The Effect of Insurance Premiums on the Housing Market and Climate Risk Expectations

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Abstract

Climate change threatens to worsen natural disasters and increase the cost of insuring against them. We study how insurance costs affect the housing market using a 2013 reform that raised flood insurance premiums for properties discontinuously around flood zone boundaries and construction year cutoffs. Using a triple-difference design, we find that treated homes experience a 2% relative decline in transaction prices. This effect is partly driven by increased expected risks triggered by higher premiums, rather than a pure cash-flow channel. The price effect is three times as large for homes exposed to long-term sea level rise, suggesting that insurance pricing can accelerate the incorporation of climate risk into asset markets. Higher premiums induce more rebuilding of treated homes, as well as reduce mortgage uptake as the required insurance becomes more costly.

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1 Introduction

The cost of billion-dollar natural disasters has increased fivefold from the 1980s to the 2010s.[1] As climate change amplifies disaster risk, insurance becomes increasingly crucial for household financial resilience. However, insurance is expensive for homeowners. The average annual premium is $2,417 in 2023 in the U.S. and above $5,000 in a few states[2]—and likely to scale with hazard rates as climate change accelerates. We study how insurance premiums affect the housing market for three reasons. First, housing is directly exposed to natural disasters, which insurance helps hedge. Second, housing makes up a large share of household wealth.[3] Third, because of its long-term nature, real estate prices reflect long-run expectations (Giglio et al. 2015).

Amid premium increases, insurance regulators in risky states have kept insurance premiums artificially low.[4] If insurance rates do not fully reflect disaster risk, which allows households to hedge disasters at an artificially low price, or if the housing market fails to account for the rising insurance premiums, it can delay the incorporation of risks in house prices. Moreover, adaptation efforts, construction, and migration may not fully incorporate the costs associated with natural disasters and climate change. In this paper, we investigate two questions. First, how do insurance rates affect home prices, liquidity, buyer financing, and rebuilding decisions? Second, if insurance rates more accurately reflect risks, will it help the market better incorporate long-term climate risks?

To study how insurance costs affect the housing market, we need to isolate the effect of insurance from the effects of changing risks and other factors that influence the housing market. We exploit a plausibly exogenous shock to flood insurance pricing in the National Flood Insurance Program (NFIP). The Biggert-Waters Act, which took effect in 2013, began phasing out subsidies for a subset of houses. The treatment is determined by discrete geographic boundaries and construc-

[1] https://www.ncei.noaa.gov/access/billions.

[2] In comparison, the median real estate tax averaged across states is $2,768 in 2021. See, https://data.census.gov/table?q=median+real+estate+taxes+paid&g=010XX00US$0400000&tid=DECENNIALSLDS.HCT020. For average insurance premiums, see https://www.marketwatch.com/guides/insurance-services/average-home-insurance-cost/ and https://www.bankrate.com/insurance/homeowners-insurance/homeowners-insurance-cost/#avg-cost-by-company [accessed on July 27, 2024]. The nationwide average is estimated to be $2,530 by Keys and Mulder (2024), close to the number we cite avove.

[3] According to Smith et al. (2021), in the bottom 90% wealth group, housing makes up 63% of non-pension wealth.

[4] See, e.g., Oh et al. (2021) and https://www.nytimes.com/2020/09/16/climate/california-home-insurance-crisis.html[accessed on August 6, 2024]. Insurers' financial conditions can also distort insurance premiums away from being actuarially fair, see e.g., Froot and O'Connell (1999), Koijen and Yogo (2015), Ge (2022). Insurers' coarse measures of risk also cause them to inaccurately price risks (Boomhower et al. 2024).

tion year cutoffs, enabling a triple-difference empirical design. The reform, motivated by the large deficit of the program, did not directly convey any changes in risks. Another reason for using the flood insurance setting is that flooding is particularly acute in the U.S., with 15 million or 10% of homes currently exposed to flooding risk. Floods account for nine of the ten most costly disasters,[5] and the risk is expected to grow due to climate change.

We have five key findings. First, affected houses with the largest rate increases experience a 2% relative price decline. Second, this house price effect is partially driven by the market updating the risk expectation of treated homes triggered by higher premiums, in addition to the direct cash flow effect of the premium increases. Third, the shock to insurance rates made home prices more sensitive to information about *future* climate risk as measured by sea level rise (SLR) exposure. Fourth, higher premiums induce meaningful decreases in buyer mortgage uptake, likely due to the higher total cost of mortgages, including mandated flood insurance. Finally, higher premiums lead to increased rebuilding, and potential climate adaptation, for the affected homes.

To identify the effect of premiums on household decisions, we exploit the variation in insurance rate changes caused by the Biggert-Waters rate reform. Starting in 2013, the reform mandated that insurance rates increased most significantly for the most subsidized properties. Specifically, these are homes built before the creation of the local Flood Insurance Rate Map (hereafter "Pre-Map"), located in areas designated as High-Risk by the NFIP.[6] We refer to High-Risk, Pre-Map homes as treated. The reform aimed to phase out large subsidies for these homes to align rates with risk, without directly conveying any changes to risks.[7] As the underlying property risk does not change more for the treated homes, this shock isolates the impact of insurance rates.

We explore housing market outcomes in response to the insurance rate shock, using administrative flood insurance data and house transaction data from Zillow between 2009 and 2018. Our main (more restrictive) sample includes 11 million (4 million) house transactions. We estimate a triple-difference model. The dependent variables are housing market outcomes. The main independent variable is a triple interaction term, *Pre-Map* $\times$ *High-Risk* $\times$ *Post-Reform*, where *Post-Reform*

[5] See, https://www.cbsnews.com/news/15-million-homes-at-risk-of-flooding-new-data-from-first-street-foundation/.

[6] High-Risk zones are defined as areas that would be inundated by a 100-year flood, which is a flood that has a 1% chance of being equaled or exceeded in any given year. These floods happen once every 100 years on average, thus called 100-year floods.

[7] See, e.g., https://www.fema.gov/sites/default/files/2020-07/questions-biggert-waters-flood-insurance-reform-2012.pdf.

indicates for 2013 and later. We control for the size of the home and granular fixed effects: zip-by-property age fixed effects and area-by-number of bedrooms-by-year fixed effects, where an area is defined by latitudes and longitudes rounded to two decimal places (approximately 0.8 square miles), as well as zip codes. The area-by-number of bedrooms-by-year fixed effects control for different trends for homes with different sizes in different areas. Our identification strategy assumes that the house value difference between Pre-Map and Post-Map homes would have evolved similarly across High- and Low-Risk areas around the reform with our controls.

Our first analysis uses the log of transaction prices as the outcome variable. The coefficient estimates on *Pre-Map* $\times$ *High-Risk* $\times$ *Post-Reform* are negative and statistically significant. Our estimates imply that the price changes around the reform for Pre-Map homes relative to Post-Map homes were 2% lower in High-Risk than Low-Risk zones. This is consistent with the reform causing a larger increase in flood insurance premiums for Pre-Map, High-Risk houses, leading to a larger relative decline in home values.

Two mechanisms can drive the effect of premiums on home prices. On one hand, increased premiums can directly affect home prices through cash flows, which we call the Insurance-Cash-Flow effect. The corresponding home price decrease should equal the net present value of the expected future premium increases. However, we cannot compute this cash flow effect, because the NFIP does not offer future premiums, other than stating premiums would eventually reach some undisclosed full-risk rates.

On the other hand, premium increases may trigger the market to update its risk expectations for treated homes, which we call the Risk-Expectation effect. This can occur for at least three different reasons. First, people may not have incorporated flooding risks in home values when they could hedge these risks at a subsidized cost before the reform, consistent with the rational inattention literature (Brown and Jeon 2024). Second, people may naively infer risks from premiums. Thus, when premiums increase, people may naively believe risks have increased, even though the premium hike is due to heightened risks.[8] and (3) as the government phases out subsidies, the market may expect increased risks related to government intervention, such as less ex-post disaster relief.

[8]Kardes et al. (2004) review the literature on consumers inferring quality from prices. In our setting, the quality of flood insurance should be correlated with flooding risks. Thus, it is plausible that households infer flood risk from flood insurance premiums based on the empirical evidence on price-quality inference. See Bordalo et al. (2022) for a review of psychological evidence and related economic studies on the effect of salience.

Higher expected risks can further drive expectations of higher future premiums, strengthening the Cash-Flow channel.

The second part of our analysis identifies whether the Risk-Expectation channel plays a role in the house price response to the insurance rate reform. To do so, we split our sample into two subsamples based on the 2009 local average flood insurance coverage. We repeat our main specification using dollar house prices as the dependent variable. In the High-Coverage sample, average coverage is 1.3 times higher than in the Low-Coverage sample. Because premiums scale with coverage for High-Risk, Pre-Map homes, the ratio of average premiums should also be 1.3 between the two samples. If only the Insurance-Cash-Flow channel operates, the price effect for the High-Coverage sample should be 1.3 times that of the Low-Coverage sample. However, we find that the effect for the High-Coverage sample is three times that for the Low-Coverage sample, inconsistent with a pure Insurance-Cash-Flow channel, implying that the Risk-Expectation channel is also at work. We estimate that the Risk-Expectation effect accounts for 63% of the total effect for the High-Coverage subsample.

Third, we find that the effect of premiums on house prices is closely linked to climate risk. We find a $153 decline in prices for houses exposed to sea level rise, compared to $38 for unexposed homes, following a $1 increase in annual premiums during our sample. Note the reform states that premiums will continue to increase after our sample period, which the market likely has accounted for, so the actual passthrough is smaller. We argue that the large effect on exposed treated houses is because premium increases induce the market to update expectations about both future premiums (Insurance-Cash-Flow channel) and long-run risks (Risk-Expectation channel), which include flooding risks and government policies. Our results suggest that insurance rate increases can trigger the incorporation of long-term climate risks into current asset values.

