Voluntary Purchases and Selection in the Market for Flood Insurance

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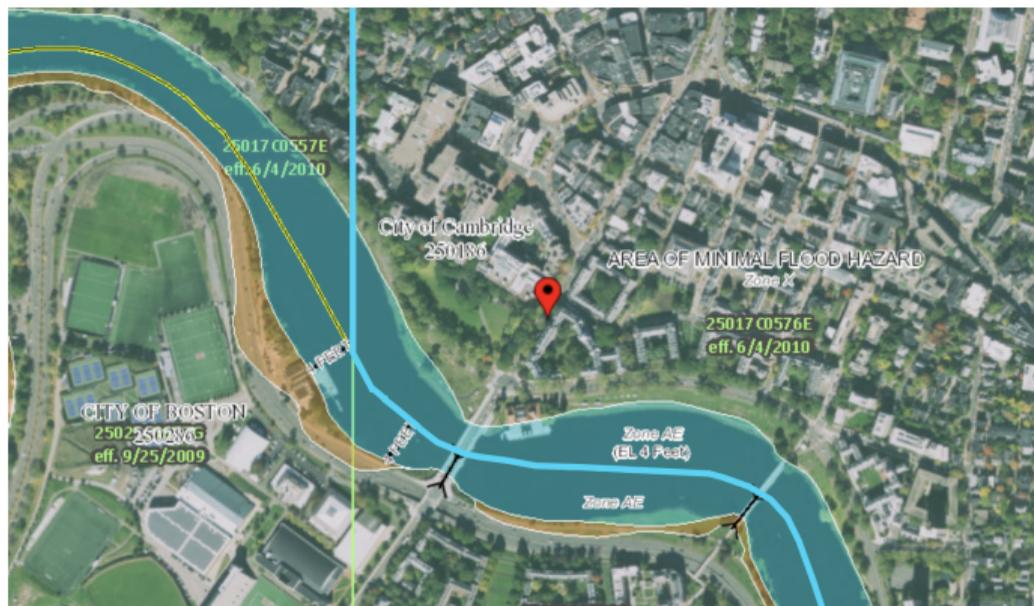University of Bristol

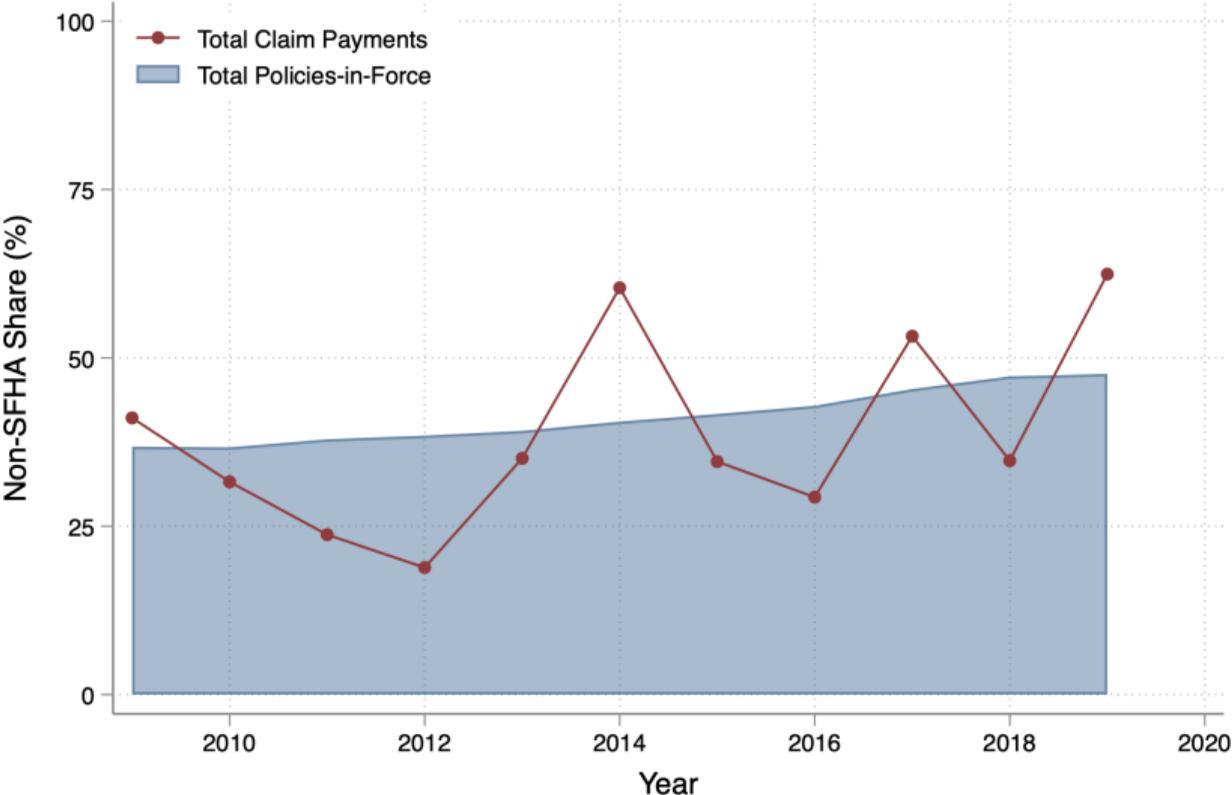February 10, 2021

Flood Insurance in the US

- Flood-related events most costly disasters in the U.S.

- 2017: just under $300B in damages (NOAA NCEI)

- By 2100: $\approx$$1.3T of residential property at risk (Zillow)

Flood Insurance in the US: National Flood Insurance Program (NFIP)

- NFIP primary provider of flood insurance $\rightarrow$ 96% of residential policies (Kousky et al., 2018)

- In addition to underwriting, NFIP responsible for publishing rate maps (FIRMs)

- Maps used to set NFIP rates, delineate Special Flood Hazard Areas (SFHAs)

Flood Insurance in the US: Voluntary Purchases

Motivation

- Policies outside SFHAs account for a large (and growing) share of overall NFIP policies and claims

- Prior work examining NFIP take-up has focused on areas within SFHAs or aggregate geographies
    - Eg, Kriesel and Landry, 2004; Kousky, 2011; Atreya et al., 2015; Mulder, 2019; Wagner, 2020

- Pending and proposed NFIP reforms (e.g., "Risk Rating 2.0") are likely to have a major impact on non-SFHA policies

Summary of Findings

- We use historical NFIP policy and claims data to examine aggregate demand for SFHA and non-SFHA policies at the tract-level
    - → Find heterogeneity in take-up on household characteristics

    - → Find non-SFHA take-up response to salient flooding events

    - → Use policy variation to estimate price elasticities: non-SFHA demand elastic relative to SFHA

    - → Find suggestive evidence that homeowners select into insurance based on un-priced risk
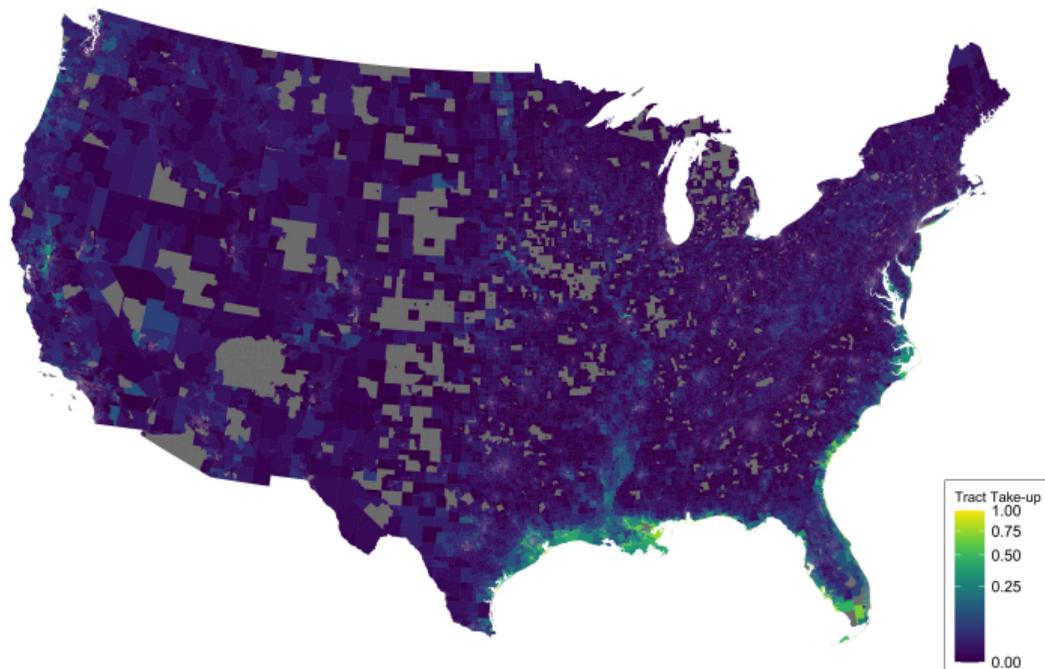
Outline

Empirical Setting: National Flood Insurance Program

Year = 2019; Grey = No PIF 2009-2019.

