A Additional Tables and Figures

Table A1: MSA Characteristics by Boom Status (2001 Q1)

Group	No Boom (N=179)	Boom (N=88)	Overall (N=267)
Structural Break Size			
Mean (SD)	0.00475 (0.0328)	0.125 (0.0477)	0.0443 (0.0683)
Median [Min, Max]	-0.00641 [-0.102, 0.0647]	0.117 [0.0651, 0.271]	0.0344 [-0.102, 0.271]
SFHA Policy Count			
Mean (SD)	2130 (4860)	13500 (34400)	5870 (20800)
Median [Min, Max]	626 [5.94, 42300]	2220 [27.2, 225000]	884 [5.94, 225000]
Non-SFHA Policy Count			
Mean (SD)	1730 (8020)	5140 (10800)	2850 (9170)
Median [Min, Max]	327 [18.8, 103000]	1240 [76.8, 79000]	515 [18.8, 103000]
Average SFHA Building Coverage (in $1,000s)			
Mean (SD)	78.4 (23.1)	108 (29.5)	88.0 (28.8)
Median [Min, Max]	72.8 [28.5, 158]	108 [48.3, 173]	81.2 [28.5, 173]
Average Non-SFHA Building Coverage (in $1,000s)			
Mean (SD)	106 (26.7)	130 (28.7)	114 (29.5)
Median [Min, Max]	102 [36.4, 185]	130 [67.0, 195]	112 [36.4, 195]
Average Risk Score, All Properties			
Mean (SD)	1.70 (0.560)	2.16 (0.874)	1.85 (0.711)
Median [Min, Max]	1.54 [1.21, 5.79]	1.86 [1.25, 6.74]	1.61 [1.21, 6.74]
Average Risk Score, SFHA Properties			
Mean (SD)	4.71 (1.16)	4.70 (1.56)	4.71 (1.30)
Median [Min, Max]	4.64 [2.39, 8.33]	4.65 [1.52, 8.82]	4.65 [1.52, 8.82]
Average Risk Score, Non-SFHA Properties			
Mean (SD)	1.56 (0.470)	1.89 (0.651)	1.67 (0.558)
Median [Min, Max]	1.43 [1.16, 5.95]	1.68 [1.22, 5.08]	1.48 [1.16, 5.95]
Population			
Mean (SD)	738 (1270)	855 (1290)	777 (1270)
Median [Min, Max]	322 [101, 9380]	386 [125, 9630]	350 [101, 9630]

Source: OpenFEMA policy and claims data, Charles et al. (2019), Bureau of Economic Analysis, FHFA Home Price Index, First Street Foundation, CoreLogic Deeds data

Table A2: Newly Enrolled Policy Count

	Dependent variable: log NFIP policy count			
	All policies		Non-SFHA pre-03	
	OLS	IV	IV	IV
	(1)	(2)	(3)	(4)
log(HPI)	0.356***	0.339***	0.423***	0.319**
	(0.066)	(0.060)	(0.127)	(0.140)
log(Income)				−0.059
				(0.362)
log(Sales)				0.016*
				(0.008)
log(Claims)				0.007***
				(0.001)
Pop. growth				0.070
				(0.672)
Emp. rate				0.784
				(0.764)
Risk × Year indicators	Yes	Yes	Yes	Yes
MSA FE	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes
First-stage F-stat	-	109.16	107.41	35.74
Observations	15,360	15,360	15,360	15,180
Adjusted R^2	0.988	0.988	0.974	0.975

Notes: This table presents OLS and 2SLS coefficients from Equation (**??**). The dependent variables are the IHS-transformed counts of newly enrolled policies in categories indicated in the top panel. The first-stage regressions follow Equation (**??**), and the corresponding F-statistics are reported in the bottom panel. Standard errors (in parentheses) are clustered by MSA. *p < 0.1; **p < 0.05; ***p < 0.01