Fourth, we find that flood insurance rates affect buyers' mortgage choices. Borrowers in High-Risk zones must purchase flood insurance. The reform made flood insurance more costly for High-Risk, Pre-Map homes, effectively increasing mortgage costs. Consistent with this, we find that the probability of buyers taking out mortgages decreases for High-Risk, Pre-Map homes after the reform.

Fifth, we explore whether homeowners are more likely to rebuild their property in response to premium increases. Higher premiums can incentivize rebuilding for three reasons: (1) as subsidies

for High-Risk, Pre-Map houses phase out, the benefits of keeping the Pre-Map status decrease; (2) as insurance becomes more expensive, households choose less coverage (Wagner 2019), and with more exposure to flood risk, they may rebuild to better withstand damage; (3) as we argue above, since the house price effects are partly due to risk updating, people may rebuild to increase flood resilience. Using permit data, we find that, in response to the rate reform, High-Risk, Pre-Map homes are more likely to be rebuilt, potentially in ways that better adapt to climate change.

Sixth, we test two hypotheses on the heterogeneous effects of premiums on house prices. First, the effect should be larger in states where sellers must disclose if the house is in a High-Risk zone. In such states, buyers are more likely to consider the premium increase in their valuation of the treated homes. Second, the effect will be larger when a house is purchased by non-primary buyers. One reason is that the reform mandates a larger premium increase for non-primary owners. Another reason is that these buyers are often more sophisticated investors and thus, more likely to consider the premium increases when valuing treated homes. Our results are consistent with both hypotheses.

Finally, we provide four pieces of evidence against potential alternative explanations for our main results on home prices. First, we examine whether Pre-Map homes are more exposed to certain risks, especially in High-Risk zones. If such risks became priced in around 2013, it could drive our results. We examine long-run flood risk due to sea level rise and short-run flood risk using various proxies. After controlling for fixed effects analogous to those in our main analyses, there is no statistically significant difference between Pre- and Post-Map homes in either High- or Low-Risk zones. Importantly, the Pre- vs. Post-Map difference is also not statistically significantly different between High- and Low-Risk zones. Thus, it is unlikely that our results are driven by High-Risk, Pre-Map homes being exposed to more flood risk, and such risks becoming priced in property values around 2013.

Second, we address the alternative explanation that expectations of flood damages may have increased more in High-Risk zones around 2013. If Pre-Map homes are more vulnerable to flood damage, this could explain our results. We restrict our sample to homes that are within 250 feet of the boundary between High- and Low-Risk zones, shrinking the difference in flood risks between High- and Low-Risk zones. The estimated coefficients on *Pre-Map* $\times$ *High-Risk* $\times$ *Post-Reform* stay similar in this subsample.

Third, we consider whether property age, rather than their Pre-Map status, drives the relative price decline for Pre-Map houses in High-Risk zones. We restrict our sample to houses that were built within three years of the local map establishment, shrinking the age difference between Pre- and Post-Map homes. Our results remain robust.

Fourth, one may be concerned that certain risks (e.g., sea level rise and storm surge risks) are higher in High-Risk zones and such risks have become intensified or priced in since 2013. If Pre-Map houses are more vulnerable to such risks, this can explain our results. Under this explanation, the coefficient on *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform* should decline in absolute magnitude towards zero when we control for *Hazard* $\times$ *Pre-Map* $\times$ *Post-Reform*, where *Hazard* proxies for properties' exposure to five other measures of flooding risks, including sea level rise and First Street Foundation Flood Factor. However, the estimated coefficient on our main triple interaction remains similar.

We contribute to several strands of literature. First, we add to the literature on insurance rates and home prices that found mixed results. Gibson and Mullins (2020), Bakkensen and Barrage (2021), and Hino and Burke (2021b) argue that insurance rates have no statistically significant impact on home prices. They also use the Biggert-Waters reform, but compare High-Risk with Low-Risk houses. However, premiums increased more for High-Risk than Low-Risk homes only in the Pre-Map subsample,[9] making it difficult to detect price effects in their difference-in-difference setting. Instead, we use a triple-difference methodology, exploiting the large premium increase for High-Risk, Pre-Map homes. Two recent papers, Georgic and Klaiber (2022) and Hennighausen et al. (2023), also use a similar strategy and find a negative effect of flood insurance premiums on house values.[10]

We make several contributions relative to these papers. We highlight that the Risk-Expectation channel partly drives the house price effect of insurance rates. Our results also suggest that when insurance rates better reflect underlying risk, the housing market is more likely to incorporate future long-term climate risk into current prices. Moreover, we uncover the important effect of insurance rates on buyer financing and rebuilding choices.

Second, we contribute to the literature studying the relationship between being in a High-

[9]Figure IA.1 in the Internet Appendix suggests that High-Risk houses on average did not experience a larger increase in premiums compared to Low-Risk houses in 2013-2015.

[10]Beyond flood insurance, Nyce et al. (2015) find a negative association between homeowners' insurance premiums and home value. However, homeowners' insurance premiums could be correlated with risks. Increased risks can also explain the reduction in home value, making it hard to infer the effect of insurance premiums.

Risk zone and house prices. This literature finds that prices of High-Risk zone homes range from 76% lower to 61% higher than comparison benchmarks (see a literature review by Beltrán et al. (2018)).[11] By using risk zone variation, this literature captures the effect of insurance premium variation across zones, as well as the effect of other channels, such as FEMA's information on property riskiness and omitted amenities associated with waterfront properties. We contribute to this literature by providing an estimate of the effect of premiums alone. Our paper also relates to recent flood insurance literature, including Wagner (2019), Sastry (2021), Mulder (2021), and Hu (2020). These papers abstract away from house prices, as their focus is different from ours.

Third, we contribute to the literature on climate change and real estate. As climate change intensifies, disasters such as flooding become a larger threat. Insurance is the main financial tool households use to hedge against disaster risk. Stroebel and Wurgler (2021) find that 42% of survey respondents think that the insurance market does not adequately price for climate risks. We shed light on how climate risks can be incorporated into home values through insurance pricing. While Bernstein et al. (2019), Baldauf et al. (2020), and Keys and Mulder (2020) show price and liquidity reductions for homes facing sea-level-rise risk, we provide evidence that insurance premiums can be an important channel through which long-term climate risks are incorporated into current asset prices.[12]

Although we use flood insurance as our study setting, our results have implications for the effect of other insurance premiums (e.g., homeowners, commercial) on asset values. Premiums in these markets have been and are likely to continue increasing in areas most affected by climate change, such as homeowners insurance in California or hurricane-exposed areas. If climate change increases the systemic risk of disasters, insurance rates are likely to increase more widely. Our results suggest that household and business assets that are more exposed to climate change can suffer significant price depreciation through rising insurance premiums.

[11] A few papers, including Gibson and Mullins (2020), Indaco et al. (2019), and Shr and Zipp (2019) find that houses see values decline when being added to High-Risk zones. However, Hino and Burke (2021a) find little effect on house prices when properties are being added to High-Risk flood zones, especially when controlling for location-time fixed effects.

[12] Murfin and Spiegel (2020) do not find a discount when comparing homes with more or less regional historic SLR, though the design is broader in geographic scope and effects may be attenuated due to migration patterns as in Bernstein et al. (2022). Other related papers in this area include Giglio et al. (2021), and Issler et al. (2020). Relatedly, Chay and Greenstone (2005), Greenstone and Gallagher (2008), and Currie et al. (2015) study the effects of air pollution and toxic emissions on the housing market.

2 Institutional Background

2.1 The National Flood Insurance Program

The National Flood Insurance Program (NFIP) was created as a result of the passage of the National Flood Insurance Act of 1968 with two primary goals: reducing future flood damage and protecting property owners.[13] It has since become a part of the Federal Emergency Management Agency (FEMA). The National Flood Insurance Program serves as the underwriter for flood insurance.

NFIP covers all 50 states and Puerto Rico, providing insurance to property owners, renters, and businesses. Except for properties located in areas covered by a suspended NFIP community (less than 0.4% of all US properties), all homeowners are eligible to obtain NFIP insurance. Between 2009 and 2018, each year NFIP underwrites on average 4.5 million flood policies, totaling $3.5 billion of premia and $1.4 trillion of building and content coverage. The NFIP underwrites the vast majority of all US flood insurance policies; only 3.5-4.5% of US flood insurance policies are provided by private flood insurance underwriters.[14] Homeowners in High-Risk zones are required to purchase flood insurance if they have a federally backed mortgage. Lenders often impose the same requirement for non-conforming mortgages. Flood insurance premium payments for High-Risk homes are escrowed by mortgage lenders as a common practice prior to 2016 and as required legally since 2016.[15]

Flood Insurance Rate Map: NFIP flood zones are organized by NFIP communities. Each community has its own Flood Insurance Rate Map (FIRM), which maps the community into different flood zones.[16] Most communities' maps were established between 1975 and 1990. We refer to properties built before the introduction of the local Flood Insurance Rate Map as Pre-Map properties, and the other properties as Post-Map properties.

High-Risk Zones: The NFIP divides areas into flood zones according to their flood risks and whether protection systems have been implemented in the area. A Special Flood Hazard Area (SFHA) is defined as an area that will be inundated by a flood with a one-percent or higher chance

[13] see `https://www.fema.gov/sites/default/files/2020-05/NFIP_50th_Final_8.5x11_Regional_Printable.pdf` for a brief history of NFIP.

[14] See Kousky et al. (2018).

[15] See, `https://www.fdic.gov/resources/supervision-and-examinations/consumer-compliance-examination-manual/documents/5/v-6-1.pdf`.

