Pricing Adaptation in the National Flood Insurance Program*

Bo-Yeon Jang and Jiayue Zhang

Abstract

Flooding risks have a profound impact on the housing market, but existing measures of the flood zone discount are often underestimated due to market valuation of insurance-mandated adaptation. This paper leverages quasi-experimental variation in adaptation mandated by the National Flood Insurance Program (NFIP) to examine how housing prices capitalize building adaptation. NFIP regulatory floodplain map updates affect property values by simultaneously providing a coarse signal of flood risk, while requiring higher construction standards. Exploiting the granular boundary variation in flood map updates, we isolate the valuation of flood-adapted homes and document an adaptation premium of 3.8%. The effect is robust to rich geographic and amenity controls, suggesting that housing markets capitalize the cost of climate adaptation through insurance requirements, which is previously overlooked by the flood discounts. Because this premium falls below typical retrofitting costs, it is unlikely to drive voluntary adoption of flood adaptation measures in existing properties.

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1 Introduction

From superstorms to rising sea levels, the possibility of catastrophic flooding continues to rise with climate change. The National Flood Insurance Program (NFIP) serves as a public safety net and insurer of last resort against this threat for millions of homeowners in the United States. The program's insurance offerings are purposefully linked to incentives for community adoption of mitigation and adaptation measures, which are governed by regulatory floodplain maps that demarcate regions with elevated flooding risk. Properties located in such areas are, on one hand, subject to higher insurance premiums and a coarse but clear signal of elevated risk, and on the other hand, more likely to be flood-adapted due to stricter building regulations. These effects are commingled in an overall "flood-zone discount", lowering market valuation of homes within the floodplain. While these floodplain maps have been decoupled from insurance premium rates by recent reforms, they remain relevant for building regulations, insurance mandates, and information disclosures.

Given the importance of home ownership for generational wealth in the United States and the increasing potential for catastrophic flooding, examining these underlying effects remains important for understanding not only the impact of the NFIP, but also market responses and demand for mitigation measures. We therefore examine the market valuation of minimum construction standards enforced within the floodplain by the NFIP, which has implications for the provision of more resilient housing in areas that may become flood-prone in the future. To isolate this effect, we build on a robust literature exploiting updates to floodplain extents over time in combination with NFIP regulations around remapped properties.

While the redrawing of floodplain maps provides a meaningful signal for risks given updated risk profiles, flood risk is not discontinuous and it is reasonable to assume

parcels within close enough distance to the boundary on either side are comparable in both risk and amenity profile, controlling for elevation. We therefore restrict our analysis to residential properties within 100 meters of the floodplain extents in both 1998 and 2012, regardless of floodplain status. Drawing from comprehensive compilations of public real estate records by ATTOM Data Solutions, we establish a sample of housing market transactions spanning 2001 to 2011 for five U.S. Atlantic or Gulf states without real estate nondisclosure laws: Alabama, Florida, Georgia, North Carolina, and South Carolina.[1]

Because we seek to evaluate the market-based valuation for flood adaptation imposed on properties that were built in the floodplain, our treatment variable proxies for floodplain status at construction through floodplain status in 1998. However, properties in the floodplain are subject to a bundle of NFIP regulations. To parse out other effects, we limit our comparison to properties that were built in the floodplain but were mapped out, versus properties that were built outside the floodplain and have remained outside through the study period.

As both groups are outside the floodplain at the time of sale, there is no difference in the insurance mandate, flood risk disclosure, or insurance premium regime. This leads to a clean identification of the adaptation value. Through this methodology, we document a nontrivial premium for flood-adapted property. Our estimates suggest a willingness to pay of 3.8% of the sale price, which may have attenuated attempts to estimate the flood risk discount. However, the costs of flood adaptation exceed its magnitude; it is unlikely that this premium can drive voluntary increases in the stock of flood-adapted housing.

The National Flood Insurance Program and its effects continue to be actively explored in the literature. We build on work exploring the capitalization of general

[1]Accessed through the Dewey Data platform.

flood risk and climate risk in the real estate market, often leveraging delineations of flood risk provided by flood maps. Bakkensen and Barrage (2022) make use of transaction-level data from Florida in a discrete-choice residential sorting model to find a marginal willingness to pay to avoid being in SFHAs of 5.8% of average housing prices as well as evidence of sorting by minority and low-income groups into SFHAs. They also suggest increases in welfare arising from new information gained by flood map updates. Gibson and Mullins (2020) examines the price effects of floodplain map updates as well as Hurricane Sandy and the insurance premium increases from NFIP regulation changes on subjective perceptions of annual flood probability. Using a hedonic differences-in-differences approach with initial flood map issuance dates, Georgic and Klaiber (2022) instead estimate the average capitalized value of subsidies to be $11,807. Hennighausen et al. (2023) likewise examines how such reforms affected both insurance takeup and the housing market.

Numerous studies estimate the reduction in housing prices from being placed in the floodplain, which is referred to as "the flood zone discount" and attributed to the information on risk contained by flood maps, to be between 5% and 20% by utilizing data from small specific regions (e.g., Bin and Landry, 2013; Shr and Zipp, 2019; Indaco et al., 2019). Hino and Burke (2021) extended the geographical coverage of this analysis to include much of the United States; their preferred specification yielded an estimate of about 2%. Since then, this approach has been increasingly favored by economists examining various aspects of the NFIP. Pollack et al. (2023), Gourevitch et al. (2023), and Weill (2023) each exploit updates to floodplain maps to examine information effects, risk valuation, and policy takeup.

Mulder (2024) leverages the Newly Remapped Subsidy to separate out the information effect of reclassification from the price effects of increasing insurance premiums in flood insurance uptake. He also makes use of reclassified homes to estimate

the effect of adaptation (referring to compliance with NFIP building requirements in floodplains) on flood insurance claims; we echo his work on disentangling the bundled effects of this program in the context of home prices. However, our analysis builds on the work of Wagner (2022) and Ostriker and Russo (2026) to examine the effect of existing adaptation measures in structures built under the NFIP floodplain standards on property valuations, rather than backing out subjective flood probabilities. Here, our contribution lies in parsing the bundle of policies that drive the overall flood zone discount to identify the valuation of mandated building adaptation measures in the floodplain. In doing so, we provide new evidence of a nontrivial flood adaptation premium that nonetheless falls short of costs.