Table A3: Lagged HPI

	Dependent variable: log NFIP policy count				
	Non-SFHA pre-03				
	(1)	(2)	(3)	(4)	(5)
$\log(\text{HPI}_t)$	0.319**				0.738
	(0.141)				(1.066)
$\log(\text{HPI}_{t-1})$		0.320**			−0.366
		(0.139)			(1.920)
$\log(\text{HPI}_{t-2})$			0.313**		0.137
			(0.136)		(1.824)
$\log(\text{HPI}_{t-3})$				0.299**	−0.097
				(0.132)	(0.956)
Economic controls	Yes	Yes	Yes	Yes	Yes
Risk-by-year Controls	Yes	Yes	Yes	Yes	Yes
MSA FE	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes
Observations	15,180	14,929	14,678	14,427	14,427
Adjusted R^2	0.981	0.981	0.981	0.982	0.982

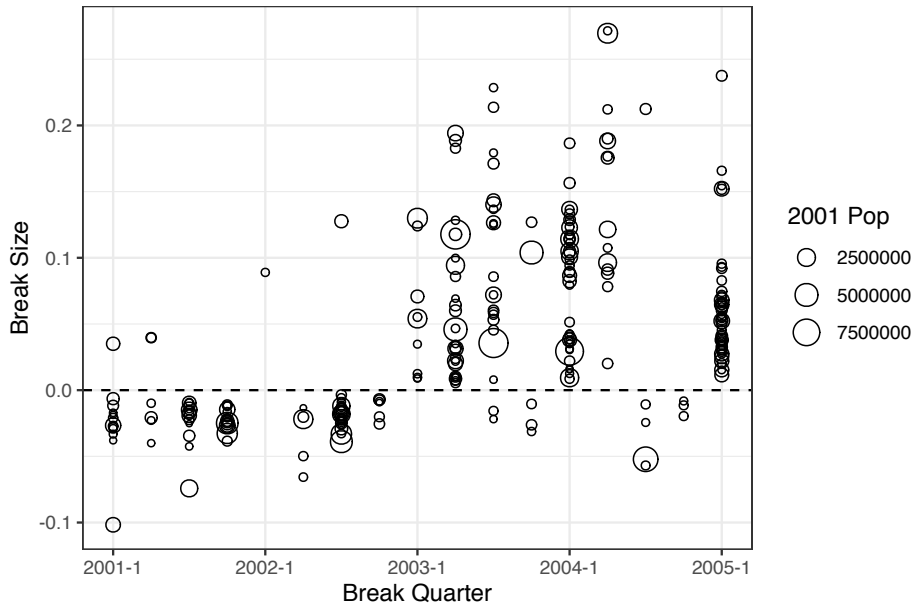
Notes: This table presents 2SLS regressions following Equation (**??**). The outcome variable is the count of policies on structures built prior to 2003 outside the SFHA throughout. Column (1) presents our main estimate using contemporaneous log HPI, whereas columns (2)-(4) use lags of log HPI by 1-3 quarters. Column (5) simultaneously includes the current and the three lags. "Risk × Year indicators" refers to a set of interaction terms between the average risk score in the MSA and indicators for each year. Standard errors (in parentheses) are clustered by MSA. *p<0.1; **p<0.05; ***p<0.01

Table A4: Summary Statistics

Statistic	Mean	St. Dev.	10th Pctile	Median	90th Pctile
Renew (%)	81.99	38.43	0.00	100.00	100.00
Home Purchase Year	2003.2	1.68	2001	2004	2005
Structure Coverage ($1,000s)	219.33	26.28	184.96	225.82	245.46
Loan-to-Value at Purchase (%)	78.05	7.94	68.91	78.56	86.32
Home Price at Purchase ($1,000s)	262.96	122.13	143.85	234.52	423.54
Total Equity ($1000s)	116.21	106.14	6.66	97.04	252.36
Equity-at-Risk ($1000s)	32.28	16.13	5.83	34.80	50.97

Notes: This dataset consists of flood insurance policies active in 2006 that were originated between 2000–2005 on homes built in the same year. Each observation is one renewal decision made by the policyholder between 2007–2012.

Figure A1: Size and Timing of the Structural Breaks



Notes: Each circle represents an MSA. The x-axis displays the quarter of the structural break, and the y-axis displays the size of the break. The size of the circle reflects population size in 2000. The structural break estimates in the above and below figures are from Charles et al. (2018).