Transaction-level policy and claims data from OpenFEMA

- Covers 2009-2020

- Includes coverage amount, premium, etc.

- Cannot *explicitly* link policies over time or claims to policies (see Mulder, 2019)

- Limited geographic data

Analyzing Demand

- NFIP take-up rate captures extensive margin demand for aggregate geography

- Let $d_{it} = 1$ if household $i \in \{1, ..., N_j\} = \mathcal{I}_j$ purchases insurance in period t, where N_j is the number of households in geography j. Then take-up rate for geography j, y_{jt} is

$$y_{jt} = \mathbb{E}_{\mathcal{I}_j}[d_{it}] = Pr_{\mathcal{I}_j}(d_{it} = 1) = N_j^{-1} \sum_{i=1}^{N_j} d_{it}$$

- Need to know the size of the relevant market, N_j

- Focus on smallest aggregate geography included in NFIP data: census tracts

Constructing Measures of non-SFHA/SFHA Take-up

- Use NYU Furman Center's method to get tract-by-non-SFHA/SFHA housing unit counts:

    → Intersect nationwide FIRMs with 2010 Census blocks

    → Assign non-SFHA/SFHA using block centroids

    → Aggregate non-SFHA/SFHA housing unit counts (2010 Census) to tract-level

- Then use annual tract-by-non-SFHA/SFHA counts of policies-in-force (PIF)

- Pro: allows us to separately examine aggregate demand for non-SFHA and SFHA areas

- Con(s): static, potential for measurement error $\implies$ use PIF to check robustness

Analyzing (Extensive Margin) Demand

- Run a series of regressions of the general form

$$y_{jt} = \boldsymbol{X'_{jt}}\boldsymbol{\beta} + c_j + c_t + \varepsilon_{jt}$$

where
  - y_{jt} is non-SFHA/SFHA take-up for tract j in year t
  - $\boldsymbol{X_{jt}}$ includes time-variant and time-invariant tract- and tract-zone-level attributes
  - c_j and c_t are unobserved effects on non-SFHA/SFHA take-up at the tract- and year-levels

- Will use both county/tract FEs to account for c_j

- Std. errors clustered at the tract-level throughout

- Robustness of all primary results to functional form: fractional response probit

Analyzing (Extensive Margin) Demand

What's in $\boldsymbol{X_{jt}}$?

- Time-varying:
    - By non-SFHA/SFHA: average policy premium, average CRS discount (FEMA)
    - Homeowner demographics/household characteristics (5-year ACS estimates)
    - Presidential disaster declarations (FEMA)
    - Individual Assistance funding (FEMA)
    - High precipitation days (NOAA)

- Time-invariant:
    - By non-SFHA/SFHA: FSF Flood Factor
    - Geographic attributes: water area, average soil permeability, coastal indicator (Decennial Census, USDA)

- Full panel covers 2009-2019
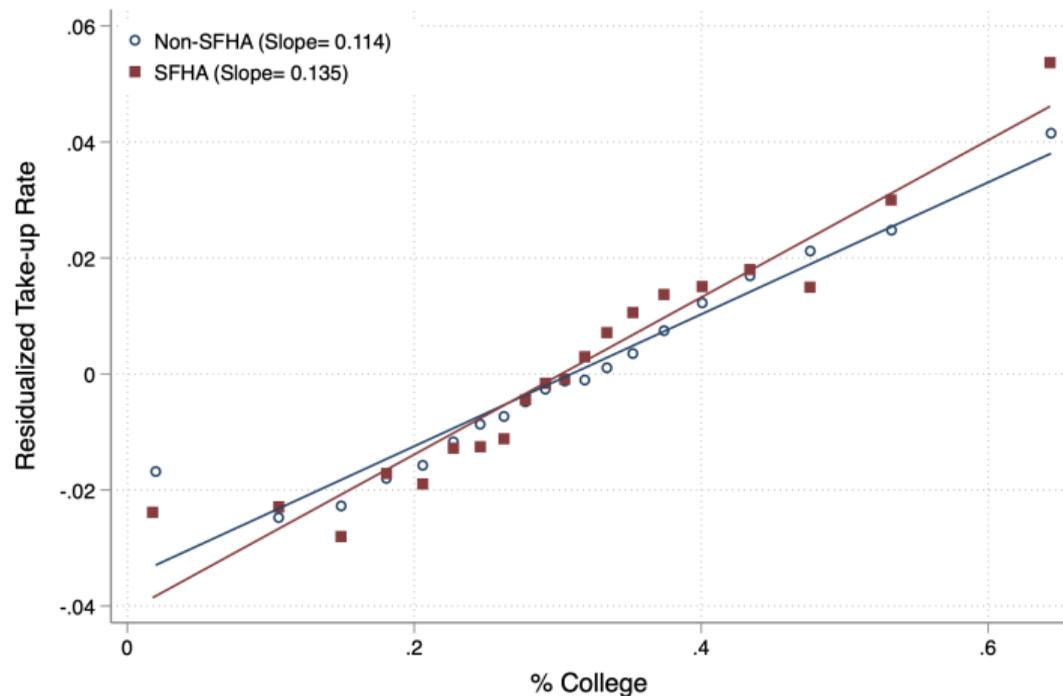
▸ Summary statistics

Outline
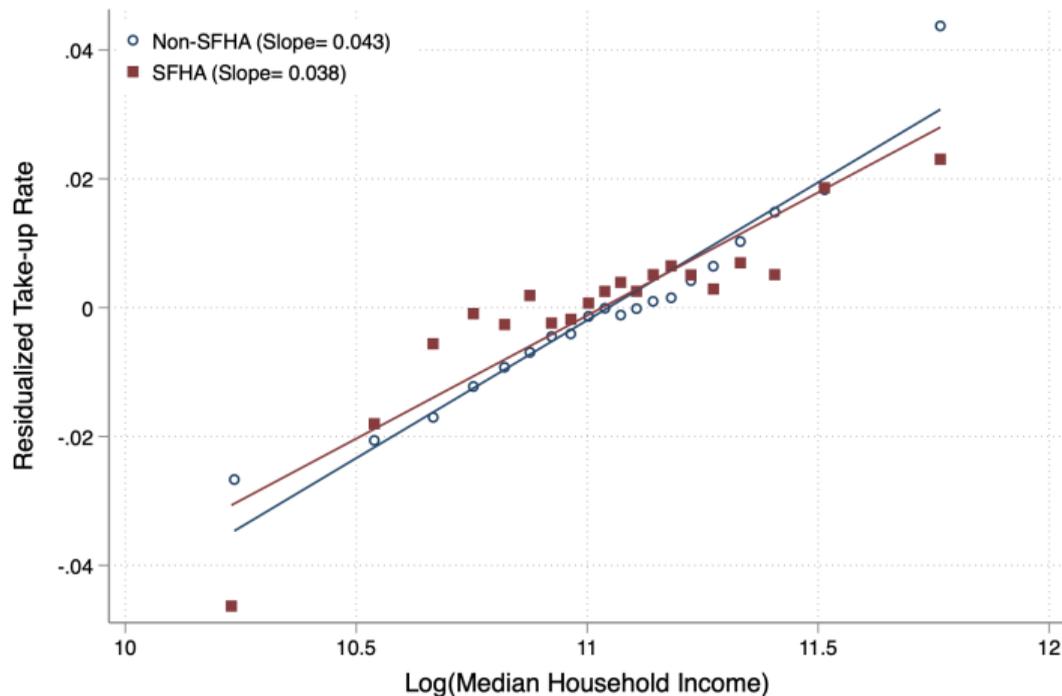
Insurance Demand and Homeowner/Household Attributes