The rest of this paper is organized as follows. Section 2 provides relevant exposition on the NFIP; Section 3 describes the data; Section 4 lays out the empirical strategy; Section 5 presents and discusses the main results; Section 6 concludes.

2 The National Flood Insurance Program

The NFIP was created by the National Flood Insurance Act of 1968 in response to a dearth of private insurance willing to cover flooding disasters following a series of devastating floods in the 1960s (Michel-Kerjan, 2010). Managed by the Federal Emergency Management Agency (FEMA), the NFIP has two mandates: to provide affordable flood insurance to homeowners and to manage the overall risk of flooding in the United States through mitigation and adaptation measures. To this end, the NFIP generates information on flood hazards that are synthesized into public flood maps, underwrites the main source of flood insurance in the United States, ensures standards and regulations put in place to mitigate flood risk, and provides funds for further adaptation measures. Over 5 million policies were provided in 22,000 communities

by the NFIP in 2021, overshadowing the limited private insurance alternatives now available (Horn and Webel, 2022).

The program functions through local partnerships: community units, which are defined by FEMA as political entities that have "the authority to adopt and enforce floodplain ordinances for the area under their jurisdiction" and tend to be smaller than counties, must opt into NFIP participation for their residents to be able to buy flood insurance and gain access to community development funds. In return, the community adopts and enforces the floodplain management standards laid out by FEMA. These standards impose restrictions and increase requirements for development within risky areas identified as Special Flood Hazard Areas (SFHAs).

SFHAs are drawn by FEMA in partnership with the local community in floodplain maps known as Flood Insurance Rate Maps (FIRMs), due to their usage in determining insurance rates. Buyers of homes within these SFHAs in participating communities are also required to purchase flood insurance in order to have a federally backed mortgage. Compliance with this requirement, which is enforced by lenders, was estimated to be around 75 to 80% overall in 2006, with the Northeast and Midwest having considerably lower rates (Dixon et al., 2006). Following the Flood Disaster Protection Act of 1973, communities whose FIRMs have been drawn to include SFHAs must join the NFIP within a year or be subject to sanctions that restrict access to both flood insurance and disaster assistance.

The minimum standards required for development within the SFHA of participating communities have remained constant since the mid-1970s (International Code Council and Federal Emergency Management Agency, 2019).[2] All such construction requires permits, encroachment reviews, anchoring, usage of flood-resistant material,

[2]The relevant regulations can be found in 44 C.F.R 60.3 (2026), which cites 41 Fed. Reg. 46975 (1976).

water and sewage systems that minimize floodwater infiltration, and elevation of the lowest floor to at least the base flood level (Federal Emergency Management Agency, 2005).[3] Excluding the elevation requirement, these are performance standards; practical implementation will vary but usually reference external building codes such as the American Society of Civil Engineers standard *Flood Resistant Design and Construction* (Ingargiola et al., 2013).

Private companies may conduct the day-to-day servicing of NFIP insurance policies, but all underwriting is done by the U.S. government. Coverage is limited to a maximum of $500,000 for residential building coverage. The rating structure for premiums did not fundamentally change from the establishment of the NFIP to mid-2021: the flood zone status, occupancy type, height above the base flood elevation, and the presence of basements or elevated structures were used to classify structures into national risk rating groups that determined the premium (Horn, 2022).

Subsidies allowed insurance to be provided at prices lower than the actuarial rate of the risk rating group in certain cases. Buildings that were built before the first FIRM was mapped enjoyed a lower rate in order to incentivize participation. Administrative grandfathering allowed post-FIRM buildings reclassified by map updates to purchase policies using the old FIRM's zone and base flood elevation if the building had been "constructed in compliance with the FIRM in effect at the time of construction" and remained unaltered; this did not require continuous coverage (National Flood Insurance Program, 2009). The NFIP generally broke even before 2005 with revenues from the sale of insurance, but since then has had to borrow significant sums in the wake of several devastating hurricanes and remains heavily indebted to the U.S. Treasury.

[3]The lowest floor includes basements but not parking or storage areas; such areas are required to have a prescribed number of openings for floodwater exit. Construction in the highest-risk zones is subject to additional elevation requirements.

On July 6, 2012, months before Hurricane Sandy, the Biggert-Waters Flood Insurance Reform Act (BW 2012) phased out the pre-FIRM subsidy and eliminated the practice of grandfathering. Grandfathering was restored in the subsequent Homeowner Flood Insurance Affordability Act of 2014 (HFIAA 2014), and the phasing out of pre-FIRM subsidies was slowed to 18% per year. The Newly Mapped Subsidy was also introduced, providing structures that are mapped into an SFHA after April 2015 with premiums in line with their previous risk rating that rise in subsequent years to the full risk rating premium; this is the procedure used instead of grandfathering when structures are moved into the SFHA. In October 2021, Flood Risk Rating 2.0 was introduced to calculate insurance premiums based on the average annual loss, the uncertainty in loss estimates, and expenses rather than floodplains (Horn, 2022). The SFHA remains relevant for floodplain management regulations such as the mandatory purchase requirement and minimum building standards; we seek to examine the effect of the latter.

3 Data

Our analysis brings together data from various sources and spatial scales. We limit the geographic scope of our analysis to 5 states bordering the Gulf of Mexico or the southern Atlantic: Alabama, Florida, Georgia, North Carolina, and South Carolina.[4] Housing transactions and characteristics are sourced from ATTOM Data Solutions, which provides comprehensive compilations of public real estate records.[5] From its Recorder dataset, we extract sales price, recording and instrument date, mortgage information, and transaction details for deed transfers (Attom, 2025a). We restrict

[4]We exclude Louisiana, Mississippi, and Texas due to the presence of real estate nondisclosure laws, which affect availability of sales price data.