Figure A2: Housing Boom Size Across MSAs

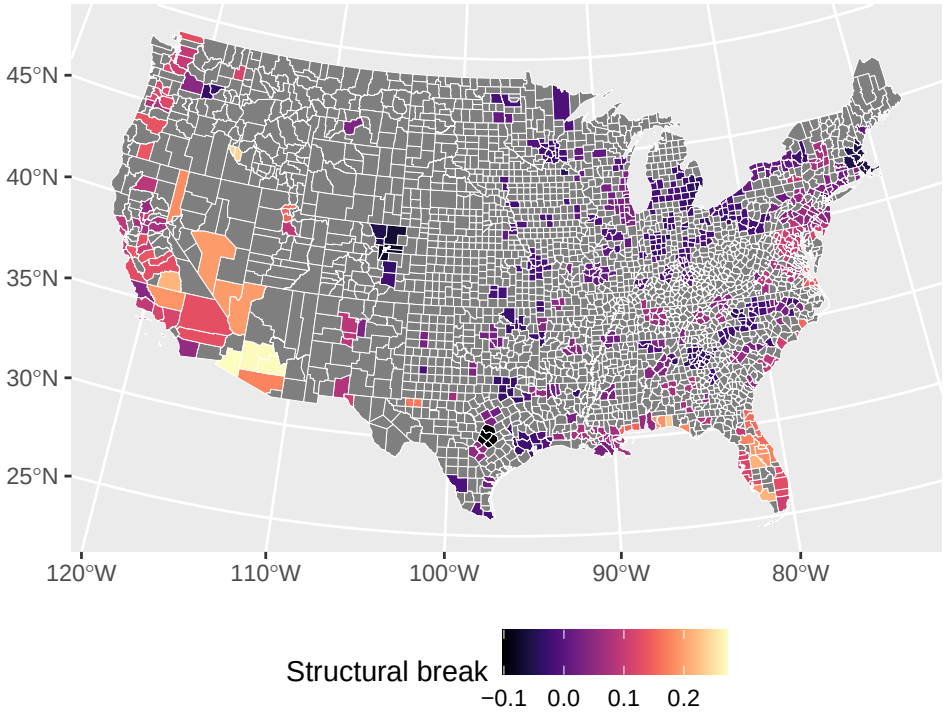
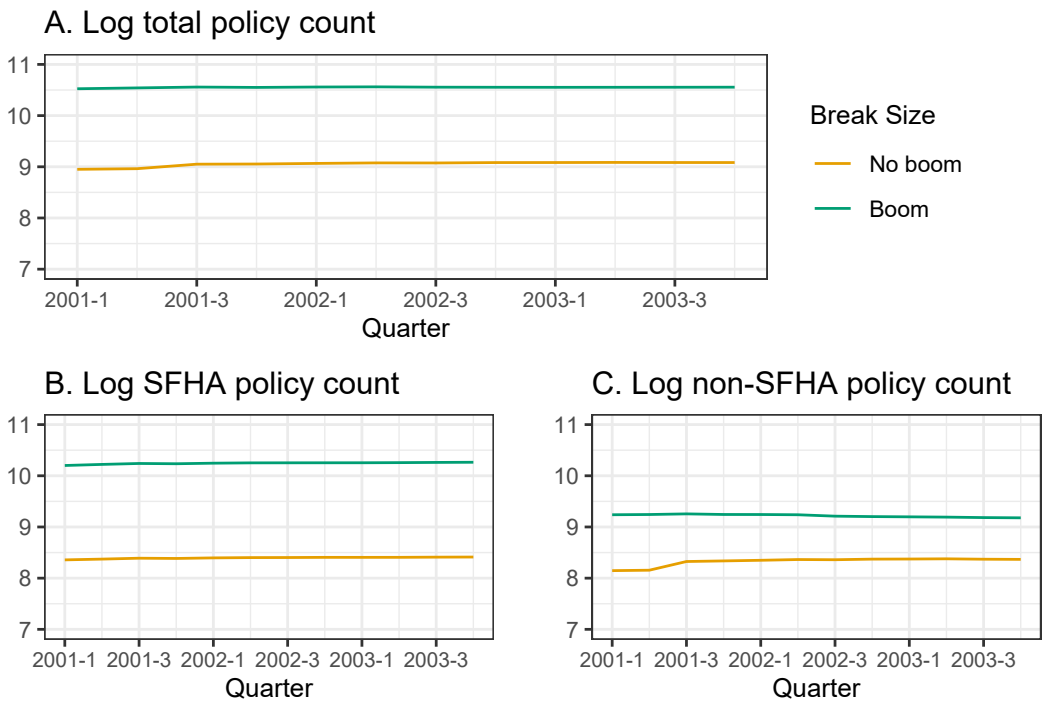
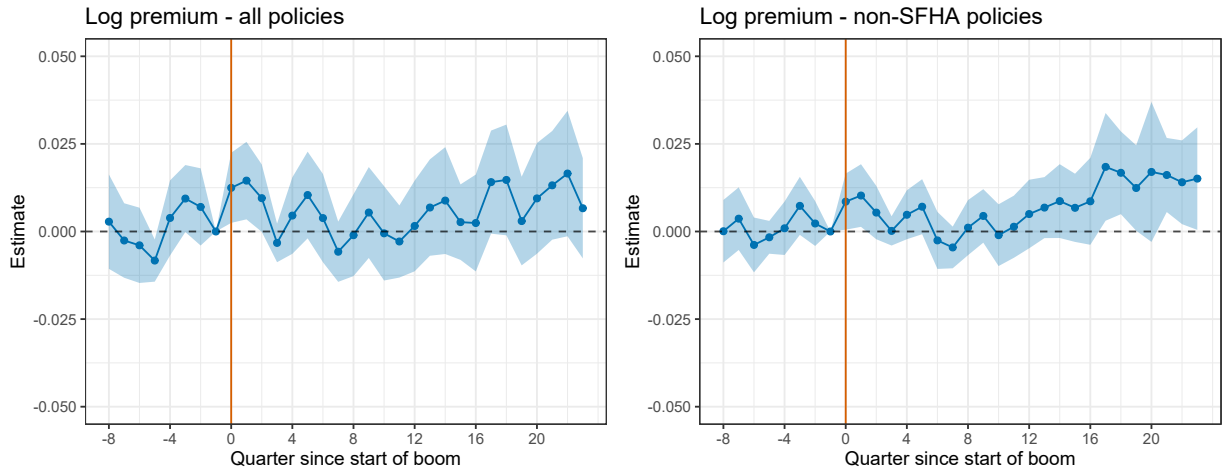