- Mean non-SFHA tract-level take-up: 0.041

- Mean SFHA tract-level take-up: 0.299

- Year- and county-FE's

- Conditional on observed controls

▸ PIF results   ▸ Full results

Insurance Demand and Homeowner/Household Attributes

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▸ PIF results   ▸ Full results
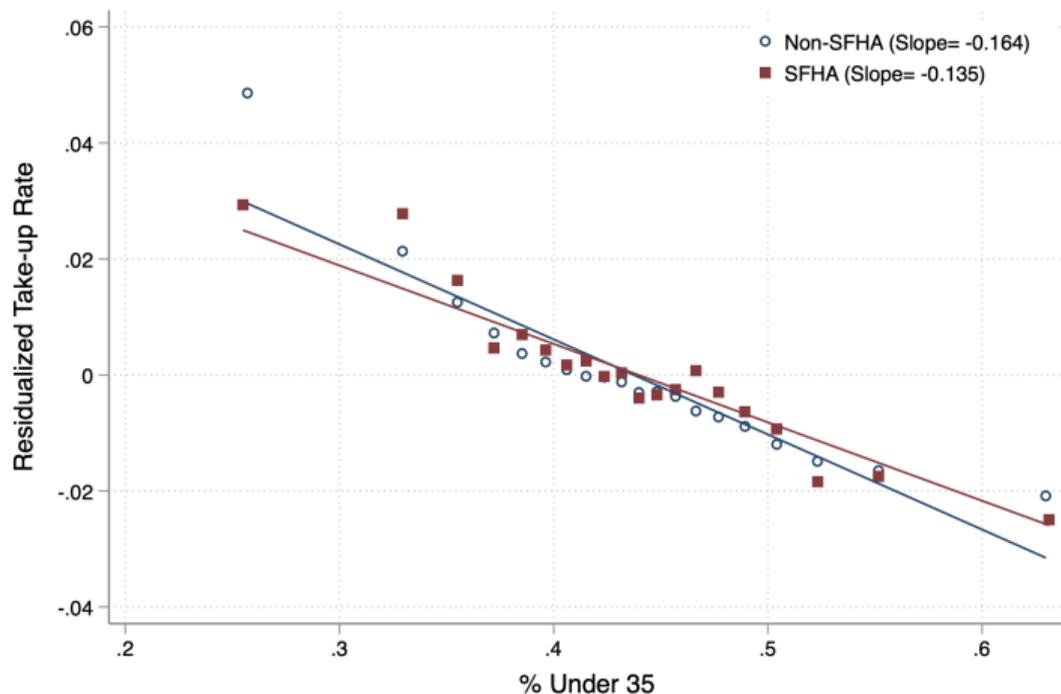
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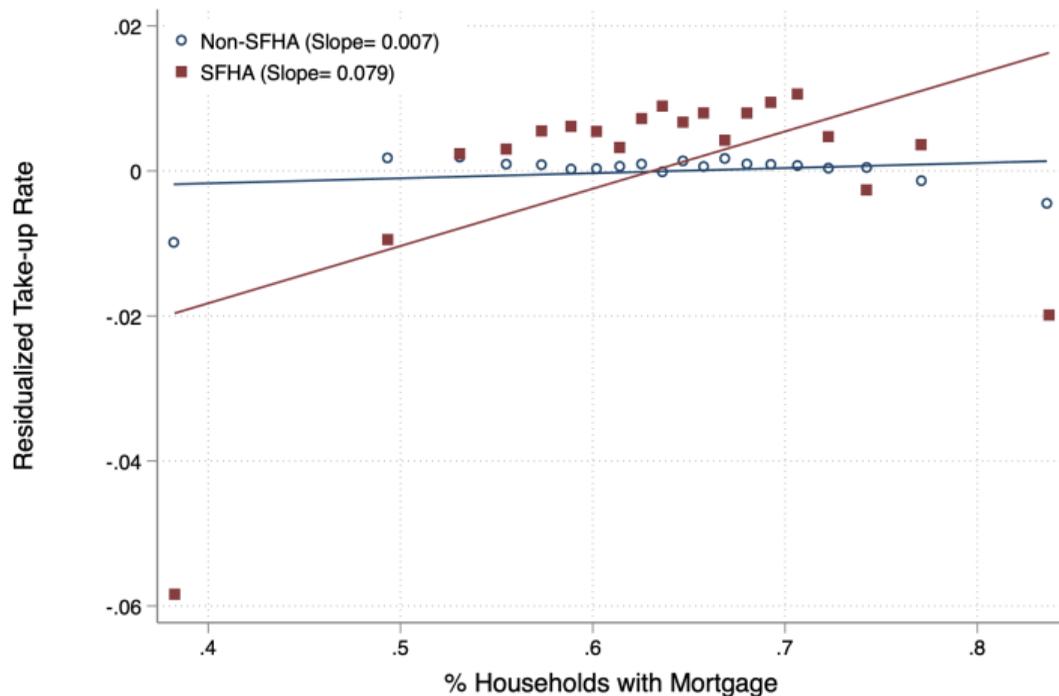
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Outline

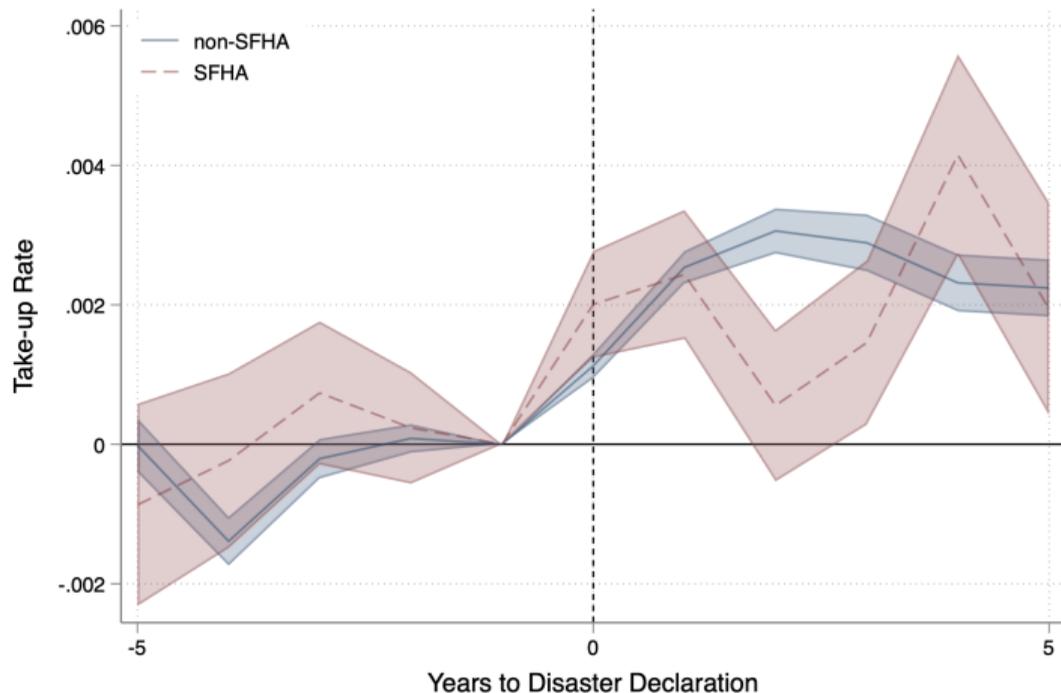# Insurance Demand and Salient Flooding Events

- Relevant disaster declarations: flooding, severe storms, coastal storms, hurricanes

- Event study around all relevant declarations

- Estimated using year- and tract-FE's and controls

▸ Lagged PDD   ▸ Storm Events

Outline

Estimating Price Elasticities

- Despite controlling for a rich set of observables, potential for price endogeneity
    - $\rightarrow$ Need to isolate price variation that is uncorrelated with demand determinants (risk, etc.)