[16] Generally speaking, each NFLP community covers the geographical area of a town or a city.

in any given year. We refer to SFHA simply as High-Risk zones, and areas outside of SFHA as Low-Risk zones. During our sample period, High-Risk zones share the same insurance pricing rule, and Low-Risk zones share the same pricing rule.[17]

Premium Setting: Aside from the aforementioned risk zones, premiums are also a function of the chosen amount of building and content coverage, as well as deductibles. The maximum building coverage is $250,000 and the maximum content coverage is $100,000. Community-level mitigation efforts can also bring discounts to flood insurance premiums. Premiums are also determined by whether the property was built before the local map was introduced. Homes built prior to the local map introduction can elect for Pre-Map rates, which are widely considered heavily subsidized. These Pre-Map rates are independent of the house elevation. Post-Map homes' rates depend on the elevation of the lowest floor relative to the Base Flood Elevation.[18] Higher house elevation corresponds to lower premiums. Table A1 presents premiums for different categories of homes with the maxmium building coverage calculated using book rates.

Owners of Pre-Map houses can choose to obtain an elevation certificate and a Post-Map premium rate. It is advantageous to do so if the Post-Map rate for the house' elevation is cheaper than the Pre-Map rate. Elevation certificates cost on average $600 and can cost $2,000 or more.[19] We identify whether a house is Pre-Map using the year a house was built relative to the introduction year of the local flood map. The fact that Pre-Map homes can opt for Post-Map rates creates noise in our Pre-Map variable, which would bias our results toward zero.

2.2 Flood Insurance Rate Reform

In July 2012, President Obama signed the Biggert-Waters Flood Insurance Reform Act (BW-12) into law, with most of its clauses taking effect in 2013. It implemented rate changes, with the goal of increasing the NFIP's fiscal soundness.[20] The Act was unanticipated, as argued by Strother (2018). In Figure A1 in the Appendix, we plot the number of related news articles in Factiva for each

[17] In 2021, a new NFIP rating methodology, called "Risk Rating 2.0" started pricing using more granular measures of risk.

[18] Base Flood Elevation is defined by FEMA as "the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year."

[19] See, https://www.massivecert.com/blog/what-does-elevation-certificate-cost.

[20] See, https://www.fema.gov/sites/default/files/2020-07/questions-biggert-waters-flood-insurance-reform-2012.pdf and https://www.ncua.gov/regulation-supervision/letters-credit-unions-other-guidance/guidance-biggert-waters-flood-insurance-reform-act-2012

month between 2011 and 2014. As the figure shows, there was barely any mention of the reforms until July 2012 when the Act was signed into law.[21] Before the 2012 reform, Pre-Map properties in High-Risk zones received subsidized rates that are considered to be well below the actuarially fair rate. The Act mandates an annual increase of up to 25% in premiums for these subsidized properties when they are sold to new owners until premiums reach the full-risk rate.[22] After the passage of the 2012 reform, the outcry by affected people pushed Congress to pass the Homeowner Flood Insurance Affordability Act (HFIAA) in 2014, which changed some of the provisions in the Biggert-Waters Act. The subsequent 2014 reform revised the increase in premiums to be between 5% and 15% annually for all High-Risk, Pre-Map homes, including those not transacted.[23]

Neither the laws nor the NFIP gave projections of how premiums would change in the future, beyond NFIP's published rate tables for the upcoming policy year. NFIP rolled out Risk Rating 2.0 in 2021, a new pricing methodology intended to set premiums using more accurate property-level risk measures. Mulder and Kousky (2023) find that 40% of the pre-map, high-risk policies saw a decrease in premiums, which suggest that the prior premiums were punitively high for these policyholders. This finding highlights the difficulty for NFIP and thus, also the households to predict future "full-risk" premiums ex ante.

Table A1 tabulates premiums for $250,000 coverage for different categories of policies from 2012 to 2018, according to the NFIP rate tables. High-Risk, Pre-Map primary residence houses experienced an annual increase in premiums of 5.8% per year and saw a cumulative increase in premiums of $594. In contrast, Low-Risk houses and Post-Map, High-Risk houses experienced an average annual increase in premium rate between -3.8% and 3.5% or a cumulative change between -$1,099 and $277.

[21] The reform on Pre-Map, High-Risk houses took effect in Jan 2013. Premium increases for businesses, severe repetitive loss properties, and lapsed policies took effect in Oct 2013, which can explain the drastic increase in media coverage in late 2013.

[22] The law requires that premiums be set to the full-risk rate if a High-Risk, Pre-Map property is sold starting from October 2013. Setting the full-risk rate will require an elevation certificate. However, in case a new homeowner does not submit an elevation certificate, the rate increase will be set to 25% per year until reaching the full-risk rate, which is assumed to be double the original subsidized rate. When it is advantageous to do so, buyers of High-Risk, Pre-Map can limit their rate increase to 25% by not submitting an elevation certificate, effectively capping the rate increase at 25%. See, Pages 31-32 in the full report found on https://www.gao.gov/assets/gao-13-607.pdf.

[23] See, https://crsreports.congress.gov/product/pdf/R/R44593.

3 Data

3.1 Flood Insurance Data

3.1.1 National Flood Insurance Program (NFIP) Policy Data

The NFIP Policies dataset is an administrative dataset that contains the universe of the policies written by NFIP, with a total of around 50 million policy transactions. The data are available starting in 2009. There are about 4.5 million policies each year. It contains information on both the policy as well as the characteristics of the insured property. We can observe the start and end date of the policy, the total premium of the policy, building/content coverages, deductibles selected, as well as some of the other relevant information used to set the policy rate. Regarding the property characteristics, we can observe the occupancy type (single-family/multiple-family), building construction date, which flood zone it belongs to, the elevation of Post-Map properties, whether the property is Pre-Map as of the policy year,[24] whether the property is a primary residence, etc. The policies dataset is redacted to protect privacy. As a result, we do not observe the address of the properties under the policy. However, we observe the five-digit zip code as well as latitude and longitude rounded to one decimal place.

3.1.2 National Flood Hazard Layer (NFHL)

The National Flood Hazard Layer (NFHL) is a collection of map layers that divides United States geography into flood communities and flood zones. It allows researchers to accurately map any address or latitude-longitude location into the correct community and flood zone. The NFHL covers 95% of all US properties. Areas not covered in the NFHL data usually have low population densities. Through NFHL we can identify whether a property is located in a High- or Low-Risk zone, thus matching them to the correct premium rate according to the NIFP insurance rating schedule.[25] The digital shape files we have access to are from 1996 and 2021. We use the 2021 version. We conduct a robustness test of our main results in Table A2 using houses whose High-Risk designation did not change between 1996 and 2021. Our main result holds.

[24] Houses' Pre-Map status can change when there is an update to local maps. We address this using the National Flood Hazard Layer and NFIP Community Status Book as described below.

[25] We exclude areas whose shapefiles are not available digitally, (e.g., the state of Ohio).

3.1.3 NFIP Community Status Book

The NFIP Community Status Book contains information about a community's initial flood map date. Merging the Community Status Book with the National Flood Hazard Layer allows us to pin down the flood map introduction date of each community.

3.2 Zillow Data

We obtain property-level data from the real estate assessor and transaction datasets in the Zillow Transaction and Assessment Dataset (ZTRAX). ZTRAX is a comprehensive national real estate database with information on more than 374 million detailed public records across 2,750 US counties. It also includes detailed assessor data including property characteristics, geographic information, and valuations on over 200 million parcels in over 3,100 counties. Assessor characteristics can be matched directly to underlying transactions.

The Zillow assessor data contain information on a broad set of property information including square footage, the number of bedrooms/bathrooms, whether the house has a basement, and the year built. We classify properties built before the map introduction date for the corresponding community as Pre-Map, while those built after as Post-Map. We exclude houses built in the same year as the map introduction year from our sample. We also observe whether or not the unit is owner-occupied following the sale. We further filter the data as follows. First, we retain only transactions of residential properties for which the price of the transaction is between $50,000 and $5,000,000. In addition, we only include transactions where both How- and High-Risk properties, according to FEMA, exist within the zip code or a smaller geographic area as defined by our fixed effect structure. Finally, we only include properties with sufficient non-missing property information, which we control for in the regression analyses. The final dataset has around 11 million transactions including zip code level geographic effects, which reduces to 4.7 million when we condition on there being both High- and Low-Risk properties in each zip code by latitude and longitude rounded to two decimal places.

3.3 Physical Risk Measures

The Zillow assessor files also provide the geo-coded location of each property which we use to map to four different measures of physical risk. 1) We utilize the location data to provide a set of location-based risks and characteristics. First, we connect latitude and longitude to the National Oceanic and Atmospheric Administration (NOAA) Sea Level Rise risk (see Marcy et al. 2011). We define an indicator SLR Exposure to be equal to 1 if the property would experience chronic tidal flooding after six feet of global average sea level rise. 2) Using the same data on SLR from NOAA, we identify the distance between a property and the current highest high tide (SLR=0) for all homes within 5 miles of this layer. This we define as the distance to the coast. Because 73% properties are outside this sample, we transform this variable in the following way. We first sort houses into 10 bins based on their distance to water. We then assign 11 to the properties that are more than 2 miles away from the coast. 3) We run an analogous process to identify the property's exposure to NOAA storm surge risk. Those maps are raster-based (see Zachry et al. 2015) so here we find the house location within the raster file and extract the raster value at that point. We define the indicator Storm-Surge to take a value of 1 if the property would experience flooding (e.g. Storm-Surge height greater or equal to 1 foot) after a category three hurricane. 4) We merge our data with First Street Flood Factor 30-year flood risk data by choosing the point in the First Street risk file that is closest to each property based on longitude and latitude.

3.4 Matching Flood Insurance and Zillow Data

We match the premium and insurance coverage information from NFIP to our Zillow data. Because the insurance policy data only provides longitude/latitude rounded to one decimal place without other detailed location data for the covered houses, we cannot match premium rates to the Zillow transaction data at the property level. Even if this were feasible, houses that do not have flood insurance coverage in a year will have missing premiums, while new buyers may take flood insurance into account, especially in High-Risk zones where it is required for obtaining a federally backed mortgage.