Figure A3: Pre-Boom Trends in NFIP Take-Up by Structural Break Tercile



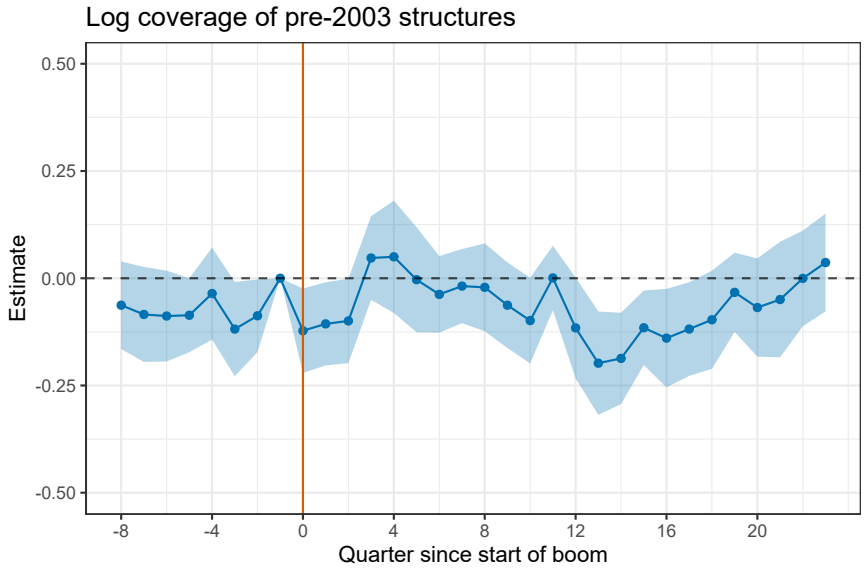
Notes: This figure shows the quarterly time series of NFIP policy in force during 2001–2003 in the raw data. Each color represents one group of MSAs in each structural break tercile. Panel A plots the IHS-transformed total policy count, and Panels B and C plot the IHS-transformed count of SFHA and non-SFHA policies, respectively.