- Use two policy-induced sources of variation:
    - non-SFHA: Homeowner Flood Insurance Affordability Act (HFIAA) of 2014

    - SFHA: Biggert-Waters Flood Insurance Reform Act of 2012

Non-SFHA Price Variation: HFIAA 2014
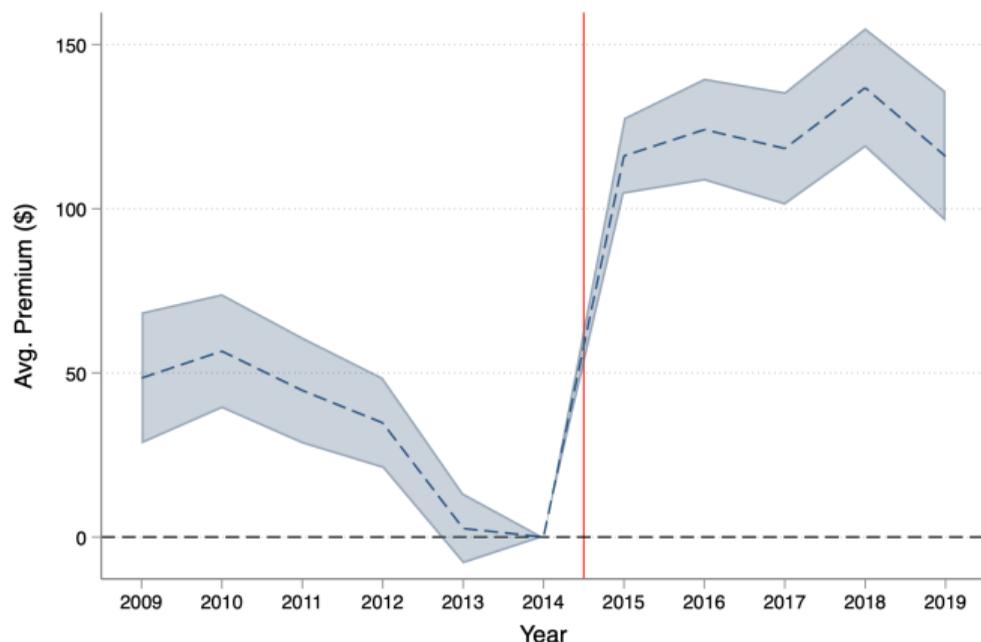
- Generally very little variation in non-SFHA rates

- HFIAA 2014: introduced differential surcharge for primary/non-primary homes

- $z^{nSFHA} = \mathbb{1}[t \geq 2015] \times (\%nonPrimary_{j,t=2014}^{nSFHA})$

- Identifying assumption: $\mathbb{E}[z^{nSFHA} \times \varepsilon_{jt} | \boldsymbol{X_{jt}}, c_j, c_t] = 0$

SFHA Price Variation: Biggert-Waters 2012
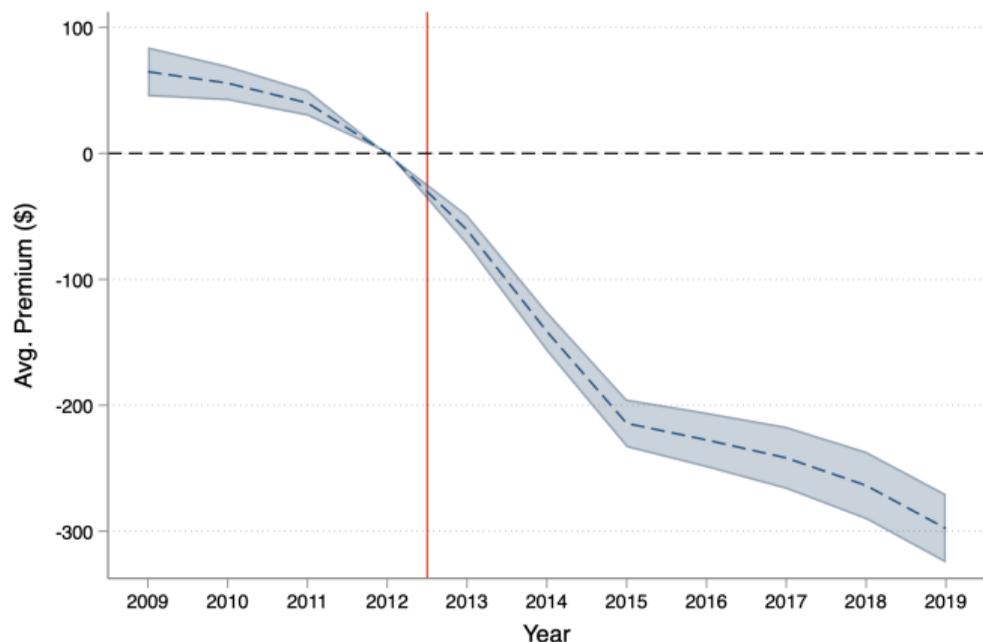
- Policy variation used in Wagner (2020) for SFHA demand

- B-W 2012/HFIAA 2014: introduced differential price change for pre-/post-FIRM construction homes

- $z^{SFHA} = \mathbb{1}[t \geq 2013] \times (\%postFIRM_{j,t=2012}^{SFHA})$

- Identifying assumption: $\mathbb{E}[z^{SFHA} \times \varepsilon_{jt} | \boldsymbol{X_{jt}}, c_j, c_t] = 0$

Price Elasticity Estimates

	nSFHA Take-up		SFHA Take-up	
	OLS	2SLS	OLS	2SLS
Avg. Policy Cost nSFHA	-0.017***	-0.023**		
	(0.002)	(0.011)		
Avg. Policy Cost SFHA			0.008***	-0.055***
			(0.001)	(0.009)
Elasticity Estimate	-0.213	-0.282	0.032	-0.209
K-P F Stat		245.368		796.082
Observations	286,666	272,331	234,265	225,756

- All results estimated with non-price (time-varying) controls, tract- and year-FE
- OLS estimates biased upward
- Greater price-sensitivity outside SFHA

▸ Probit results   ▸ Event study figs

Outline

Selection in the Market for Flood Insurance

- Potential for (adverse) selection major factor in proposed and potential NFIP reforms

- Specific concern: given coarse rate schedule, large subsidies, potential for selection on unpriced risk

Testing for Asymmetric Information

- Question: Is the NFIP characterized by asymmetric (or asymmetrically used) information about risk?

- Finkelstein and Poterba (2014): "unused observables" test
    - An attribute represents asymmetric (or asymmetrically used) information if it is correlated both with subsequent claims experience and insurance demand conditional on prices
    - Does not require exogenous changes in unused obervable
    - Unused observable: FSF Flood Factors

- Construct cost measures using NFIP claims data:
    - Claim probability for non-SFHA and SFHA
    - Average claim per $1 of coverage by tract-year for non-SFHA and SFHA

Testing for Asymmetric Information: Demand
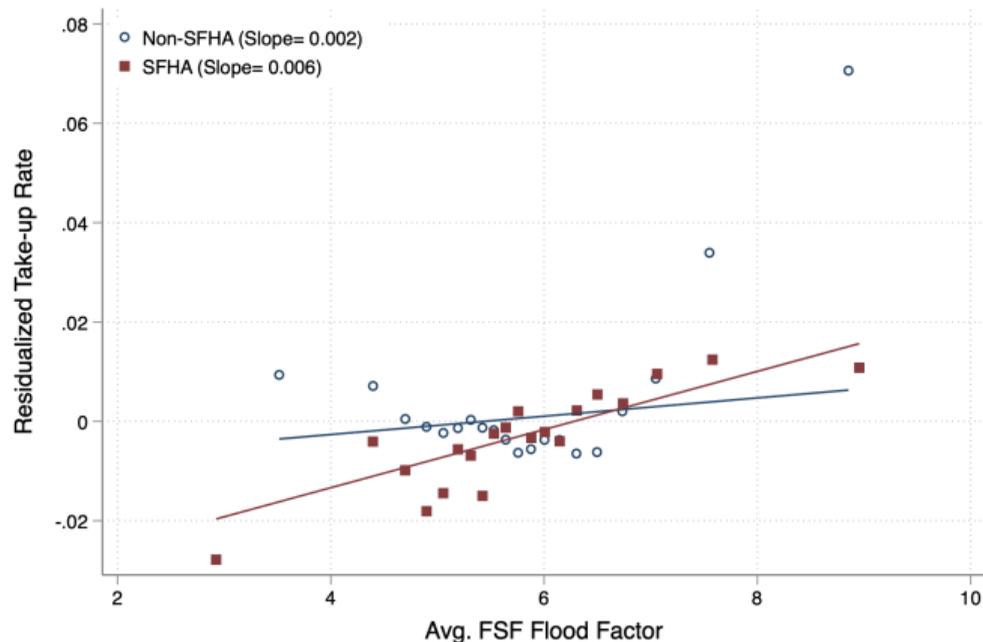
- FSF Flood Factor $\in \{1, ..., 10\}$