[5]All data were accessed through the Dewey Data platform.

the sample to single-parcel arm's-length transfers likely to reflect conventional real estate transactions.[6] The transaction date of each record equals the instrument date if available and recording date if not. Following the literature, we exclude transactions with sale prices below $1,000 or above the 99th percentile by state in sales price, area, or elevation. For parcels in this sample, we link lot and building area, bedroom and bathroom count, parcel-centroid coordinates, census tract, and built year from the Tax Assessor dataset reflecting the most recent assessment record (Attom, 2025b). The sample is further restricted to parcels larger than 100 square feet with known parcel-centroid coordinates that are coded as single-family residential units.

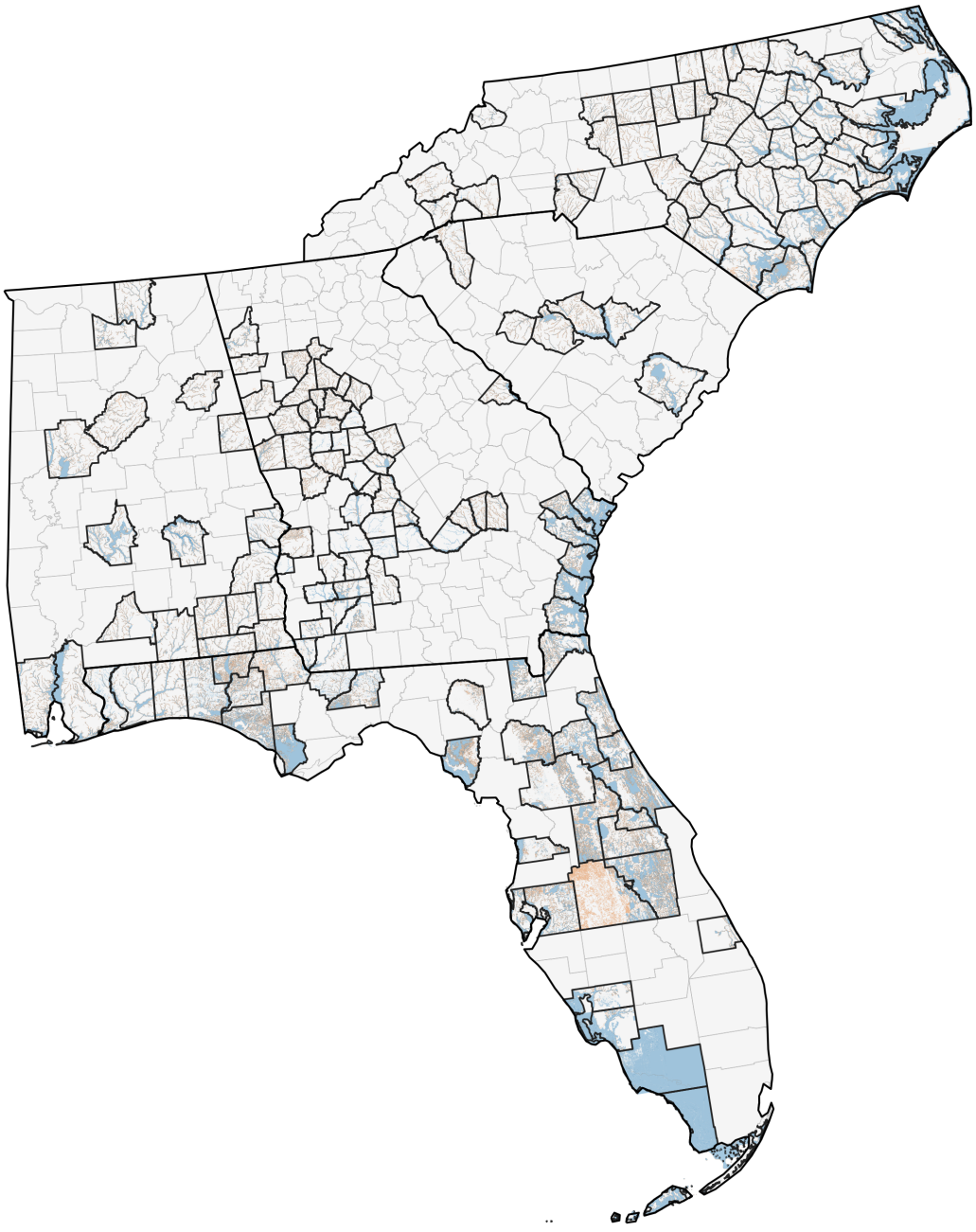
Our study period spans 1998 to 2011.[7] We drop all parcels with effective build years after 2011, which indicate either new buildings or renovations. The first available digitized flood maps come from the FEMA Q3 Database, which Hino and Burke (2021) describe as updated to 1998. Once large-scale digitization of flood maps took place, digital FIRMs were collected in the National Flood Hazard Layer data product and updated in real time. FEMA does not create or store historical versions of the NFHL, but Weill (2026) has conducted extensive archival work to reconstruct yearly snapshots from 2012. We use the Q3 floodplain extents from Hino and Burke (2021) and the 2012 snapshot from Weill (2026) to bookend our study period and identify changes in the SFHA within this time, keeping only counties that appear in both datasets. Figure 1 depicts the counties in this sample.

While floodplain maps were updated piecemeal through this period, we do not have data on intermediary changes. We follow previous studies in assuming that the Q3 maps were valid from their stated effective date until the earliest recorded map update, and that features in the NFHL 2012 snapshot were in effect from the latest

[6] This excludes quitclaims, foreclosures, and documents not coded as deed transfers.

[7] Although records date as far back as 1900, there is "relatively poor coverage of the property data prior to 2000 and in certain so-called disclosure states" (Kermani and Wong, 2026).