Figure A4: Dynamics of NFIP Premium



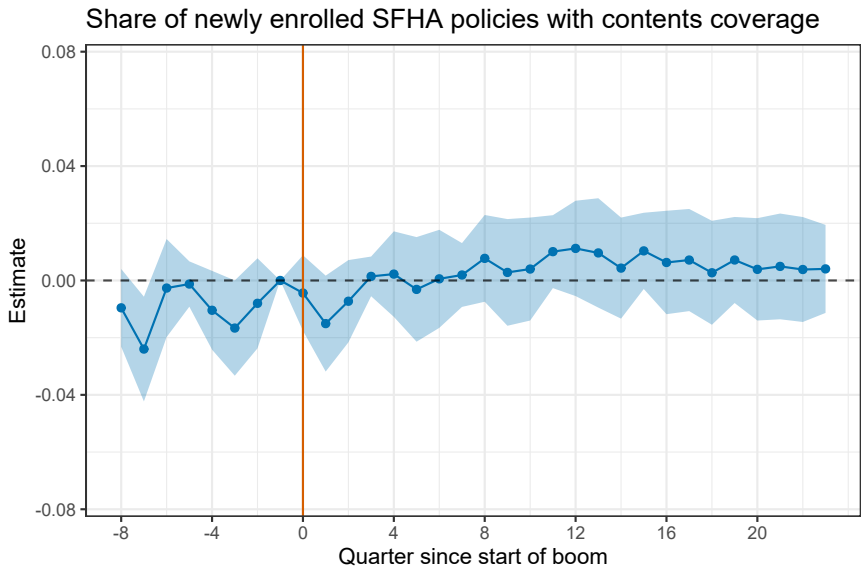
Notes: This figure plots the estimated coefficients and their 95 percent confidence intervals from Equation (**??**) for premium, measured as cost per $100 coverage, of all policies (left panel) and non-SFHA policies (right panel). Both dependent variables are IHS transformed.

Figure A5: Dynamics of Building Coverage



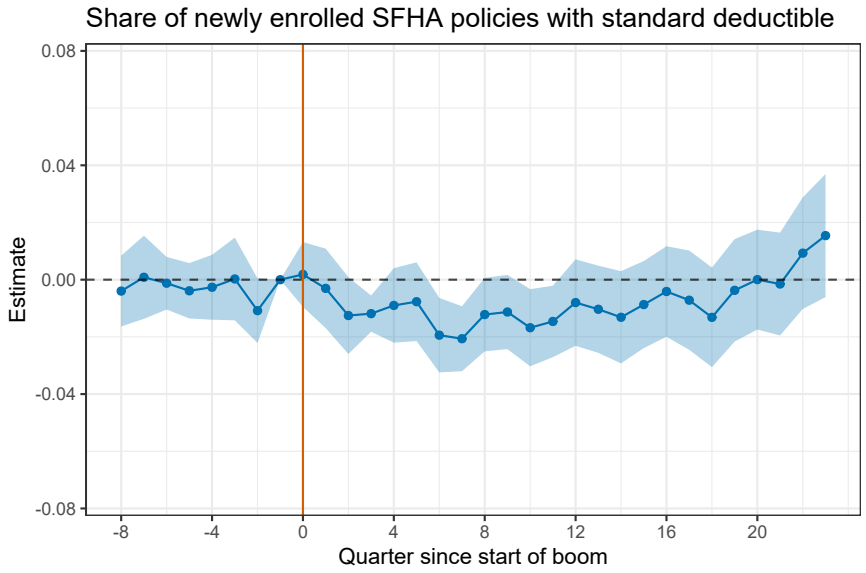
Notes: This figure plots the estimated coefficients and their 95 percent confidence intervals from Equation (**??**) for coverage purchased on flood insurance policies on structures built before 2003. Both dependent variables are IHS transformed.