- Mean non-SFHA tract-level take-up: 0.041

- Mean SFHA tract-level take-up: 0.299

- Conditional on price, non-price controls, year- and county-FE's

Testing for Asymmetric Information: Cost
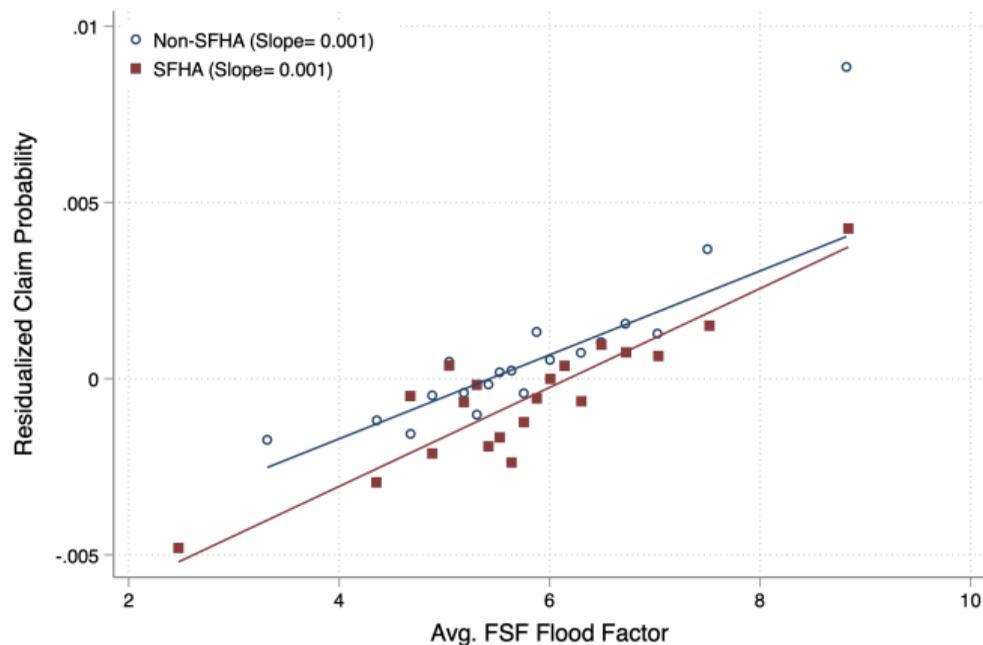
▸ Avg. claim amount

- FSF Flood Factor $\in \{1, ..., 10\}$

- $Pr(\text{claim})_{jt} = \frac{\text{Total claims}_{jt}}{\text{Total PIF}_{jt}}$

- Mean non-SFHA claim probability: 0.012

- Mean SFHA claim probability: 0.018

- Conditional on price, non-price controls, year- and county-FE's

Testing for Asymmetric Information

- Suggestive evidence of the form of private information in flood insurance markets

- Correlation between demand and FSF Flood Factor suggests presence asymmetric risk information in both segments of market

- Correlation between cost and FSF Flood factor supports conclusion that this is active adverse selection due to unpriced risk

▸ Selection on (un)observables

Summary

- We use historical NFIP policy and claims data to examine aggregate demand for SFHA and non-SFHA policies at the tract-level
  - → Use policy variation to estimate price elasticities: non-SFHA demand elastic relative to SFHA
  - → Find suggestive evidence that homeowners select into insurance based on un-priced risk

- Important implications for
  - → "Risk Rating 2.0" and other potential reforms: unraveling, NFIP fiscal solvency
  - → Private entry in flood insurance market

Backup slides

Summary of Tract-level Panel

	Mean	St. Dev.	Min	Max
SFHA Take Up	0.30	0.32	0.00	1.00
nSFHA Take Up	0.04	0.11	0.00	1.00
SFHA PIF	99.97	357.69	0.00	13,713.00
nSFHA PIF	67.36	191.61	0.00	7,106.00
Total NFIP Claims: SFHA	1.88	30.36	0.00	3,804.00
Total NFIP Claims: nSFHA	0.80	11.25	0.00	1392.00
Avg. CRS Discount SFHA	0.05	0.08	0.00	0.45
Avg. CRS Discount nSFHA	0.01	0.02	0.00	0.10
Avg. Policy Cost SFHA	1053.40	816.28	0.00	35,756.96
Avg. Policy Cost nSFHA	515.20	191.72	0.00	5,603.29
Observations		355,674		

▸ Go back

Summary of Tract-level Panel

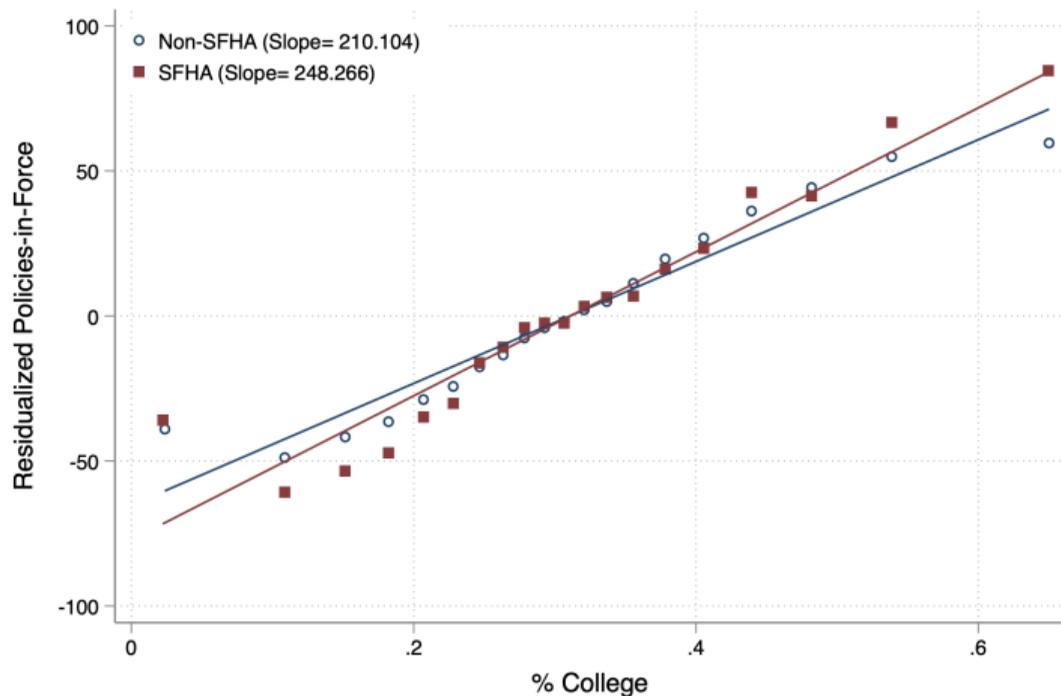|	Mean	St. Dev.	Min	Max
Homeowner Attributes				
Pct. of Pop. with College Degree	0.31	0.19	0.00	1.00
Millenial Pct. of Pop.	0.19	0.08	0.00	0.90
Unemployment Rate	0.08	0.05	0.00	0.70
Minority Pct. of Pop.	0.22	0.22	0.00	1.00
Total Population	4,835.10	2,285.07	0.00	72,041.00
Household Attributes				
Median HH Income	69,744.12	34,527.77	2,499.00	297,918.32
Median Home Value	269,331.20	223,657.43	9,999.00	2,157,289.39
Median Year of Home Const.	1975.49	15.47	1939.00	2014.00
Pct. of HH with a Mortgage	0.64	0.14	0.00	1.00
Observations		355,674		