We match each house in the Zillow data to an average insurance premium and coverage each year as follows. First, we calculate the annual average premium rate (total premium divided by

building plus content coverage) and the average coverage for houses within a group that shares the same characteristics as follows: NFIP latitude and longitude which are rounded to one decimal place, zip code, flood zone, year built, and policy year. Second, we match the average premium rate and the average coverage to each house transaction in Zillow by the above grouping, equating the sale year in Zillow and the policy year in NFIP. For properties not matched, we adjust its built year by +1, -1, +2, -2, +3, and -3, consecutively until a match is found.

3.5 Data Summary

Table 1 summarizes the key variables for our main sample. First, we find that residential properties in our filtered sample trade on average at $301k. 10% of the properties in our sample are in High-Risk zones, and 37% are constructed prior to the flood map for their area. Around 4% of all homes in our sample are High-Risk and Pre-Map.

We match our sample with flood insurance premiums using latitude and longitude rounded to one decimal place, zip, and age. Although we have a premium for each observation in our sample, the premium data are averaged over the matched bin and so are not property-specific. We find that the average premium across our whole sample is $480 per year, partially reflecting the very low premiums for homes in Low-Risk areas.

Lastly, we present several property-specific flood factors. 9% of the homes are exposed to six-feet SRL risk. Lastly, about 13 percent of homes are exposed to storm-surge risk in the event of a level-3 hurricane.

4 The Effect of Reform on Flood Insurance Premiums

4.1 Methodology

The reform mandates the gradual removal of subsidies for High-Risk, Pre-Map houses. The actual premiums households face are determined by NFIP's implementation of the reform. Even though Table A1 shows that the book rate for High-Risk, Pre-Map homes increased the most compared to other properties, the actual premiums policyholders paid could deviate from those prescribed by the book rate due to factors such as community discounts. In addition, as we point out earlier, a house

we identify as Pre-Map may in reality obtain Post-Map premium when it is more advantageous, as discussed in Section 2.1. In this section, we test whether High-Risk, Pre-Map houses (according to our classification) indeed experience a larger relative increase in flood insurance premiums post-reform. We estimate the following regression.

$$Premium_{i,t} = \sum_{y=2009}^{2019} \beta_y \times High\text{-}Risk_i \times Pre\text{-}Map_{i,t} \times \mathbf{1}_t^y + Lower\ Order\ Terms$$
$$+ FE_{zip \times age} + FE_{zip \times loc \times t} + \epsilon_{i,j,t}$$

The dependent variable, *Premium*, is policy premium rates scaled to \$250k building coverage, in \$1,000, where premium rates are matched to properties as described in Section 3.4. By scaling premiums to a fixed coverage amount, we remove the effect of the reform on coverage amount from the estimates. Pre-Map is time-varying for each parcel *i* because the house can be rebuilt and changing from Pre-Map to Post-Map. $\mathbf{1}_t^y$ is an indicator for policy year *t* being in year *y*. *Lower Order Terms* include the standalone terms, as well as all the lower-order interactions between *High-Risk*, *Pre-Map*, and the year dummies. They include the following: 1) *Pre-Map* $\times$ *Year Indicators*, whose coefficient captures the average premium trend for Pre-Map houses relative to Post-Map houses in Low-Risk zones; 2) *High-Risk* $\times$ *Year Indicators*, whose coefficient captures the average trend in Post-Map premiums for High-Risk zones relative to Low-Risk zones; 3) *High-Risk* $\times$ *Pre-Map*, whose coefficient captures the difference in premiums of Pre-Map minus Post-Map houses between High-Risk and Low-Risk zones; 4) *High-Risk*, whose coefficient captures the average Post-Map premium differences between High-Risk and Low-Risk zones; 5) *Pre-Map*, whose coefficient captures the average price of Pre-Map relative to Post-Map houses in Low-Risk zones.

The fixed effects structure mirrors those we control for in our main analyses on house prices as discussed in the next section. We control for zip-by-property age fixed effects. We also control for zip-by-*loc*-by-year fixed effects, where *loc* is a location defined by longitude and latitude rounded to one decimal place, which is the most granular location information provided in the NFIP dataset. Standard errors are two-way clustered by quarter and zip code.

Figure 2 plots the estimated coefficients on the triple interaction terms, *High-Risk* $\times$ *Pre-Map* $\times$ *Year Indicators*. Figure 2 indicates that the difference in premiums between Pre-Map and Post-Map homes in High-Risk zones increased drastically relative to Low-Risk zones from 2012 to 2013, and

continued to increase following 2013, as the reform mandates. Note that outside of the rate reform, rates do generally increase every year by a small amount. The increase can differ depending on risk zones and Pre-Map status, which can explain the small variation before the reform.

5 The Effect of Insurance Premium Reform on House Prices

5.1 Methodology

We identify the effect of flood insurance premiums on house prices by exploiting the differential effect of the Biggert-Waters flood insurance pricing reform on different properties. The houses that faced the largest insurance rate increases are those in high-risk flood zones (*High-Risk*) that are Pre-Map (built before the corresponding community's flood map was released). We identify the effect of flood insurance premiums on house prices through the estimated coefficient on the triple interaction term: *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform*. We estimate the following regression using the period of 2009 to 2018 using transaction prices of parcel *i* in year *t*:

$$\begin{aligned} Log(Price)_{i,t} =& \beta_1 \times High\text{-}Risk_i \times Pre\text{-}Map_{i,t} \times Post\text{-}Reform_t + Lower\ Order\ Terms \\ &+ \beta_2 \times SquareFootage + FE_{zip \times age} + FE_{area \times \#bedrooms \times t} (+FE_i) + \epsilon_{i,j,t} \end{aligned}$$

The Lower Order Terms include the following. 1) *Pre-Map* $\times$ *Post-Reform*, whose coefficient captures the average price change for Pre-Map houses relative to Post-Map houses in Low-Risk zones; 2) *High-Risk* $\times$ *Post-Reform*, whose coefficient captures the average change in Post-Map house prices for High-Risk relative to Low-Risk zones; 3) *High-Risk* $\times$ *Pre-Map*, whose coefficient captures the difference in the prices of Pre-Map minus Post-Map houses between High-Risk and Low-Risk zones; 4) *High-Risk*, whose coefficient captures the average price differences in prices of Post-Map houses between High-Risk and Low-Risk zones; 5) *Pre-Map*, whose coefficient captures the average price of Pre-Map houses relative to Post-Map houses in Low-Risk zones. Again, Pre-Map is time-varying for each parcel *i* because the house can be rebuilt and changing from Pre-Map to Post-Map.

We control for the square footage of the house and a set of highly saturated fixed effects. We include zip-by-property age fixed effects, and thus partially out the average prices of houses of the same age within the same zip code. We also control for area-by-number of bedrooms-by-year fixed effects, where an area is defined by either zip codes or zip-by-latitude/longitude rounded to

two decimal places (approximately 0.8 square miles). Therefore, we control for the time trend in average prices of houses with the same number of bedrooms in the same narrow area. In one of the specifications, we also include property fixed effects, which addresses the concern that it is the different characteristics of houses sold pre- and post-reform drive our results.

Our identifying assumption is that absent the flood insurance rate reform, prices of Pre-Map homes relative to Post-Map homes would have evolved similarly between High-Risk and Low-Risk areas, after controlling for the highly saturated set of fixed effects. We present a host of evidence against concerns about potential violations of this assumption in Section 11.

5.2 Effects of Insurance Reform on House Prices

Table 2 displays the results of our triple-difference regressions. In Column (1), we include zip-by-property age and zip-by-number of bedrooms-by-year fixed effects. We only include zip codes where there are both Low- and High-Risk houses. The estimated coefficient on the triple interaction term is -0.023, suggesting that Pre-Map homes in High-Risk zones trade at a 2.3% discount after the reform. More precisely, Pre-Map minus Post-Map home values in High-Risk zones drop by 2.3% more than that in Low-Risk zones around the reform.

In Column (2), we add property fixed effects and effectively compare the within-house price changes across property types. The estimate of the coefficient on the triple interaction term stays similar, at -0.018, and remains statistically significant. Note that the variable *Pre-Map* is not omitted as we add property fixed effects, because when a property is rebuilt, we treat it as the same property when the parcel identifier remains the same in the Zillow data.

Our benchmark specification, Column (3), includes zip-by-latitude/longitude-by-number of bedrooms-by-year fixed effects. Here, we only include locations (defined by zip-by-latitude/longitude) where there are both Low- and High-Risk houses. Throughout the paper, we use this specification as our primary analysis. In this model, the geographic controls are granular while allowing us to preserve the majority of our sample. We find a similar estimated coefficient on the triple interaction of -0.021. In Column (4), we repeat Column (3), with the dollar sales price (in $1000s) as the dependent variable. Following the reform, we find that prices on High-Risk, Pre-Map homes on average fall relatively by $12,292 dollars.

In Table A2 of the Appendix, we conduct four robustness tests. In Column (1), we exclude 2013 and 2014, the period between the two reforms. Column (2) replaces fixed effects with Zip × Age × High-Risk fixed effects and Zip × Loc × Year × Beds × High-Risk fixed effects. Column (3) includes additional controls: exposure to sea level rise, First Street Foundation flood factor, exposure to storm surge, distance to highest-tide water, more than 3 past floods, and whether the home has a basement. In Column (4), we only include houses, for which the flood map, i.e. the High-Risk dummy, did not change between 1996 and 2021—the two versions of digital maps available to us. The results are all similar to those in Table 2.

Figure 3 illustrates the time series of the effect of the rate reform by using our benchmark model from Column (3) of Table 2. Specifically, we replace the *Post-Reform* indicator with a series of year indicators. Thus, the triple interaction term, *High-Risk* × *Pre-Map* × *Post-Reform*, is replaced with 10 interaction terms, each being *High-Risk* × *Pre-Map* × *Year Indicator*, where *Year Indicator* is an indicator for each of the years between 2009 and 2018. In the years prior to the rate reform, we observe larger confidence bands and no individual year with a coefficient that is different from the omitted year, 2012. This indicates that there is no pre-trend in home prices prior to the reform. After the rate changes started in 2013, the triple interaction began taking on a negative and statistically significant coefficient, implying that High-Risk, Pre-Map homes experience a relative price discount. The discount persists until the end of our sample. Even though the effect of the reform on premiums of treated homes increases over time, the relatively stable house price discount suggests that the market valuation of house prices early after the reform incorporates the premium increases that come later.