Figure 1: Sample of Q3 and NFHL Floodplain Extents



Note: This map plots the floodplain boundaries in the 1998 Q3 SFHA and the 2012 NFHL SFHA for counties that appear in both snapshots within Alabama, Florida, Georgia, North Carolina, and South Carolina.

recorded map update to 2012; transactions that occur for parcels between updates are removed. To estimate the dates of the earliest and latest map revision for each parcel, we first match parcels to the NFIP community they belong to as well as every panel they may have been subject to using centroid coordinates and the panel and community boundary layers from the NFHL.[8] A parcel may be matched with multiple panels, but only one community. For each panel, we note the first and last revision dates between 1998 and 2012 extracted from the catalog of panels from the NFIP Map Service Center as well as the dates provided in the NFHL layer. We further link the parcel to the census-tract effective dates for the first digital FIRM and the DFIRM available by 2019 compiled by Weill (2026) if they occur within that window of time. The first update is considered to be the earliest date and the final update before 2012 the latest across these effective dates.[9]

Parcels are considered flood-adapted if constructed within the SFHA after the initial FIRM is established. The effective date of each community's FIRM can be found in the NFIP's Community Status Book. This dataset includes not only the current participation status of each community in the NFIP, but also records historical dates such as date of entry into the NFIP regular program and the date of the initial FIRM. We exclude transactions from communities that are indicated to be sanctioned, suspended, or not participating in the NFIP. Pre- and post-FIRM dummies are generated for each parcel by comparing the effective built date to the initial FIRM date from the Community Status Book. If the building was built in the same year as the initial FIRM, we classify it as a pre-FIRM building in accordance with NFIP policy.

Elevation is a strong determinant of flood risk, but our data unfortunately do

[8]These layers are taken from a 2022 vintage of the NFHL as they are not available for 2012.
[9]Parcels that remain without revision dates after this process are dropped.

not include either the elevation of the land or the building foundations. We instead assign elevation using the Digital Elevation Model rasters in the National Map 3DEP Downloadable Data Collection (U.S. Geological Survey, 2024). The data takes the form of 1 degree by 1 degree tiles containing elevation information at the 1/3 arc-second resolution (around 10 meters), which we assign to each parcel using the parcel-centroid coordinates. We further construct binned distances to streams or rivers using the National Hydrography Dataset (U.S. Geological Survey, 2025) as well as to primary and secondary roads using 2012 state-level shapefiles from the TIGER/Line database (US Census Bureau, 2012).

4 Methodology

Our identification strategy leverages changes in the floodplain extents drawn on digitized FIRMs across the United States in a limited sample designed to isolate the capitalization of flood adaptation from higher building standards. We opt for a boundary-matching design that uses the 1998 floodplain extents as the determinant for which of the homes close but not in the floodplain are treated with flood adaptation.

To ensure comparability between treated and control groups, we first limit our sample to properties within 100 meters of either side of the boundaries in both the 1998 and 2012 floodplain extents.[10] Revisions in flood maps may represent either corrections of misidentified areas of risk or tangible changes in risk, for example through erosion. Because of this, comparing properties moved into or out of the boundary with those with unchanged status may not provide clear identification. However, it is reasonable to assume flood risk tends to be continuous and does not

[10]The buffer size of 100 meters—a little less than 330 feet—is well within the range used in this literature: Pollack et al. (2023) uses 1,000 feet and Ostriker and Russo (2026), 100 feet.

diverge dramatically in the neighborhood of the floodplain boundaries. Properties located near the SFHA boundary in both the old and new floodplain maps are likely to be comparable, particularly if land elevation is accounted for.

We next consider the potential effects from NFIP regulations bundled in the SFHA status. Currently being inside the SFHA assigns a signal of elevated flood risk and the requirement to carry flood insurance for homeowners with a federally backed mortgage. Insurance premiums were higher inside the SFHA if the property was built in the SFHA after the community's initial FIRM came into effect, but not otherwise.[11] A property currently outside the SFHA is subject to neither the information effect, the insurance mandate, nor the higher premium.

While these effects depend on current SFHA status, whether a property would have been subject to stricter building standards depends on SFHA status at the time of construction. A property built in the SFHA is likely to be "flood-adapted" to meet NFIP requirements, provided that construction began after the initial FIRM. Because "pre-FIRM" buildings constructed prior to the first flood maps are not treated in this way, we exclude them from the analysis sample. We then take the SFHA status assigned by the FEMA Q3 Database to indicate treatment for being flood-adapted. In doing so, we assume that the database is a good proxy for the floodplain extents of the initial FIRM; while data constraints necessitate this assumption, we acknowledge that it may not hold especially for early entrants into the NFIP.

Table 1 depicts the NFIP bundle determined by the interaction of the initial and current SFHA status, which in our data are represented by the 1998 Q3 and 2012 NFHL floodplain extents. Comparing parcels that are currently in the SFHA against those that are currently out leads to estimates reflecting the effects of more than one

[11] This is due to administrative grandfathering for properties moved into the SFHA, which was in force until BW 2012.

regulation. However, homes built in the SFHA and then mapped out of the current SFHA retain the flood adaptation while no longer subject to the other regulations. The effect of flood adaptation can be isolated using a control group of "always-out" properties that are otherwise similar in characteristics and risk. We believe this is a plausible assumption, considering the restriction of our sample to properties within 100 meters of both floodplain extents and the fact that both groups are classified as out of the SFHA by 2012. This means our sample is further limited to transactions of properties near but outside of the 2012 SFHA, with 1998 SFHA status providing the treatment indicator. To maintain comparability, we keep only transactions that occur after the property's most recent floodmap revision date, regardless of treatment status; this leads to our sample containing only sales from 2001 to 2011.