Summary of Tract-level Panel

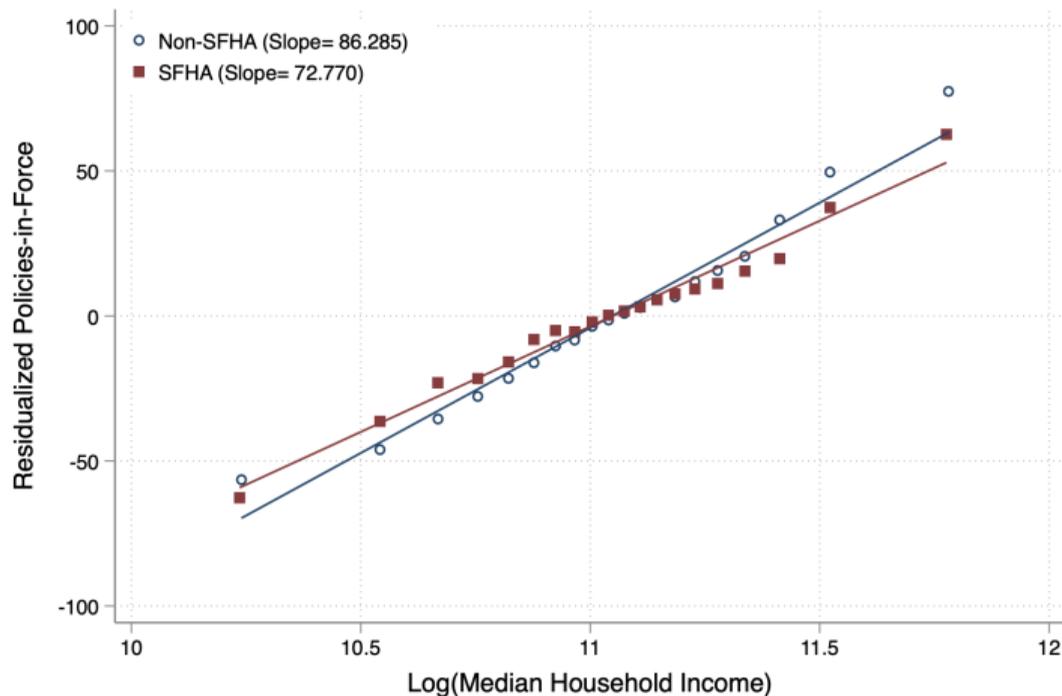|	Mean	St. Dev.	Min	Max
Geography Attributes				
Number of High Precipitation Days	59.11	20.30	1.00	134.00
DD: All Rel. Cumul. 5-year Lag	2.18	1.99	0.00	12.00
Total IA Count Cumul. 5-year Lag	53462.73	159795.36	0.00	1000652.00
Coastal Tract	0.00	0.06	0.00	1.00
Total Tract Area: Water	0.00	0.02	0.00	1.23
Total Tract Area: Land	0.11	0.52	0.00	24.59
Soil Permeability	24.93	24.77	0.25	126.89
Avg. FF SFHA	6.07	2.41	0.00	10.00
Avg. FF nSFHA	5.43	1.45	0.00	10.00
FSF-FEMA Exposed Pct. Diff.	3.19	16.02	-100.00	100.00
Observations		355,674		

Insurance Demand and Homeowner/Household Attributes

- Mean non-SFHA tract-level PIF: 67.3642

- Mean SFHA tract-level PIF: 99.972

- Year- and county-FE's

- Conditional on observed controls

▸ Go back

Insurance Demand and Homeowner/Household Attributes

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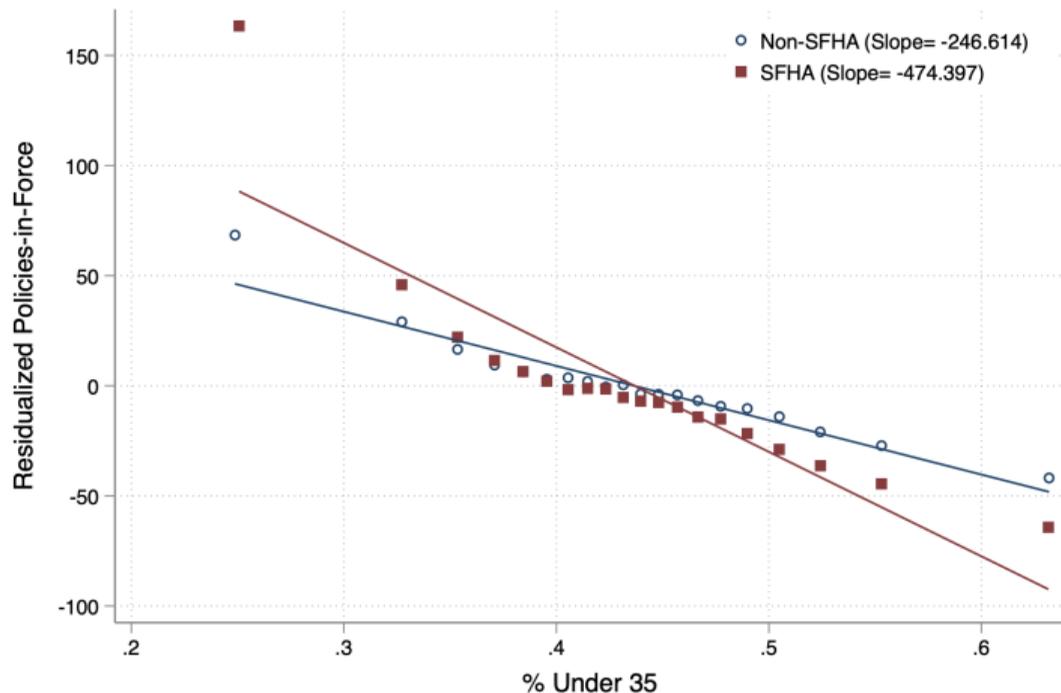
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▸ Go back

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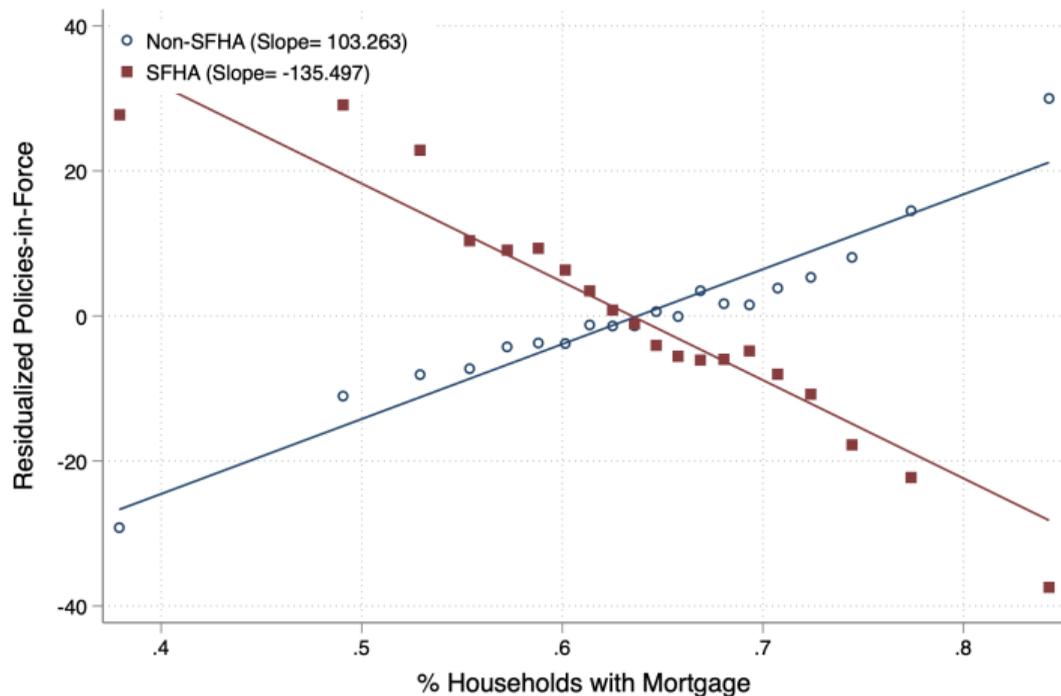
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▸ Go back