5.3 Mechanism: Insurance-Cash-Flow and Risk-Expectation

Two channels can drive the effect of premiums on home prices. We refer to the first one as the "Insurance-Cash-Flow" channel. Increased premiums can lower home prices due to increased cash flows arising directly from the legislation. The corresponding price decrease should be the net present value of the expected future premium increases. However, We cannot compute this cash flow effect, because NFIP does not disclose future premiums, other than stating that premiums would eventually reach full-risk rates without offering information on the full-risk rates. We also

cannot use Post-Map policies' premiums to back out the full-risk rates for Pre-Map houses because we do not know the lowest-floor elevation required to calculate the rates based on NFIP's rate tables. Mulder and Kousky (2023) find that 40% of the pre-map, high-risk policies saw a decrease in premiums following another reform outside of our sample, which suggests that the prior premiums were punitively high for these policyholders. This finding highlights the difficulty for us to back out the expected present value of future "full-risk" premiums.

We refer to the second channel as the "Risk-Expectation" channel—premium increases can lower home prices by increasing the market's flood risk expectations. There are at least three reasons for an increase in expected risks. First, prior to the reform, people may underestimate risks when flood risks could be insured at a lower cost, which is consistent with the rational inattention literature (see, e.g., Brown and Jeon 2024). When the insurance costs increase, households are more likely to assess their insurance coverage needs. To do so, they may give more consideration to the underlying risk. Second, homeowners may infer an increase in risk from insurance premiums due to the salience of the premium shock (as evidenced by the large number of news articles summarized in Figure A1. This is related to the behavioral economics literature on salience (see, e.g., Bordalo et al. 2022). Third, as the government phases out flood insurance, the market may update other risks related to government actions, such as reduced disaster aid after future floods. While unrelated to the flood probabilities, these policy changes can increase flood-related costs.

Regardless of the specific reason, if buyers' expected risk increases due to the insurance premium shock, house prices should decrease. There is feedback from the second channel to the first: as the market expects an increased probability of flooding, it will also expect a higher future premium, strengthening the Insurance-Cash-Flow channel. However, the Risk-Expectation channel should have an effect on home values above and beyond the direct effect through insurance cash flows.

To test whether the Risk-Expectation channel plays a role, we exploit data on flood insurance coverage from NFIP. In Table 3, we split our sample into two subsamples based on the average 2009 coverage amount matched to each property. We choose the 2009 coverage amount to ensure that coverage is not affected by the premium changes of the reform.[26] We choose the sample

[26]We match the average coverage amount by zip and longitude-latitude (rounded to one decimal place—the finest provided by FEMA) in 2009 to each property. We use the area average (rather than further match by detailed flood zone and year built as described in Section 3.4) to include more houses that may be excluded from the estimation sample due

median as the cutoff. In Column (1), we repeat our main specification with dollar house prices as the dependent variable, as in Column (4) of Table 2, using the Low-Coverage sample. For this subsample, the coverage amount has a mean of around $175,671. In Column (2), we use the High-Coverage sample, for which the average coverage is 1.3 times as large, around $222,561.

If the effect on house prices is only through the Insurance-Cash-Flow channel, the dollar effect on house prices should scale with the coverage amount, because premiums for High-Risk, Pre-Map homes mostly scale with coverage. In other words, the house price effect for the High-Coverage subsample should be 1.3 times as large as that for the other subsample.[27]

What would the Risk-Expectation channel predict? A large portion of the houses in the High-Coverage sample have the maximum coverage, $250k. Presumably, many of these houses have a rebuilding cost higher than $250k, so the value of the structure of the High-Coverage sample relative to that of the Low-Coverage sample would be higher than 1.3. It is hard to pin down the exact predicted ratio of the house price effect under this channel.[28] However, if the house price effect for the High-Coverage subsample is more than 1.3 times as large as that for the other subsample, it can be consistent with the Risk-Expectation channel.

In Column (1), using the High-Coverage sample, the coefficient on the triple interaction term is -17.7. In Column (2), using the Low-Coverage sample, the coefficient is -4.7. In Column (3), we use the entire sample and add an interaction between an indicator for higher-than-median coverage and our main triple interaction term, as well as with lower-order terms. Our main triple interaction term has a coefficient of -5.5, and its interaction with the High Coverage dummy has a coefficient of -11.3, which is twice as large. Both coefficients are statistically significant. Thus, the effect in the High-Coverage sample is around three times that in the Low-Coverage sample, which is much larger than the 1.3 times predicted by the pure Insurance-Cash-Flow channel.

Other reasons can potentially explain this result. For example, the buyers of Low-Coverage,

to some properties not having flood insurance in 2009.

[27] Table IA.2 in the Internet Appendix tabulates the detailed book rate for one dollar of coverage for High-Risk, Pre-Map houses. The rate per dollar of coverage within the basic coverage limit is actually slightly higher than that of additional coverage beyond the basic coverage limit. (The basic limit was either $50,000 or $60,000 during our sample period.) Thus, the premiums and their house price effect for the High-Coverage subsample should be less than 1.3 times as large as that for the other subsample.

[28] The Risk-Expectation effect would be somewhat proportional to the combined value of the uninsured part of the building replacement cost, part of the land value, as well as other costs associated with flood-related disasters (e.g., being displaced temporarily). If the Low-Coverage houses have most of the building replacement costs insured and High-Coverage houses cannot, the difference in the Risk-Expectation effect between the two samples can be large.

treated houses may be less sophisticated and do not fully take into account further increases in future premiums. Thus, the effect in the Low-Coverage sample may be an under-reaction. Although it is difficult to rule out all the other explanations, the results in Table 3 can be consistent with the Risk-Expectation channel.

These results suggest that our effects are not only driven by a pure Insurance-Cash-Flow channel, but also by the Risk-Expectation channel through an increase in expected risks of the High-Risk, Pre-Map properties. We can use the estimates above to calculate a lower bound of the effect of the Risk-Expectation channel in the High-Coverage sample. For the Low-Coverage sample, the effect only due to cash flows should be smaller than \$4.7k, the total effect for this subsample, in absolute magnitude. The cash flow effect for the High-Coverage subsample should be less than \$6.1k (=1.3×\$4.7k) in absolute magnitude, as the average coverage amount is 1.3 times as large as that for the Low-Coverage sample. The total effect in this sample is \$17.7k. Therefore, the risk expectation effect is at least \$17.7k-\$6.1k=\$11.6k in absolute magnitude. In other words, the risk expectation channel causes at least \$11.6k drop in the average home value of the High-Coverage subsample, which makes up 63% of the average total effect, \$17.7k.

6 Sea Level Rise and Home Price Response to Insurance Reform

6.1 Larger House Price Effects in the Sample Exposed to Sea Level Rise

As we argue in the section above, the flood insurance rate reform can affect house values by increasing the current and expected future insurance premiums (the Insurance-Cash-Flow channel). We also argue above that the Risk-Expectation channel is also at work: the market updates the risk expectation of the treated homes in response to premium increases. A natural question is whether the market updates short-term or long-term risk/premium expectations more.

We examine two hypotheses. First, if the rate increases prompt buyers to update future premium expectations or to gather more information about flood risks unrelated to insurance, the effect is likely to be larger in places that face higher long-term flood exposure that is not obvious to discern (e.g. those exposed to long-term sea-level-rise risk). Alternatively, if the insurance rate change causes buyers to update short-term premiums or risks, then the effect is likely to be larger where the current risk is higher.

In Table 4, we examine whether the geographic variation in long-term and short-term flood risk impacts the house price response to the flood insurance rate reform. First, we examine whether the price effect of the insurance rate reform is correlated with long-horizon flood risk related to a six-foot sea level rise. Even before the sea level rises by six feet, exposed homes will likely experience more flooding because a small rise of of sea level can still make rivers overflow during heavy rainfalls and because sea level rise amplifies the risk of hurricane- and storm-related flooding. In Column (1), we include the interaction between our main triple interaction term and *Sea Level Rise*, which is an indicator for whether the property is exposed to a 6-foot sea level rise. In Column (2), we add interactions between our main triple interaction term and each of four proxies of short-term flood exposure, including First Street Foundation's flood factor which proxies for flood risk within the next 30 years, whether the house is exposed to storm surge, distance to the highest-tide water,[29] and whether FEMA has declared three flooding disasters in the local area. We include all the lower-order interaction and standalone terms, but suppress them for presentation.

The estimated coefficient on *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform* $\times$ *Sea Level Rise* is negative. It is also the only one that is statistically significant among all the quadruple interaction terms. In Column (2), its estimated coefficient is -0.02, 1.6 times that of the coefficient on the triple interaction term. This suggests that the house price effect on treated homes in the sample exposed to sea level rise is 1.6 times of that not exposed. The results suggest that, in response to increases in flood insurance rates, people likely update future *long-run* premiums or risk expectations. The results also suggest that the effect of the rate reform is not stronger for houses with higher *short-run* flood risk. Perhaps, these existing risks have been priced into the properties and the shock to insurance rates does not lead to meaningful updating.

6.2 Climate Risk Expectation Updating

In Section 5.3, we provide evidence that the effect of insurance premiums on house prices is partly driven by the Risk-Expectation channel using subsamples of houses by the average local coverage. Subsection 6.1 argues that the effect of flood insurance premiums on house prices is much larger for houses exposed to sea level rise. To detect whether the Risk-Expectation channel partly explains the

[29] We determine the distance to highest-tide water by first measuring the distance between each house and the current highest high tide line as established by the NOAA SLR zero feet maps within a five-mile radius.

large effect on houses exposed to sea level rise, we regress house prices (in thousands of dollars) on our triple interaction term and its interaction with the indicator for sea level rise exposure, using the sample split by average local flood insurance coverage in 2009, as described in Section 5.3.