Figure A6: Dynamics of Contents Coverage



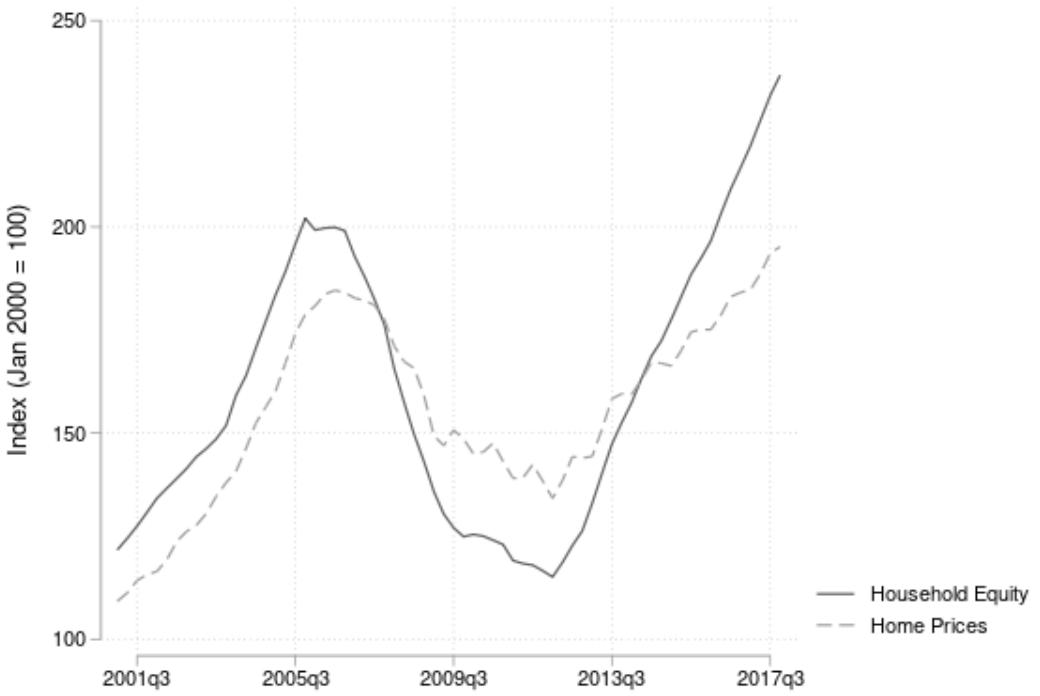
Notes: This figure plots the estimated coefficients and their 95 percent confidence intervals from Equation (**??**) for the share of newly enrolled SFHA policies that include contents coverage.

Figure A7: Dynamics of Deductible Choice



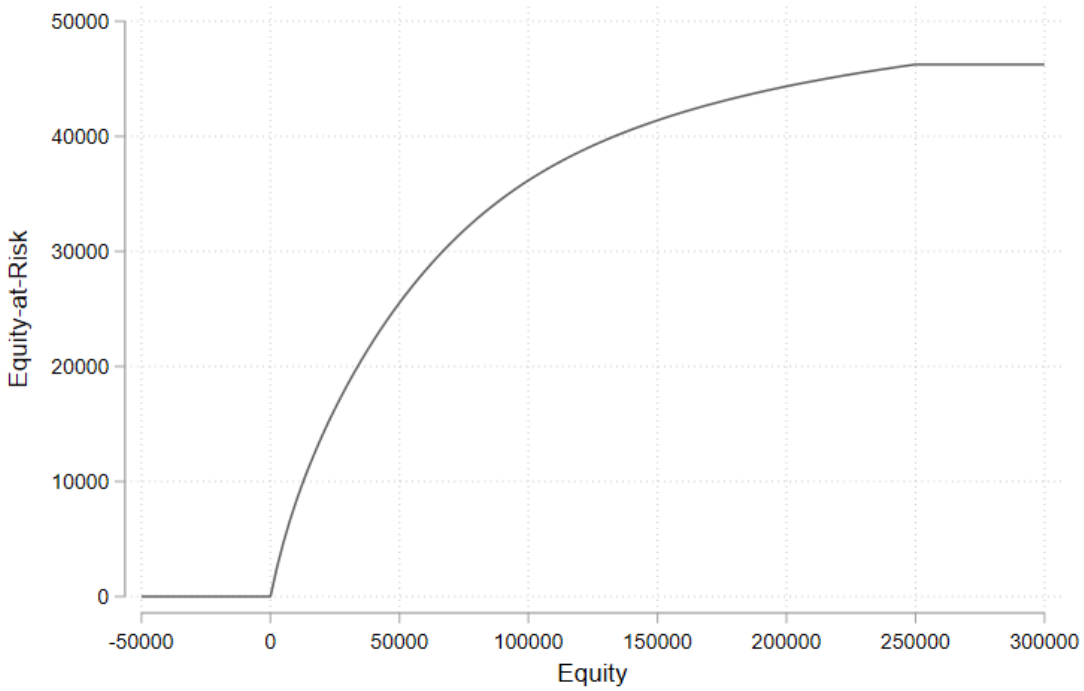
Notes: This figure plots the estimated coefficients and their 95 percent confidence intervals from Equation (**??**) for the share of newly enrolled SFHA policies with the standard deductible.