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‣ Go back

Full results

|	nSFHA Take-up		SFHA Take-up	
	(1)	(2)	(3)	(4)
Homeowner Attributes				
Pct. of Pop. with College Degree	0.046***	0.015***	0.040**	0.024**
	(0.006)	(0.004)	(0.020)	(0.011)
Pct. of Pop. under 35	-0.097***	-0.021***	-0.104***	-0.046***
	(0.008)	(0.004)	(0.024)	(0.012)
Unemployment Rate	0.026**	0.013***	0.036	0.037***
	(0.012)	(0.004)	(0.035)	(0.013)
Minority Pct. of Pop.	-0.016***	0.004	-0.065***	-0.009
	(0.004)	(0.003)	(0.014)	(0.009)
Log(Total Population)	-0.003*	0.020***	0.026***	0.050***
	(0.002)	(0.003)	(0.005)	(0.006)
Household Attributes				
Log(Median HH Income)	-0.003	-0.000	-0.026***	-0.000
	(0.003)	(0.001)	(0.009)	(0.004)
Log(Median Home Value)	0.027***	-0.001	0.059***	0.022***
	(0.003)	(0.001)	(0.007)	(0.003)
Median Home Construction Age	0.000	-0.000***	0.003***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Pct. of HH with a Mortgage	0.009	-0.001	0.150***	0.026***
	(0.006)	(0.002)	(0.017)	(0.007)
County FE	✓		✓	
Tract FE		✓		✓
Year FE	✓	✓	✓	✓
Observations	287,201	286,666	233,778	234,265

Full results

	nSFHA Take-up		SFHA Take-up	
	(1)	(2)	(3)	(4)
Geography Attributes				
Number of High Precipitation Days	0.004***	0.003***	0.009**	0.007***
	(0.001)	(0.000)	(0.004)	(0.002)
DD: All Rel. Cumul. 5-year Lag	0.000**	0.001***	0.000*	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Total IA Count Cumul. 5-year Lag	0.001***	0.001***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
Coastal Tract	0.033***		0.034***	
	(0.004)		(0.005)	
Total Tract Area: Water	0.130*		-0.569***	
	(0.068)		(0.152)	
Total Tract Area: Land	-0.006***		-0.022***	
	(0.001)		(0.004)	
Soil Permeability	0.005***		0.005***	
	(0.001)		(0.002)	
FSF-FEMA Exposed Pct. Diff.	-0.001***		-0.000	
	(0.000)		(0.000)	
Avg. FF nSFHA	0.002**			
	(0.001)			
Avg. FF SFHA			0.008***	
			(0.001)	
County FE	✓		✓	
Tract FE		✓		✓
Year FE	✓	✓	✓	✓
Observations	287,201	286,666	233,778	234,265

Full results

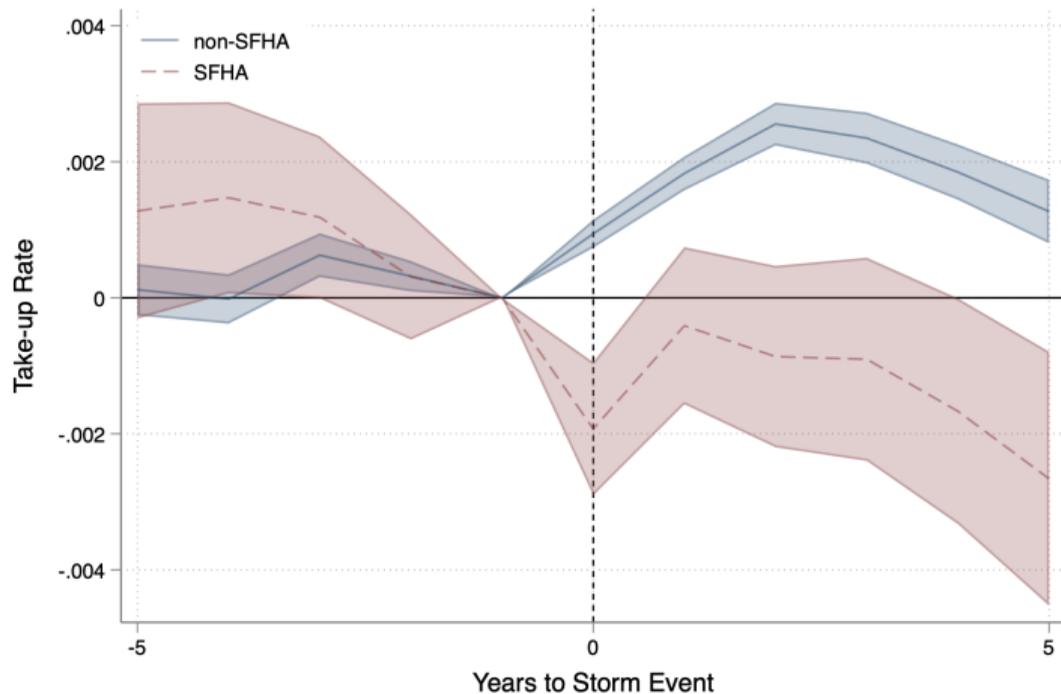|	nSFHA Take-up		SFHA Take-up	
	(1)	(2)	(3)	(4)
NFIP Policy Attributes				
Avg. CRS Discount nSFHA	0.390***	-0.074***		
	(0.047)	(0.009)		
Avg. Policy Cost nSFHA	0.048***	-0.017***		
	(0.004)	(0.002)		
Avg. CRS Discount SFHA			0.573***	0.208***
			(0.035)	(0.020)
Avg. Policy Cost SFHA			0.031***	0.008***
			(0.003)	(0.001)
County FE	✓		✓	
Tract FE		✓		✓
Year FE	✓	✓	✓	✓
Observations	287,201	286,666	233,778	234,265

Insurance Demand and Salient Flooding Events
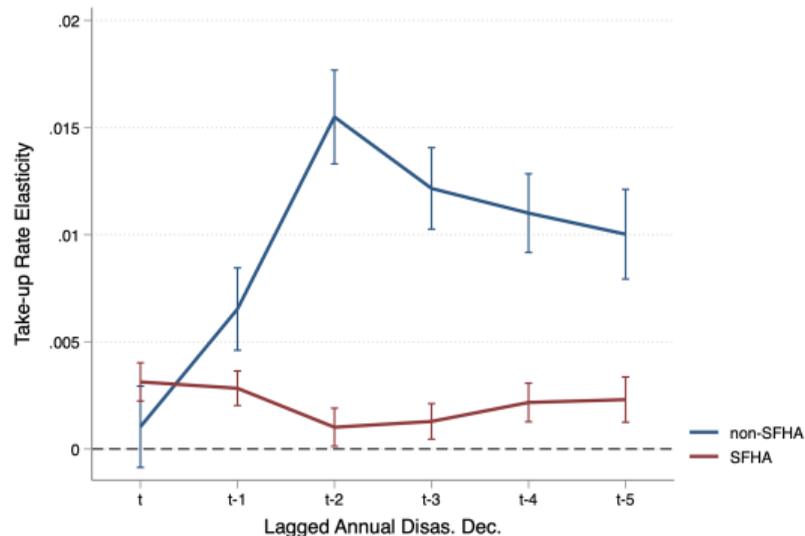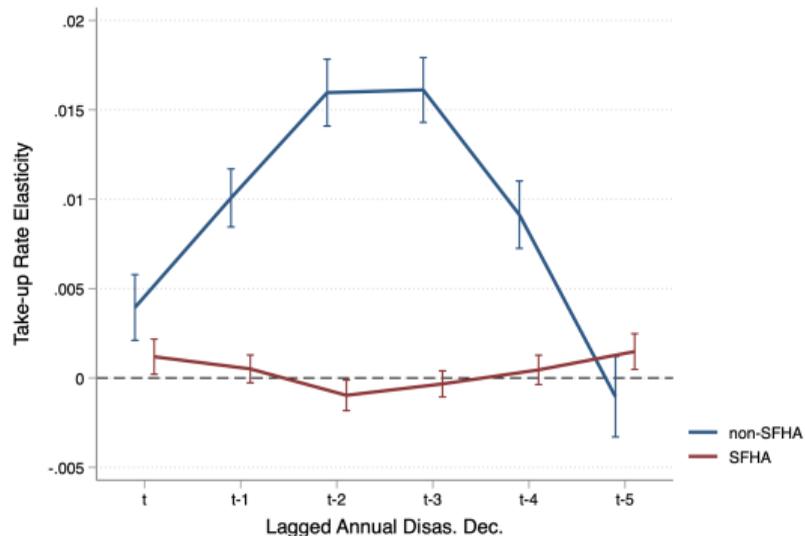
- Take-up elasticities wrt. lagged PDD counts
- RHS conditional on lagged IA funding amounts