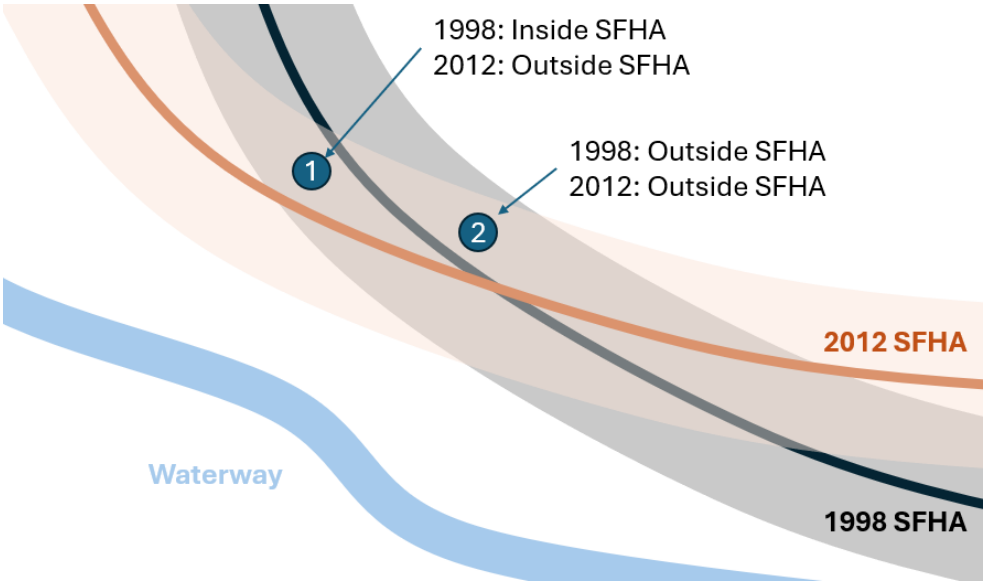
Table 1: Bundle of Regulations by SFHA Status

		Current SFHA Status	
		In	**Out**
Initial SFHA Status	**In**	Flood Adaptation Higher Premium Information Insurance Mandate*	Flood Adaptation
	Out	Information Insurance Mandate*	

Note: This table depicts the NFIP regulations in place by initial and current SFHA status for post-FIRM properties before BW 2012. Flood Adaptation refers to the property having been built to meet stricter requirements; Information refers to the signal of elevated flood risk provided by being in the SFHA; and Higher Premium refers to the increase in rate from the baseline lower rate outside the SFHA. *Insurance mandate applies to homeowners with federally backed mortgages.

We illustrate this identification strategy in Figure 2. The gray shaded area represents the 100-meter buffer around the 1998 SFHA boundary in black; this serves as our proxy for the initial FIRM. The orange shaded area represents the 100-meter buffer around the 2012 SFHA boundary, drawn in thick orange. Our analysis sample is restricted to properties located in the overlap between the two buffers. The 1998 SFHA extended from the waterway in blue to the boundary in black, while the 2012 SFHA extended from the waterway to the boundary in thick orange. Point 1 is inside the 1998 SFHA but outside the 2012 SFHA, representing the top right quadrant of Table 1. Point 2 represents the bottom right quadrant of always-out properties.

Figure 2: Identification Strategy



Note: The gray shaded area represents the 100-meter buffer around the 1998 Q3 SFHA boundary, drawn in black; the orange shaded area represents the 100-meter buffer around the 2012 NFHL SFHA boundary, drawn as the thick orange line. The SFHA for each vintage extends from the waterway, in blue, to the drawn SFHA boundary. Point 1 is a property that was in the 1998 Q3 SFHA but has been mapped out of the SFHA by 2012, while point 2 was built and remained outside the SFHA.

Comparing point 1 to point 2 yields an estimate of how flood adaptation through the SFHA building requirements is capitalized in property valuation. We estimate

the following specification following the hedonic literature:

$$\ln(p_{ict}) = \beta \text{In 1998 SFHA}_i + \gamma Z_i + \psi_{ct} + \epsilon_{ict}$$

$\ln(p_{ict})$ indicates log prices for house i in cluster c at year t. In 1998 SFHA_i indicates whether the property was built in the SFHA and therefore is flood-adapted, and Z_i is the vector of house characteristics (effective building year, log lot size, log living area, bedroom count, bathroom count, cubic spline of elevation, and distance to stream or river, primary roads, and secondary roads). The cluster is defined as either the community or the 1998 FIRM panel containing the property, used to cluster standard errors and construct cluster-year fixed effects ψ_{ct}; we show results using each.

5 Results

Our analysis sample comprises more than 36,000 sales transactions in 314 NFIP communities. Table 2 presents summary statistics by treatment for pre-treatment parcel characteristics such as elevation, log lot area, and distance to geographic features in Panel A, which we test for covariate balance. Panels B and C provide descriptive statistics for building characteristics and the outcome variable. We follow Imbens and Rubin (2015) in assessing balance with standardized differences.[12] The magnitude is modest for all pretreatment variables except for elevation at 0.277.[13] Figure A1 illustrates that the distributions are similar in shape and support; this difference reflects the tendency of properties originally mapped in the floodplain to be lower in elevation. We therefore control for elevation as a cubic spline.

[12] T-tests would be uninformative given the large sample.

[13] Caetano and Callaway (2024) state that "standardized differences of around 0.1 or smaller are typically considered small differences, standardized differences around 0.3 are medium/important differences, and standardized differences of 0.5 or larger are considered large differences".

Table 2: Baseline Characteristics of Lots and Buildings

	All	Out of 1998 SFHA	In 1998 SFHA	Std. Diff.
	(1)	(2)	(3)	(4)
A. Pre-Treatment Covariates				
Elevation (m)	75.34	80.55	53.79	0.277
	(103.00)	(106.00)	(86.20)	
Ln(Lot Area)	9.29	9.28	9.34	-0.083
	(0.83)	(0.84)	(0.79)	
Distance to stream/river				
0 - 100m	3.0%	2.9%	3.5%	0.078
100 - 500m	9.1%	9.4%	7.5%	
500m+	87.9%	87.6%	89.0%	
Distance to primary road				
0 - 100m	0.1%	0.1%	0.1%	0.044
100 - 500m	2.1%	2.2%	1.6%	
500m+	97.8%	97.7%	98.3%	
Distance to secondary road				
0 - 100m	3.4%	3.6%	2.6%	0.089
100 - 500m	18.1%	18.6%	16.2%	
500m+	78.5%	77.8%	81.2%	
B. Building Characteristics				
log(Living Area)	7.54	7.54	7.54	
	(0.37)	(0.38)	(0.36)	
# Bedrooms	2.97	2.93	3.09	
	(1.27)	(1.30)	(1.13)	
# Bathrooms	2.53	2.54	2.52	
	(0.88)	(0.89)	(0.85)	
Effective Year Built	1998	1998	1998	
	(8.27)	(8.32)	(8.10)	
C. Outcome				
log(Price)	12.02	12.01	12.05	
	(0.71)	(0.72)	(0.70)	
Observations	36,891	29,714	7,177	

Notes: This table reports balance for pre-treatment covariates on lot characteristics (Panel A), building characteristics post treatment (Panel B), and housing prices post treatment (Panel C). Std. dev. in parentheses. Column (4) reports standardized mean differences between treated (3) and control (2) sample for pre-treatment covariates (Imbens and Rubin, 2015).

