.0177)	(0.0182)
Oct_12_Oct_13	−0.0081***	0.0019	0.0021
	(0.0020)	(0.0018)	(0.0021)
Oct_13_Oct_14	−0.0189***	−0.0006	−0.00003
	(0.0038)	(0.0041)	(0.0044)
Oct_14_Oct_15	−0.0302***	−0.0040	−0.0030
	(0.0053)	(0.0058)	(0.0060)
after_Oct_15	−0.0410***	−0.0091	−0.0074
	(0.0066)	(0.0074)	(0.0074)
SRL	−0.0130	−0.0124	
	(0.0141)	(0.0142)	
monthly_time_trend	0.0030***		
	(0.0004)		
monthly_time_trend_squared	−0.00002***		
	(0.000003)		
Controls	Yes	Yes	Yes
ZIP FE	Yes	Yes	No
Month FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Individual FE	No	No	Yes
Clustered SE	State	State	State
Observations	715,804	715,804	715,804
R^2	0.1098	0.1098	0.7407
Adjusted R^2	0.0972	0.0971	0.6987
Residual Std. Error	0.3810	0.3811	0.2201

Notes: Instead of analyzing coverage choices of the 2009 cohort renewing in each year between 2010 and 2018 (see Table 8), here we study coverage choices of the 2010 cohort renewing in each year between 2011 and 2018. Dependent variable is the ratio of building coverage and in 2010 initial chosen building coverage. Column (1) gives the results of a pooled ordinary least squares model including ZIP and month fixed effects as well as a quadratic monthly time trend. Column (2) modifies the model given in column (1) and allows for year fixed effects instead of a quadratic time trend. Finally, column (3) extends column (2) in replacing ZIP fixed effects with individual fixed effects. All models include home and policy characteristics as control variables.

Table 12: Regression Results: Coverage Choices of the 2009 Policy Cohort Between 2010 and 2018

	Dependent variable:		
	coverage choice		
	(1)	(2)	(3)
SRL:Oct_12_Oct_13	−0.0085	−0.0086	−0.0030
	(0.0159)	(0.0160)	(0.0065)
SRL:Oct_13_Oct_14	−0.0052	−0.0061	−0.0113
	(0.0273)	(0.0273)	(0.0121)
SRL:Oct_14_Oct_15	−0.0158	−0.0166	−0.0167
	(0.0356)	(0.0358)	(0.0151)
SRL:after_Oct_15	−0.0674***	−0.0684***	−0.0555***
	(0.0249)	(0.0247)	(0.0138)
Oct_12_Oct_13	−0.0169***	−0.0116***	−0.0086***
	(0.0022)	(0.0030)	(0.0018)
Oct_13_Oct_14	−0.0331***	−0.0287***	−0.0215***
	(0.0036)	(0.0064)	(0.0037)
Oct_14_Oct_15	−0.0484***	−0.0456***	−0.0336***
	(0.0050)	(0.0103)	(0.0055)
after_Oct_15	−0.0572***	−0.0638***	−0.0452***
	(0.0065)	(0.0150)	(0.0072)
SRL	0.0091	0.0091	
	(0.0093)	(0.0094)	
monthly_time_trend	0.0043***		
	(0.0003)		
monthly_time_trend_squared	−0.00002***		
	(0.000002)		
Controls	Yes	Yes	Yes
ZIP FE	Yes	Yes	No
Month FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Individual FE	No	No	Yes
Clustered SE	State	State	State
Observations	1,681,346	1,681,346	1,681,346
R^2	0.0357	0.0359	0.8277
Adjusted R^2	0.0260	0.0263	0.7736
Residual Std. Error	0.6746	0.6745	0.3252

Notes: Instead of analyzing coverage choices of the 2009 cohort renewing in each year between 2010 and 2018 (see Table 8), here we study all coverage choices of the 2009 between 2010 and 2018. Dependent variable is the ratio of building coverage and and the building coverage chosen in 2009. Column (1) gives the results of a pooled ordinary least squares model including ZIP and month fixed effects as well as a quadratic monthly time trend. Column (2) modifies the model given in column (1) and allows for year fixed effects instead of a quadratic time trend. Finally, column (3) extends column (2) in replacing ZIP fixed effects with individual fixed effects. All models include home and policy characteristics as control variables.