The average coverage amount for houses exposed to sea level rise in the High-Coverage sample is 1.3 times that in the Low-Coverage sample. For houses exposed to sea level rise, if the effect on house prices is partly driven by the Risk-Expectation channel , the effect on house prices in the High-Coverage sample should be more than 1.3 times that of the Low-Coverage sample. The reason again is that the average coverage ratio is 1.3 and the pure Insurance-Cash-Flow effect should also be 1.3 as insurance premiums scale with coverage for High-Risk, Pre-Map houses.

Table 6 presents the results. Column (1) uses the High-Coverage sample. The coefficient on the triple interaction term, High-Risk $\times$ Pre-Map $\times$ Post-Reform, is -8.22. The coefficient on the interaction term with Sea Level Rise is -19.47. Both of these coefficients are statistically significant. Adding up the two, the total effect of the reform on the treated homes that are exposed to sea level rise is -27.69 in the High-Coverage sample. Column (2) uses the Low-Coverage sample. The total effect on the treated homes that are exposed to sea level rise is -14.57 (=-3.992-10.58)—the sum of the coefficients on the triple and quadruple interaction terms. Thus, the effect in the High-Coverage sample is 1.9 (=-27.69/-14.57) times that in the Low-Coverage sample.[30] This 1.9 ratio is larger than the ratio of average coverage, 1.3—the ratio implied by a pure Insurance-Cash-Flow channel. Therefore, it is likely that part of the price effect on homes exposed to sea level rise is due to the market updating risk expectations related to climate change triggered by the premium increase. For these houses, the Risk-Expectation effect should be more negative than -$8.75k (=-27.69+14.57$\times$1.3).

Note that for houses not exposed to sea level rise, the price effect is -8.22 in the High-Coverage sample and -3.99 in the Low-Coverage sample. The estimates suggest that for these houses, the Risk-Expectation effect should be more negative than -$3k (=-8.2+4.0*1.3) in absolute magnitude, smaller in absolute magnitude than the $8.75k for houses exposed to sea level rise.

The results discussed in Sections 6.1 and 6.2 reflect a consistent narrative. A large part of the home price effect is driven by re-evaluation of the long-term risk exposure of the property or the

[30] One caveat is that when testing the statistical significance of the difference, we do not find the two effects, -27.69 and -14.57, statistically significant when clustering standard errors at the zip and year-quarter level.

associated costs, in addition to a pure insurance cash flow channel. In particular, buyers demand a larger sea-level-rise-related discount after an increase in insurance rates. These findings highlight that insurance pricing is an important channel through which that the housing market updates its long-term climate risk expectation and embeds climate risk in current prices.

6.3 Passthrough of Premiums to House Prices

To better understand how the house price response to insurance premium changes varies with exposure to sea level rise, in Table 5, we examine the dollar price effect among houses exposed to sea level rise and the rest separately. Columns (1) and (4) estimate how house prices (in thousands of dollars) respond to the insurance reform following our main specification for the two samples separately. Column (1) indicates that, among properties not exposed to six feet of sea level rise, prices of the High-Risk, Pre-Map homes drop by $4,823 more following the rate reform. The magnitude for homes exposed to sea level rise is much larger, $25,845, according to Column (4).

To estimate the passthrough from premiums to house prices, we estimate the effect of the insurance reform on insurance premiums in Columns (2) and (5). The estimates suggest that premiums increased by $85 more for the treated homes that are not exposed to sea level rise and by $116 more for these homes in the exposed sample. The larger magnitude of premium changes for the exposed homes is due to the larger average coverage amount among these homes. The effect on premium per dollar of coverage for treated homes is slightly larger for homes not exposed to sea level rise.

Columns (2) and (5) use premiums that are matched to the house transactions in the same year. The issue with this method is that we estimate the passthrough from the observed average premium changes to house values. However, the reform stipulates that subsidies will phase out gradually for High-Risk, Pre-Map homes until reaching "full-risk" rates. Although households cannot observe the future rates, they may form some expectation of the trajectory of future premiums. One useful exercise is to examine the passthrough of premium increases on house values assuming that, since 2013, the market had expected insurance rates to be what they ended up being in 2018. To this end, in Columns (3) and (6), we repeat Columns (2) and (5), using premium rates in 2018 to match home transactions between 2013 and 2018. The estimates suggest that premiums increased

by $128 more for the most treated homes in the sample not exposed to sea level rise and by $165 more for these homes in the exposed sample.

6.3.1 Interpreting the Effect as Purely Driven by Observed Insurance Cash Flows

We argue in Section 5.3 that the house price effect is also driven by the premium increase triggering the market to update risk expectations. However, let us assume in this paragraph that the house price effects are due to the Insurance-Cash-Flow channel to estimate an upper-bound of the passthrough of premiums to house prices. Based on Columns (1) and (3) in Table 5, for one dollar of premium increase in 2018, house prices fall by $38 (=4,823/128) in the sample not exposed to sea level rise.[31] Based on Columns (4) and (6), in the sample exposed to sea level rise, for one dollar of premium increase in 2018, house prices fall by $153 (=25.845/0.168).

The premium-to-house price passthrough calculated above is overstated for two reasons. First, the market likely expects a larger treatment effect on premiums to increase after 2018. Indeed, in a 2013 report by the Government Accountability Office, it is estimated to take 20 years or more to reach "actuarially fair" rates for all previously subsidized homes as mandated by the reform (GAO 2013). Second, we assume here that the house price effect is purely due to the Insurance-Cash-Flow channel. As we argue in Section 5.3, the house price effect is also driven by the premium increase triggering the market to update risk expectations. Therefore, the true passthrough of premium cash flows to house prices should be smaller. The overstatement of the passthrough is more severe for houses exposed to sea level rise. One reason is that for this sample, the market should expect a larger premium increase for the treated homes in the future due to their higher long-term flood risk. Another reason is that the Risk-Expectation channel should play a larger role in this sample, as we argue in Section 6.2.

[31] This result implies a discount rate of 2.7% (=128/4,823) if the treatment effect on premiums is expected to stay the same as in 2018 in perpetuity. 2.7% should be the lower bound of the implied discount rate, as this passthrough is overstated. An implied discount rate above 2.7% is reasonable given that Giglio et al. (2021) estimate the average (expected) returns of real estate to be 6% in the short/median run, and Giglio et al. (2015) estimate the very long-run discount rate to be 2.6%.

7 Insurance Rate Reform and Mortgage Choice

When the flood insurance rate reform made flood insurance more costly for High-Risk, Pre-Map homes, it effectively increased the costs of mortgages for these homes because GSEs and lenders require borrowers to purchase flood insurance in High-Risk zones. Higher costs may make mortgages less attractive to borrowers. Lenders may also become more concerned about borrowers' default risk given the higher costs, and thus lower the approval rate for mortgages. Therefore, we hypothesize that the probability of buyers taking out mortgages decreases for High-Risk, Pre-Map homes after the reform.

In Table 7, we rerun the specifications in Table 2 replacing the dependent variable with an indicator for whether the buyer of a transaction takes out a mortgage. The mortgage information is based on assessor data provided by Zillow. In our regression sample, the percentage of home buyers taking out a mortgage is around 50%, which is lower than recent numbers based on industry reports.[32] This indicates that our mortgage data include substantial noise. However, it is unlikely that such noise is correlated with our key independent variables to generate biased estimates.

The triple interaction term, High-Risk $\times$ Pre-Map $\times$ Post-Reform, has a negative and statistically significant coefficient in all three columns with different fixed effects. The magnitudes suggest that the probability of buyers of High-Risk, Pre-Map homes taking out mortgages falls by between 1.0 and 1.6 percentage points after the reform, which is between 2% and 3% of the sample mean probability. This result suggests that flood insurance rate increases can have implications on households' financing decisions. This result is related to Blickle and Santos (2022), who find that when the coverage of High-Risk zones of a census tract increases due to flood map updates, banks reduce mortgage lending in that census tract. Their result could be driven by an information channel. Banks update their understanding of the flood risks of the affected probabilities based on map changes. This information channel is absent in our setting, so we can isolate the effect of flood insurance premium changes.

One interpretation of the mortgage effect is that households reduce take-up because mortgages, together with the required insurance, become effectively more expensive. There is a slightly different interpretation, which is the other side of the same equilibrium. As insurance rates increase

[32] See, `https://www.redfin.com/news/all-cash-down-payment-april-2023/`.

for High-Risk, Pre-Map homes, homeowners are more likely to decrease their flood insurance coverage (Wagner 2019), making these properties riskier for mortgage lenders. Sastry (2021) argues that lenders require higher downpayment for borrowers who under-insure. This can also make mortgages less attractive than prior to the reform.

The decrease in mortgage uptake after the exogenous change in insurance prices highlights the nuance required to set good policy in this space. To the extent that FEMA wants to better align risk and insurance prices, the reform removes subsidies and alter prices in a way that is consistent with aligning buyers' expected risk with reality. However, if buyers respond to increased premiums by taking out fewer mortgages, then this re-concentrates the risk of flood damage in the hands of homeowners, potentially making households more vulnerable to such risk.

8 Heterogeneous Effects of Insurance Premiums on House Prices

8.1 By State Flood-Zone Disclosure Requirements

Many anecdotes suggest that buyers often overlook whether a house is in a High-Risk zone until lending banks require them to obtain flood insurance after they pay commitment fees to sellers. Some states requiresellers to disclose if the property is in a High-Risk flood zone and otheres do not. Figure 4 shows states' requirements for flood zone disclosure. The darker color indicates that the state requires such disclosure. We hypothesize that the effect of flood insurance premiums on house prices will be stronger if a state requires such disclosure because buyers are more likely to take flood insurance premiums into consideration in their valuation of properties.