Table 3 displays our baseline estimates. Here, the coefficient of interest is that of the treatment dummy variable "In 1998 SFHA", which indicates whether the property being sold was within the 1998 SFHA and is a proxy for having been built with flood-adapted features. In the first three columns, we include community-by-year fixed effects and cluster standard errors at the community level. Column 1 regresses log price on treatment and elevation controls, while Column 2 controls for the amenity value of observable building characteristics and Column 3 incorporates controls for distance to waterways, primary roads, and secondary roads. Columns 4 to 6 follow the same pattern, but control for 1998 FIRM panel-by-year fixed effects and cluster standard errors at the 1998 FIRM panel level.

Across all columns, we find a statistically significant premium for the treated properties; our preferred specification of Column 6 yields a premium of 3.8%, with a 95% confidence interval of $[2.00\%, 5.76\%]$. Taking the ratio of the treatment coefficient to that of the log living area suggests that this premium is equivalent to increasing the living area by 4.5%. In dollar terms, the premium amounts to \$8,060 for the average home, or \$4 per square foot.[14] This estimate reflects willingness to pay for flood-resistant construction features required by the NFIP in SFHAs. Because we limit our sample to properties that face similar underlying flood risk but are no longer within the SFHA, we isolate the valuation of this flood adaptation from insurance price effects or flood disclosures, which may have confounded previous estimates of adaptation effects.

Table 4 demonstrates the robustness of this estimate to sample and specification choices. Column 1 reproduces the preferred specification in Column 6 of Table 3. Column 2 controls for elevation linearly rather than with a cubic spline, which we find shifts the point estimate of the premium from 3.8% to 3.9%. To ensure within-

[14]Mean sales price and living area can be found in Appendix Table A1.

Table 3: Price Effect of Required Flood Adaptation

	Ln(Sale Price)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Year-community FE			Year-FIRM panel FE		
In 1998 SFHA	0.050***	0.029***	0.030***	0.059***	0.039***	0.038***
	(0.015)	(0.011)	(0.010)	(0.013)	(0.009)	(0.009)
Ln(Living Area)		0.924***	0.922***		0.854***	0.851***
		(0.050)	(0.050)		(0.027)	(0.027)
Ln(Lot Area)		0.026*	0.027*		0.070***	0.069***
		(0.015)	(0.014)		(0.010)	(0.010)
# Bedrooms		-0.037***	-0.035***		-0.028***	-0.028**
		(0.014)	(0.013)		(0.011)	(0.011)
# Bathrooms		0.115***	0.113***		0.072***	0.071***
		(0.016)	(0.016)		(0.009)	(0.009)
Effective Year Built		0.003**	0.003**		0.004***	0.005***
		(0.001)	(0.001)		(0.001)	(0.001)
Constant	11.843***	-1.173	-1.742	12.134***	-4.145**	-4.162**
	(0.154)	(2.745)	(2.755)	(0.155)	(1.889)	(1.860)
Observations	36,680	36,680	36,680	35,169	35,169	35,169
Adj. R^2	0.275	0.555	0.559	0.457	0.648	0.649
Elevation controls	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	No	No	Yes	No	No	Yes

Note: Standard errors in parentheses. Columns (1)-(3) include year-community fixed effects, with errors clustered at the community level. Columns (4)-(6) include year-1998 FIRM panel fixed effects, with errors clustered at the panel level. Observations are within 100 meters of both the 1998 and 2012 SFHA boundaries. Elevation controls use a cubic spline with 4 knots.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

panel comparisons, we restrict the sample to panels containing at least one treated and control property in Column 3; the point estimate remains at 3.8%. Column 4 removes all transactions that occurred in the property's effective year built to exclude new-construction sales that may incorporate construction costs, which lowers the premium by 0.7 percentage points to 3.1%. Column 5 examines potential concerns from the uncertainty in map revision timing by limiting the sample to properties for which we observe only one flood map revision. Because the SFHA status for such properties is always known between 1998 and 2012, the treatment timing is sharp; this reduces the sample to 14,339 while raising the point estimate from 3.8% to 5.9%.

The premium remains positive and statistically significant across these robustness checks; it is not sensitive to linear elevation controls, panel restrictions, or new construction exclusions. The increase in the estimate from 3.8% to 5.9% in Column 5 suggests some attenuation bias from measurement error in map revision timing. The premium is unlikely to be driven by differential building timings, as the distributions of effective build years by 1998 SFHA status track closely (Appendix Figure A2). State-level regressions presented in Appendix Table A2 yield positive estimates across all five states, although statistical significance is lost for Alabama and North Carolina, where panel-level sample size is limited. Interacting the treatment indicator with a linear trend in sale year yields no evidence of a time trend in the premium, as shown in Appendix Table A3.