Figure A8: Home Prices and Homeowner Equity



Notes: This figure plots the household equity (home value minus mortgage debt) and home prices over the sample period.

Figure A9: Relationship Between Equity and Equity-at-Risk



Notes: This figure plots the relationship between equity (x-axis) and equity-at-risk (y-axis) for a Florida home with an insured structure value of $250,000.

B Theoretical Framework

We present a theoretical framework to illustrate the role of home equity in disaster insurance demand. We start by describing a baseline model with no relationship between home equity and willingness to pay for insurance. In this simplified model, because disasters damage a building's structure, the other components of home equity—land value and mortgage debt—have no direct effect on demand.

We extend the model to allow homeowners to default on their mortgage debt rather than pay the repair costs from a disaster. Mortgage default provides implicit insurance to leveraged homeowners and creates a positive relationship between their home equity and flood insurance demand.

B.1 Baseline Model

Consider a single-period model with an agent endowed with a property H. The equity value of H is given by $E_H \equiv L_H + R_H - M_H$, where L_H is the land value, R_H is the structure value, and M_H is the outstanding mortgage debt. We assume the agent starts with positive home equity, or $L_H + R_H \geq M_H$.

The model proceeds in three phases: "pre-disaster," "disaster," and "post-disaster." Pre-disaster, the agent receives income $\overline{W}$ and chooses whether to insure their structure against disaster risk. We consider a single insurance contract covering the full value of R_H with no deductible or copay. Denote the purchase decision by $I = 0, 1$ and the price of the insurance P_I.[1]

In the disaster phase, a disaster occurs with probability p and causes damages to the structure. The potential repair cost L is distributed as follows:

$$\begin{cases} L = r \sim f(r), r \in (0, R_H] & \text{with probability } p, \\ L = 0 & \text{with probability } 1 - p \end{cases}$$

If uninsured, the agent must pay the full cost of L. If insured, L is paid by the insurer.

In the post-disaster period, the agent derives linear utility from wealth and home equity:[2]

$$E_H + \overline{W} - I \cdot P_I - (1 - I) \cdot L.$$

The agent maximizes their expected utility. Assuming $P_I \leq W$, the agent will purchase the insurance if and only if expected utility without insurance is lower than utility with insurance:

$$\mathbb{E}\left[E_H + \overline{W} - L\right] \leq E_H + \overline{W} - P_I. \tag{B1}$$

Clearly, the agent's willingness to pay for insurance, denoted $\widehat{P}$, equals their expected repair costs:

$$\widehat{P} = \mathbb{E}(L). \tag{B2}$$

The agent's valuation of disaster insurance is not affected by their home equity because the agent fully bears the risk to their structure, which is independent of land value and mortgage debt.

[1] In practice, the NFIP caps structure coverage at $250,000. Adding this to the model would not change any of our directional predictions about how home equity affects disaster insurance demand.

[2] We follow much of the insurance literature in defining a utility function over wealth to motivate insurance demand, as in Einav et al. (2010). We abstract away from non-housing assets or risk aversion over home equity because the central point of the model—the directional relationship between home equity and demand for disaster insurance—holds for any weakly concave utility function over wealth.

B.2 Insurance willingness to pay with Mortgage Default

We extend the baseline model to allow the agent to default on their mortgage debt after a disaster. When an uninsured agent defaults, they do not pay repair costs L but forfeit their equity E_H and pay a default cost $\widehat{M}$.