Columns (1)-(3) of Table 8 test our hypothesis above. We repeat our main specification in Column (3) of Table 2, using the transactions in states that do not require any disclosure in Column (1) and using states that require disclosure in Column (2). The estimated coefficient on *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform* is negative and statistically significant in both columns. The magnitude in Column (2), -0.034, is 50% larger than that in Column (1), -0.021. This result is consistent with the hypothesis that the effect of flood insurance premiums is stronger in states where properties' flood-zone information is more readily available to potential buyers. In Column (3), we test whether the difference between Columns (1) and (2) is statistically significant, by using the entire sample and adding a quadruple interaction, *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform* $\times$ *Disclosure*. The estimated

coefficient on this term is negative, but not statistically significant at conventional levels.

8.2 Non-primary vs Primary Owner

The effect of flood insurance premium changes on house prices can be different if the buyer is a non-primary owner, i.e. those that purchase a property for investment or as a second home. One reason is that such buyers can be more sophisticated and more likely to take into account flood insurance premiums in their property valuation. Robinson (2012) finds that such buyers tend to have better credit scores and higher incomes, suggesting that they are likely to be more sophisticated. The other reason is that investors (or non-primary owners) receive larger increases in premiums. The flood insurance reform capped the increase in premiums for High-Risk, Pre-Map homes at 18% annually for a primary residence, and 25% annually for a non-primary residence. With segmentation and illiquidity in the housing market as documented by Piazzesi et al. (2020), flood insurance premiums can have different effects on transaction prices depending on whether the buyer is an investor.

We test whether the effect of flood insurance premiums on house prices is stronger when the buyer is a non-primary owner in Columns (4)-(6) of Table 8. Our Zillow transaction data tell us whether a property is owner-occupied after the transaction, which we use as a proxy for whether the property is purchased by a primary owner.

We use the sample of houses sold to primary owners in Column (4) and those sold to non-primary owners in Column (5). The estimated coefficient on *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform* is negative and statistically significant in both columns. The magnitude using the sample of non-primary owners, -0.035, is almost three times that using the sample of primary owners, -0.012. Column (6) tests whether the effect of insurance premium changes on house prices is statistically significantly different between the two subsamples, by using the entire sample and adding a quadruple interaction term: *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform* $\times$ *Non-Primary*. The coefficient on this interaction term is negative and statistically significant, suggesting that the house price effect is different depending on whether the buyer is a primary owner.

9 Insurance Rate Reform and House Transaction Probability

In this section, we examine the effect of the flood insurance rate reform on the liquidity of affected homes. We do so by examining the probability of each house being transacted in our triple-difference setting. Specifically, we regress an indicator for whether a house is transacted on the triple interaction term, *High-Risk* $\times$ *Pre-Map* $\times$ a dummy variable for each year, as well as all lower-order (interaction) terms and the fixed effects as in Column (3) of Table 2, our benchmark regression on the price effect.

Figure 5 plots the coefficients on *High-Risk* $\times$ *Pre-Map* $\times$ *Year Dummies*. The results indicate that the 2012 reform first had a negative effect on the transaction probabilities of High-Risk, Pre-Map homes in 2013 and 2014, which then disappeared from 2015 through 2018. These patterns are consistent with details in the Biggert-Waters 2012 reform and the subsequent Homeowner Flood Insurance Affordability Act of 2014. According to the 2012 reform, starting from Oct 1, 2013, new buyers of High-Risk, Pre-Map homes are supposed to receive full-risk rates, which is a a much larger premium increase than current owners. This would make a potential new owner's valuation of such a home lower than the current owner, lowering the probability that a High-Risk, Pre-Map house is transacted. The subsequent 2014 reform reversed the special treatment of transacted homes effective on May 1, 2014 and made it a priority to immediately refund new home-buyers who paid the full-risk rates. This can explain the reversal of the declining transaction probability starting from 2015.

10 Insurance Rate Reform and Rebuilding Activity

Finally, we examine whether the larger rate increases for High-Risk, Pre-Map homes induce more rebuilding activities of such homes. There are at least three reasons to hypothesize that higher premiums can incentivize homeowners to rebuild. First, as subsidies for High-Risk, Pre-Map houses phase out, the benefits of keeping the Pre-Map status of a house decrease. Second, as flood insurance becomes more expensive, households choose less insurance coverage, as documented by Wagner (2019). With less flood insurance coverage and thus, more exposure to flood risk, households may become increasingly likely to rebuild in a way that can better withstand flood damage.

If owners elevate the foundation of High-Risk, Pre-Map homes, they can qualify for a lower flood insurance rate. Third, if some of the effects on house prices are due to the market updating risk expectations, people are more likely to rebuild to increase the flood resilience of their properties.

We test our hypothesis Using CoreLogic permit data as well as historical tax assessor data in Table 9. This table repeats Column (1) of Table 2. In Column (1), the dependent variable is one if the house in that year is matched to a permit that is of the type "New Building", where the permit year is after the initial year built of the property. The dependent variable also equals one if the year equals a built year that is later than the built year based on the property from tax assessor data. In Column (2), the dependent variable is one if the house in that year is matched to a permit that is of the type "Demolition", where the permit year is after the initial year built of the property. In Column (3), the dependent variable equals one if either the dependent variable for column (1) or (2) is one. The coefficient on the triple interaction term is positive and statistically significant, suggesting that High-Risk, Pre-Map homes are more likely to be rebuilt in response to flood insurance rate increases.

11 Evidence Against Alternative Explanations

In this section, we address alternative explanations which argue that expectations of flood damages may have increased more for Pre-Map houses in High-Risk zones around 2013. As shown in Figure 3, the coefficient estimate on the triple interaction term *High-Risk* $\times$ *Pre-Map* $\times$ *Year Dummy* is not statistically significant before 2013. This suggests that the difference between Pre-Map and Post-Map house prices does not differ between High-Risk and Low-Risk zones prior to the implementation of the Biggert-Waters Act. Exposure to other risks, even if especially high for Pre-Map houses in High-Risk zones, would need to be abruptly reflected in house prices in 2013 to be able to explain our findings. One may be especially concerned about the expectation of sea level rise confounding our results since an emerging literature argues that the risk of sea level rise (SLR) began to be priced for exposed properties around 2012 to 2013 (see, e.g., Bernstein et al. 2019). If Pre-Map homes in High-Risk zones experience a larger increase in the expectation of flood damages in High-Risk zones, this could drive our results. We present four pieces of evidence against this and other concerns.

11.1 Restricting to Houses Built around Map Year

Another potential concern is related to the idea that Pre-Map houses are older than Post-Map ones and older houses are more vulnerable to flooding. If around 2013, the expected flood frequency or/and severeness increased more for High-Risk than Low-Risk zones, then older, more vulnerable houses in High-Risk zones are likely to experience a larger price drop.

We address this concern in Column (1) of Table 10. We restrict our sample to houses that were built between three years before and after the local map year. The sample used here is only 9% of that in our baseline regression. If we control for area-by-year-by-number of bedrooms fixed effects as in our benchmark model, where an area is defined by zip and rounded latitude/longitude, we lose more observations and thus, power. Hence, we replace the area-by-year-by-number of bedrooms fixed effects with zip-by-year-by-number of bedrooms fixed effects. The estimated coefficient on the triple interaction term, *High-Risk* $\times$ *Pre-Map* $\times$ *Post-Reform*, remain negative and statistically significant. The magnitude of the estimate is around 50% larger than that in our benchmark result.

11.2 Restricting to Houses Near Flood Zone Borders

If around 2013, the expected flood frequency and/or severeness increased more for High-Risk than Low-Risk zones, and Pre-Map homes are more vulnerable than Post-Map homes, we could observe a larger decline in value for Pre-Map houses in High-Risk zones. To address this concern, we repeat our main analyses using homes that are close to the boundary between High- and Low-Risk zones. Restricting to such a subsample should at least shrink the difference in the trend between High- and Low-Risk houses.

Column (2) of Table 10 presents the results. We restrict our analysis to properties within 250 feet of the border. The estimated coefficient on our main variable, the triple interaction term, remains similar to our main result.

11.3 Control for Other Risk Exposure

We provide another piece of evidence against the alternative hypothesis raised in the beginning of Section 11.2. We supplement our analysis by directly controlling for the level and time-varying effects of exposure to future sea-level-rise risk and current storm/flood by estimating the following

equation in Table 11.

$$\begin{aligned} Log(Price)_{i,t} = \beta_1 \times High\text{-}Risk_i \times Pre\text{-}Map_{it} \times Post\text{-}Reform_t \\ + \beta_2 \times Hazard_i \times Pre\text{-}Map_i \times Post\text{-}Reform_t \\ + \textit{Lower-Order Terms} + FE_{zip \times age} + FE_{area \times \#bedrooms \times t} + \epsilon_{i,j,t}. \end{aligned}$$

Like before, the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform* is our coefficient of interest. *Lower-Order Terms* includes all lower-order interactions between *High-Risk/Hazard*, *Pre-Map*, and *Post-Reform*, as well as standalone terms that are not absorbed by fixed effects.

Hazard is an indicator for whether or not the house is exposed to six feet of sea level rise in Column (1); the standardized value of First Street Foundation's flood factor in Column (2); an indicator for whether or not the house is exposed to storm surge in the case of a category-3 hurricane in Column (3); standardized buckets of distance to highest-tide water in Column (4); whether or not the county experienced a flood declared by FEMA as a disaster in more than three years since 1950 in Column (5).

If one is concerned about present-day and future flood risks, captured by *Hazard*, being correlated with High-Risk, then controlling for *Hazard* × *Pre-Map* × *Post-Reform* should address the concern. The coefficient on *Hazard* × *Pre-Map* × *Post-Reform* should capture the price changes of Pre-Map relative to Post-Map houses related to these risks. The estimated coefficients on our main triple interaction term, *High-Risk* × *Pre-Map* × *Post-Reform*, remain similar to our main results in Table 2. This suggests that our results are unlikely driven by the correlation between High-Risk and storm/flood/see-level-rise risks, these risks worsening around 2013, and Pre-Map houses being more vulnerable to these other risks.