Table 4: Robustness to Sample and Specification Choices

	Ln(Sale Price)				
	(1) Baseline	(2) Linear Elevation	(3) Balanced Panel	(4) No New Builds	(5) Clean Update
In 1998 SFHA	0.038***	0.039***	0.038***	0.031***	0.059***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.017)
Ln(Living Area)	0.851***	0.852***	0.863***	0.880***	0.865***
	(0.027)	(0.027)	(0.024)	(0.028)	(0.035)
Ln(Lot Area)	0.069***	0.069***	0.068***	0.081***	0.041***
	(0.010)	(0.010)	(0.010)	(0.009)	(0.012)
# Bedrooms	-0.028**	-0.028**	-0.031***	-0.021**	-0.008
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
# Bathrooms	0.071***	0.071***	0.070***	0.062***	0.061***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.013)
Effective Year Built	0.005***	0.005***	0.005***	0.009***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Constant	-4.162**	-4.239**	-4.154**	-12.813***	-3.173
	(1.860)	(1.886)	(1.870)	(1.644)	(3.007)
Distance controls	Yes	Yes	Yes	Yes	Yes
Elevation controls	Spline	Linear	Spline	Spline	Spline
# Clusters	1,035	1,035	953	979	543
Observations	35,169	35,169	34,695	31,534	14,339
Adj. R^2	0.649	0.649	0.651	0.715	0.648

Note: Standard errors in parentheses are clustered by 1998 FIRM panel. Observations are within 100 meters of both the 1998 and 2012 SFHA boundaries. Column 1 reports the baseline specification. Column 2 replaces the cubic spline of elevation with a linear control. Column 3 restricts the sample to 1998 FIRM panels with within-panel treatment variation. Column 4 excludes transactions of houses sold in the same year they were built. Column 5 restricts the sample to parcels with a single flood map revision between 1998 and 2012.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusions

Our results document a 3.8% flood adaptation premium attributable to NFIP-mandated construction regulations. Though positive, this willingness-to-pay is unlikely to lead to voluntary increases in the stock of existing houses with flood adaptation, given retrofitting costs: The approximate cost of elevating an existing house by 2 feet, under the most favorable conditions, was $17 per square foot in 1998 according to the Federal Emergency Management Agency (1998), or roughly $23 in 2011.

It is plausible that costs are lower at initial construction, suggesting that flood adaptation will be concentrated in new development. Whether the NFIP building standards in the SFHA are worthwhile as a private investment depends on pricing the initial construction cost. Buyers may also be underestimating the flow of adaptation benefits, which can be substantial; Mulder (2024), for example, estimates that flooding insurance claims were 30% larger for homes in the floodplain that were not subject to building requirements compared to those that were. Further work is needed to examine the implications of this private valuation of adaptation in a housing market that grows increasingly risky with climate change.

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A Appendix Figures and Tables

Table A1: Summary Statistics

	(1) All	(2) AL	(3) FL	(4) GA	(5) NC	(6) SC
In 1998 SFHA	0.19	0.09	0.23	0.15	0.17	0.12
Price	208251.64	218878.63	211791.21	179623.34	230247.59	173692.64
salesyear	2008.19	2009.09	2007.85	2009.37	2008.55	2007.64
Living Area (sq. ft)	2013.95	2001.19	1965.08	2216.06	2057.10	1925.97
Lot Area (sq. ft)	15944.99	38704.84	12610.01	19666.74	23642.45	10438.58
# Bedrooms	2.97	2.04	3.21	3.33	2.08	2.98
# Bathrooms	2.53	2.06	2.41	2.88	2.68	2.57
Elevation (m)	75.34	65.62	16.02	207.33	93.20	234.92
Effective Year Built	1998.03	1997.23	1997.70	1998.28	1999.03	1997.57
Distance to stream/river						
0-100m	0.03	0.08	0.03	0.01	0.03	0.08
100-500m	0.09	0.11	0.08	0.09	0.12	0.06
500m+	0.88	0.81	0.89	0.90	0.86	0.85
Distance to primary road						
0-100m	0.00	0.00	0.00	0.00	0.00	0.00
100-500m	0.02	0.02	0.01	0.03	0.03	0.04
500m+	0.98	0.98	0.99	0.96	0.96	0.96
Distance to secondary road						
0-100m	0.03	0.05	0.04	0.02	0.03	0.01
100-500m	0.18	0.26	0.19	0.16	0.16	0.20
500m+	0.78	0.68	0.77	0.82	0.80	0.79
Communities	314	26	78	88	106	16
1998 FIRM panels	1,541	142	392	304	632	71
Observations	36,891	513	21,077	4,858	7,425	3,018

Table A2: Robustness: Regressions by State

	log(Sale Price)					
	(1) All	(2) AL	(3) FL	(4) GA	(5) NC	(6) SC
In 1998 SFHA	0.039***	0.093	0.035***	0.062**	0.021	0.085***
	(0.009)	(0.156)	(0.011)	(0.024)	(0.024)	(0.024)
ln(Living Area)	0.852***	0.455**	0.878***	0.869***	0.665***	0.993***
	(0.027)	(0.209)	(0.031)	(0.037)	(0.042)	(0.064)
ln(Lot Area)	0.069***	0.192*	0.128***	0.041**	0.055***	-0.009
	(0.010)	(0.102)	(0.012)	(0.016)	(0.017)	(0.011)
# Bedrooms	-0.028**	0.132**	-0.067***	-0.004	-0.002	0.010
	(0.011)	(0.060)	(0.016)	(0.013)	(0.016)	(0.022)
# Bathrooms	0.071***	0.047	0.082***	0.094***	0.062***	0.022
	(0.009)	(0.094)	(0.013)	(0.013)	(0.017)	(0.016)
Effective Year Built	0.005***	0.011*	0.007***	0.010***	0.001	-0.004
	(0.001)	(0.006)	(0.001)	(0.002)	(0.001)	(0.004)
Constant	-4.239**	-15.284	-8.678***	-15.333***	5.195*	10.171
	(1.886)	(11.773)	(2.145)	(4.263)	(2.934)	(8.075)
Elevation controls	Yes	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes	Yes
# Clusters	1,035	57	314	194	418	52
Observations	35,169	313	20,661	4,565	6,664	2,966
Adj. R^2	0.649	0.464	0.669	0.683	0.569	0.600

Note: Standard errors in parentheses are clustered by 1998 FIRM panel. Observations are within 100 meters of both the 1998 and 2012 SFHA boundaries. Column 1 regresses log prices on 1998 SFHA status for the full analysis sample; Columns 2 - 6 runs the same regression for each state separately. While the main specification controls for elevation with a cubic spline, it is controlled linearly here to accommodate the more limited variation within clusters for the state-level sample. This does not materially affect the coefficient for having been subject to SFHA building standards (0.038 vs. 0.039). The 0-100 m bin for distance to primary roads is empty for Alabama.