▸ Go back

Insurance Demand and Salient Flooding Events

- Relevant disaster declarations: flash flooding, flooding, hurricane, storm surge/tide, tropical storm

- Event study around all relevant events

- Estimated using year- and tract-FE's and controls

Price Elasticity Estimates

	nSFHA Take-up		SFHA Take-up	
	2SLS	Probit	2SLS	Probit
Avg. Policy Cost nSFHA	-0.023**	-0.056***		
	(0.011)	(0.017)		
Avg. Policy Cost SFHA			-0.055***	-0.123***
			(0.009)	(0.013)
Instrument	$\mathbb{1}[t \geq 2015] \times (\%nonPrimary_{j,t=2014}^{nSFHA})$		$\mathbb{1}[t \geq 2013] \times (\%postFIRM_{j,t=2012}^{SFHA})$	
Elasticity Estimate	-0.282	-0.815	-0.209	-0.507
K-P F Stat	245.368		796.082	
Observations	272331	272596	225756	225963

- 2SLS estimated with non-price (time-varying) controls, tract- and year-FE
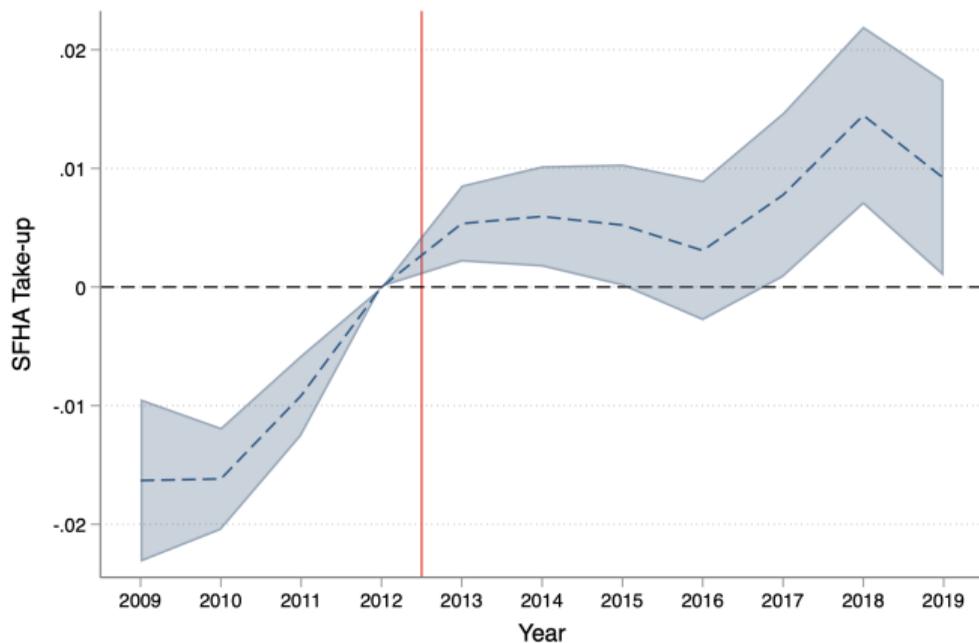- Probit results estimated using Papke and Wooldridge (2008) approach

▸ Go back

Non-SFHA Price Variation: HFIAA 2014

- HFIAA 2014: introduced differential surcharge for primary/non-primary homes

- Non-SFHA take-up regressed on $\sum_{t=2009}^{2019} \mathbb{1}[t = year] \times (\%nonPrimary_{j,t=2014}^{nSFHA})$

- Includes time-varying controls, tract- and year-FE

▸ Go back

SFHA Price Variation: Biggert-Waters 2012

SFHA Take-up plotted against Year (2009–2019), with a vertical red line at 2012 and a horizontal dashed line at 0.

- Policy variation used in Wagner (2020) for SFHA demand

- B-W 2012/HFIAA 2014: introduced differential price change for pre-/post-FIRM construction homes

- SFHA take-up regressed on $\sum_{t=2009}^{2019} \mathbb{1}[t = year] \times (\%postFIRM_{j,t=2012}^{SFHA})$

- Includes time-varying controls, tract- and year-FE

▸ Go back

Testing for Asymmetric Information: Cost
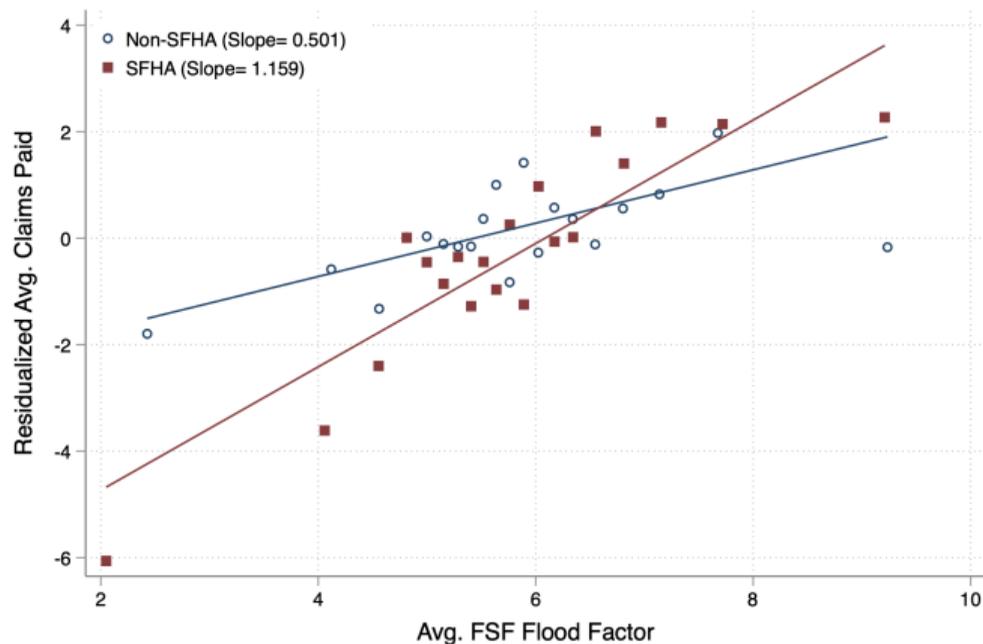
- FSF Flood Factor $\in \{1, ..., 10\}$

- Mean non-SFHA claim payment/\$1000 of coverage: \$12.130

- Mean SFHA claim payment/\$1000 of coverage: \$14.108

- Conditional on price, non-price controls, year- and county-FE's

▸ Go back

Selection on (Un)observables

	nSFHA Claim Prob.		SFHA Claim Prob.	
Avg. Policy Cost nSFHA	0.017*	-0.002		
	(0.010)	(0.020)		
Avg. FF nSFHA	0.001***			
	(0.000)			
Avg. Policy Cost SFHA			-0.008***	-0.056***
			(0.002)	(0.004)
Avg. FF SFHA			0.002***	
			(0.000)	
Tract FE		✓	✓	
County FE	✓		✓	
Year-FE/Controls	✓	✓	✓	✓
K-P F Stat	493.240	363.989	2092.459	1822.775
Observations	318,786	321,002	282,922	284,923

- $z^{nSFHA} = \mathbb{1}[t \geq 2015] \times (\%nonPrimary_{j,t=2014}^{nSFHA})$
- $z^{SFHA} = \mathbb{1}[t \geq 2013] \times (\%postFIRM_{j,t=2012}^{SFHA})$

▸ Go back