Uninsured agents default when $L \geq \widehat{M} + E_H$. Thus, expected utility without insurance is

$$\mathbb{E}\left[E_H + \overline{W} - \min(L, \widehat{M} + E_H)\right].$$

Setting this expression equal to the agent's utility with insurance, which is unaffected by the default option, we derive the agent's willingness to pay for insurance with default:

$$\widehat{P} = \mathbb{E}\left[\min(L, \widehat{M} + E_H)\right] = \mathbb{E}(L) - \overbrace{p \cdot \int_{\widehat{M}+E_H}^{R_H} \Big(r - (\widehat{M} + E_H)\Big) \cdot f(r)dr}^{\textbf{implicit insurance effect}} \tag{B3}$$

The key difference between Equation (B3) and Equation (B2) is the "implicit insurance effect" of default that is subtracted from expected repair costs. The willingness to pay specified in (B3) is strictly less than that in (B2) when the probability of disaster-induced default is nonzero.

Further, we can derive how $\widehat{P}$ changes with respect to E_H:

$$\frac{d\widehat{P}}{dE_H} = p \cdot \Big(1 - F(\widehat{M} + E_H)\Big) > 0. \tag{B4}$$

where $F(\cdot)$ is the cdf of the disaster damages function. This expression shows that the marginal effect of equity on the agent's value of insurance is given by the likelihood of getting a damage level that is high enough for the homeowner to default. Intuitively, the default option provides the agent with a form of informal insurance with a deductible equal to the agent's equity plus default costs. As home equity increases, the loss from defaulting grows, and the value of this implicit insurance becomes less compared to that of formal insurance.

C Estimation: Long Difference

To separately examine the changes in flood insurance take-up over the course of the housing boom and bust, we use the long-difference approach following Charles et al. (2018). They show that the structural breaks not only predict the housing boom during 2000–2006 but also the size of the bust during 2007–2012.

For the boom period, we instrument housing price change from 2002 to 2007 using the structural breaks:

$$\Delta_{boom} lnNFIP_m = \beta_0 + \beta_{FD} \Delta_{boom} \widehat{lnHPI} + \delta' \Delta_{boom} X_m + \varepsilon_m. \tag{C1}$$

Here, Δ_{boom} represents the change in the variable between 2002 Q1 and 2007 Q1, which we apply to all variables in the original regression. We also directly control for the risk score. Our key regressor is the change in log housing price index ($\Delta lnHPI$), which we instrument with the break size instrument. The coefficient β_{FD} is the long-difference estimate of how housing price changes during the boom affect flood insurance take-up. The corresponding reduced-form regressions take the form

$$\Delta_{boom} lnNFIP_m = \alpha_0 + \alpha_{FD} \Delta P_m + \gamma' \Delta_{boom} X_m + u_m, \tag{C2}$$

where we regress the first difference in NFIP policy count directly on the structural break size and the same set of long-differenced covariates.

For the bust period, we augment the above specification by adding an interaction term between the housing price change and an indicator for whether the building was built between 2003 and 2005. These homes, which we call the "boom cohort", are likely to see close to zero or negative equity during the bust and hence be most subject to the risk shifting mechanism. The regression takes the following form:

$$\begin{aligned} \Delta_{bust} lnNFIP_m = &\beta_0 + \beta_{FD} \Delta_{bust} \widehat{lnHPI} + \beta_{FD,BC} \Delta_{bust} \widehat{lnHPI} \times 1(BoomCohort) \\ &+ \delta' \Delta_{bust} X_m \times 1(BoomCohort) + \varepsilon_m. \end{aligned} \tag{C3}$$

Here, Δ_{bust} represents the change in the variable between 2007 Q1 and 2012 Q1, which we apply to all variables in the original regression. We also include an additional control of the share of foreclosures among home sales.

References

Charles, K. K., E. Hurst, and M. J. Notowidigdo (2019). Housing booms, manufacturing decline and labour market outcomes. *The Economic Journal 129*(617), 209–248.

Charles, K. K., E. Hurst, M. J. Notowidigdo, et al. (2018). Housing booms and busts, labor market opportunities, and college attendance. *American Economic Review 108*(10), 2947–2994.

Einav, L., A. Finkelstein, and J. Levin (2010). Beyond testing: Empirical models of insurance markets. *Annual Review of Economics 2*(1), 311–336.