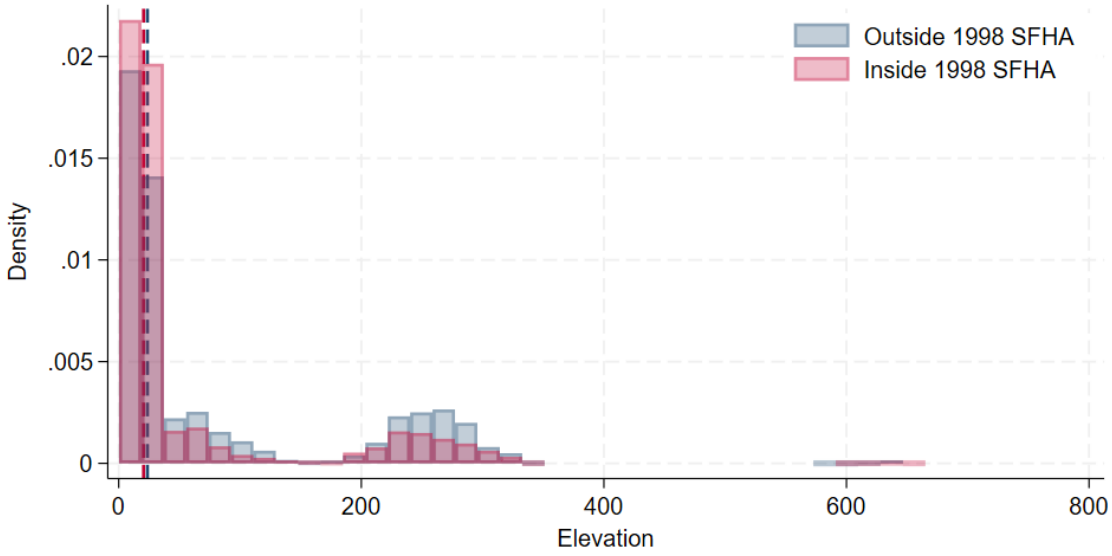
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3: Time Trend

	log(Sale Price)	
	(1) ln(Price)	(2) ln(Price)
In 1998 SFHA	0.038***	0.037***
	(0.009)	(0.014)
Time Trend		0.000
		(0.004)
ln(Living Area)	0.851***	0.851***
	(0.027)	(0.027)
ln(Lot Area)	0.069***	0.069***
	(0.010)	(0.010)
# Bedrooms	-0.028**	-0.028**
	(0.011)	(0.011)
# Bathrooms	0.071***	0.071***
	(0.009)	(0.009)
Effective Year Built	0.005***	0.005***
	(0.001)	(0.001)
Constant	-4.162**	-4.162**
	(1.860)	(1.859)
Elevation controls	Yes	Yes
Distance controls	Yes	Yes
# Clusters	1,035	1,035
Observations	35,169	35,169
Adj. R^2	0.649	0.649

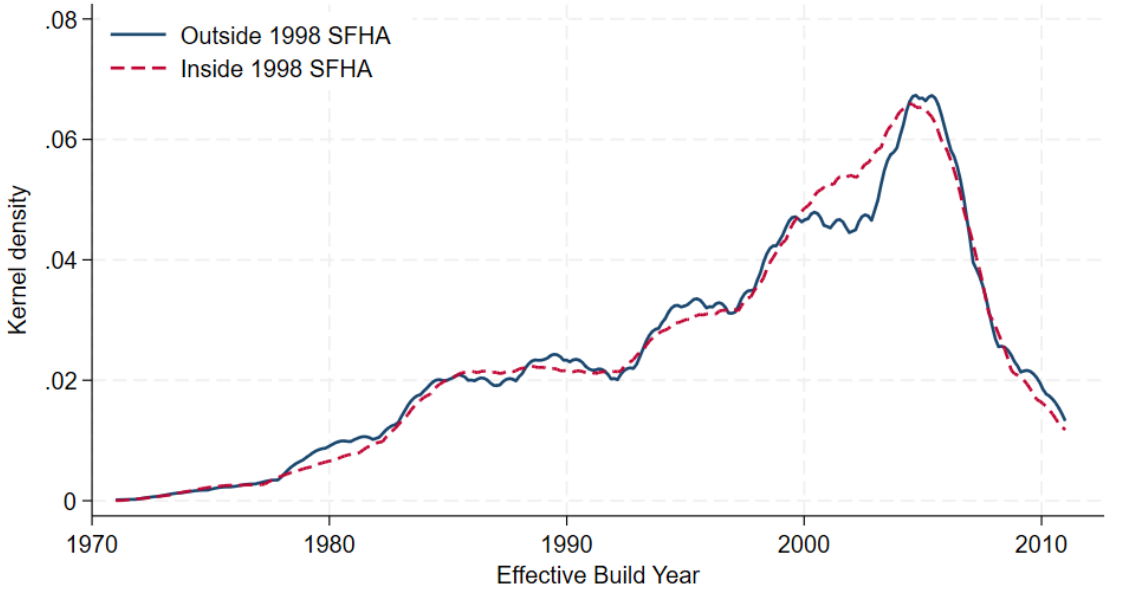
Note: Standard errors in parentheses are clustered by 1998 FIRM panel. Observations are within 100 meters of both the 1998 and 2012 SFHA boundaries. Column 1 displays coefficients for the baseline specification, while Column 2 includes a linear trend interacting the 1998 SFHA status indicator with the sales year centered around 2006.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure A1: Elevation by 1998 SFHA Status



Note: Sample is restricted to post-FIRM properties located outside the 2012 SFHA and within 100 meters of both the 1998 and 2012 SFHA boundaries (N = 36,891). Dashed lines indicate group medians, which differ by 3 meters. The support and shape of the distributions are similar, with the imbalance driven chiefly by greater density at low elevations among parcels built inside the 1998 SFHA and at moderate elevations among those built outside.

Figure A2: Effective Build Year Distribution by 1998 SFHA Status



Note: Sample is restricted to post-FIRM properties located outside the 2012 SFHA and within 100 meters of both the 1998 and 2012 SFHA boundaries (N = 36,891).