Balance of Risk Exposure The results in this section so far suggest that the correlation of High-Risk or Pre-map with other flood hazard proxies (if there is any) does not drive our main finding on house price effects. Nonetheless, Table A3 in the Appendix investigates whether Pre-Map homes are more exposed or more vulnerable to certain risks than Post-Map homes or especially so in High-Risk zones.

First, we run the following regression for the High-Risk zones and Low-Risk zones separately:

$$Risk_{i,t} = \beta_1 \times Pre\text{-}Map_i + \beta_2 \times SquareFootage + FE_{zip \times age} + FE_{area \times \#bedrooms} + \epsilon_{i,j,t}$$

The outcome variables are whether a property is exposed to (a) long-run flood risk, proxied by sea-level-rise exposure, in Columns (1) and (2); (b) more current and medium-term flood risk proxied by First Street Foundation's flood factor which proxies for flood risk within the next 30 years in Columns (3) and (4), as well as by storm surge in Columns (5) and (6) and distance to the highest-tide water in Columns (7) and (8); (c) whether they are more likely to have a basement, which is usually associated with lower elevation and larger damages from floods in Columns (9) and (10). These variables are defined in Section 3. The odd-numbered columns use houses in the High-Risk zones and the even-numbered columns use those in Low-Risk zones.

We include fixed effects analogous to those we use in our main regression, Column (3) of Table 2, and essentially narrow the comparison group to "similar" properties. Since the observations here are at the property level, rather than the property-year level as in the regressions, we modify the fixed effects to be zip-by-year built and zip-by-longitude/latitude-by-number of bedrooms. Across the board, the estimated coefficients on Pre-map are statistically insignificant, suggesting that the difference between Pre-Map and Post-Map homes is statistically indistinguishable from zero across all these risk proxies.

Importantly, We then test whether the estimated coefficients on *Pre-Map* are statistically different between the High-Risk and Low-Risk zones. The difference and t-statistics are reported in the bottom two rows. None of the differences is statistically significant, suggesting that the difference between Pre-Map and Post-Map homes is also not statistically significantly different between High- and Low-Risk zones.

12 Conclusion

We study the effect of insurance premiums on the housing market using a 2013 flood insurance pricing reform. The reform offers an exogenous shock to insurance rates, increasing premiums the most for homes built in High-Risk areas before the establishment of the local flood map. We exploit the differential rate changes for different types of homes to identify the impact of flood insurance prices on house prices, buyer financing, and rebuilding choices.

Our five main findings are as follows. First, houses with the largest rate increase experienced a relative price decline of around 2%. Second, the effect of insurance premiums on house prices is driven not only by the direct cash flow effect of the premium increases. The effect is also partly driven by the market updating the expected risk of the treated homes triggered by higher premiums. Third, the shock to insurance rates makes home prices more sensitive to *future* climate change risk, as measured by sea level rise (SLR) exposure. Fourth, this shock leads to meaningful decreases in mortgage uptake, as the total cost of mortgages, including mandated flood insurance, increases. Finally, the increase in premiums also leads to more rebuilding of the affected homes.

Our findings indicate that insurance premium changes can update the housing market's expectations of long-run flooding risks associated with sea level rise and the corresponding costs. Consequently, insurance serves as a crucial channel for incorporating sea-level-rise risk into asset prices. This paper underscores the potential pass-through of insurance premium increases to housing markets and the implications for insurance rate regulations, including flood and homeowners' insurance. If policymakers and regulators permit insurance rates to fully reflect underlying risks, particularly in areas exposed to long-term climate change-related risks, it can effectively raise awareness of future risks and facilitate their incorporation into current asset prices. This, in turn, can support climate risk adaptation by discouraging further development and migration in high-risk areas.

References

Bakkensen, L. A. and L. Barrage (2021). Going underwater? flood risk belief heterogeneity and coastal home price dynamics. *The Review of Financial Studies*.

Baldauf, M., L. Garlappi, and C. Yannelis (2020, 02). Does Climate Change Affect Real Estate Prices? Only If You Believe In It. *The Review of Financial Studies 33*(3), 1256–1295.

Beltrán, A., D. Maddison, and R. J. Elliott (2018). Is flood risk capitalised into property values? *Ecological Economics 146*, 668–685.

Bernstein, A., S. B. Billings, M. T. Gustafson, and R. Lewis (2022). Partisan residential sorting on climate change risk. *Journal of Financial Economics*.

Bernstein, A., M. T. Gustafson, and R. Lewis (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics 134*(2), 253–272.

Blickle, K. and J. A. Santos (2022). Unintended consequences of" mandatory" flood insurance. Technical report, Federal Reserve Staff Report.

Boomhower, J., M. Fowlie, J. Gellman, and A. Plantinga (2024). How are insurance markets adapting to climate change? risk selection and regulation in the market for homeowners insurance. Technical report, National Bureau of Economic Research.

Bordalo, P., N. Gennaioli, and A. Shleifer (2022). Salience. *Annual Review of Economics 14*(1), 521–544.

Brown, Z. Y. and J. Jeon (2024). Endogenous information and simplifying insurance choice. *Econometrica 92*(3), 881–911.

Chay, K. Y. and M. Greenstone (2005). Does air quality matter? evidence from the housing market. *Journal of political Economy 113*(2), 376–424.

Currie, J., L. Davis, M. Greenstone, and R. Walker (2015). Environmental health risks and housing values: evidence from 1,600 toxic plant openings and closings. *American Economic Review 105*(2), 678–709.

Froot, K. A. and P. G. O'Connell (1999). The pricing of us catastrophe reinsurance. In *The financing of catastrophe risk*, pp. 195–232. University of Chicago Press.

GAO (2013). Flood insurance: More information needed on subsidized properties.

Ge, S. (2022). How do financial constraints affect product pricing? evidence from weather and life insurance premiums. *The Journal of Finance 77*(1), 449–503.

Georgic, W. and H. A. Klaiber (2022). Stocks, flows, and flood insurance: A nationwide analysis of the capitalized impact of annual premium discounts on housing values. *Journal of Environmental Economics and Management 111*, 102567.

Gibson, M. and J. T. Mullins (2020). Climate risk and beliefs in new york floodplains. *Journal of the Association of Environmental and Resource Economists 7*(6), 1069–1111.

Giglio, S., M. Maggiori, K. Rao, J. Stroebel, and A. Weber (2021). Climate change and long-run discount rates: Evidence from real estate. *The Review of Financial Studies 34*(8), 3527–3571.

Giglio, S., M. Maggiori, and J. Stroebel (2015). Very long-run discount rates. *The Quarterly Journal of Economics 130*(1), 1–53.

Greenstone, M. and J. Gallagher (2008). Does hazardous waste matter? evidence from the housing market and the superfund program. *The Quarterly Journal of Economics 123*(3), 951–1003.

Hennighausen, H., Y. Liao, C. Nolte, and A. Pollack (2023). Flood insurance reforms, housing market dynamics, and adaptation to climate risks. *Journal of Housing Economics 62*, 101953.

Hino, M. and M. Burke (2021a). The effect of information about climate risk on property values. *Proceedings of the National Academy of Sciences 118*(17), e2003374118.

Hino, M. and M. Burke (2021b). Internet appendix to the effect of information about climate risk on property values. *Proceedings of the National Academy of Sciences 118*(17), e2003374118.

Hu, Z. (2020). Salience and households' flood insurance decisions. *Available at SSRN 3759016*.

Indaco, A., F. Ortega, and S. Taşpınar (2019). The effects of flood insurance on housing markets. *Cityscape 21*(2), 129–156.

Issler, P., R. Stanton, C. Vergara-Alert, and N. Wallace (2020). Mortgage markets with climate-change risk: Evidence from wildfires in california. *Available at SSRN 3511843*.

Kardes, F. R., S. S. Posavac, and M. L. Cronley (2004). Consumer inference: A review of processes, bases, and judgment contexts. *Journal of Consumer Psychology 14*(3), 230–256.

Keys, B. J. and P. Mulder (2020). Neglected no more: Housing markets, mortgage lending, and sea level rise. Technical report, National Bureau of Economic Research.

Keys, B. J. and P. Mulder (2024). Property insurance and disaster risk: New evidence from mortgage escrow data. Technical report, National Bureau of Economic Research.

Koijen, R. S. and M. Yogo (2015). The cost of financial frictions for life insurers. *American Economic Review 105*(1), 445–475.

Kousky, C., H. Kunreuther, B. Lingle, and L. Shabman (2018). The emerging private residential flood insurance market in the united states. *Wharton Risk Management and Decision Processes Center*.

Marcy, D., N. Herold, K. Waters, W. Brooks, B. Hadley, M. Pendleton, K. Schmid, M. Sutherland, K. Dragonov, J. McCombs, and S. Ryan (2011). New mapping tool and techniques for visualizing sea level rise and coastal flooding impacts. *In Proceedings of the 2011 Solutions to Coastal Disasters Conference, Anchorage, Alaska*, 474–490.

Mulder, P. (2021). Mismeasuring risk: The welfare effects of flood risk information. Technical report, Working Paper.

Mulder, P. and C. Kousky (2023). Risk rating without information provision. In *AEA Papers and Proceedings*, Volume 113, pp. 299–303. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

Murfin, J. and M. Spiegel (2020, 02). Is the Risk of Sea Level Rise Capitalized in Residential Real Estate? *The Review of Financial Studies 33*(3), 1217–1255.

Nyce, C., R. E. Dumm, G. S. Sirmans, and G. Smersh (2015). The capitalization of insurance premiums in house prices. *Journal of Risk and Insurance 82*(4), 891–919.

Oh, S., I. Sen, and A.-M. Tenekedjieva (2021). Pricing of climate risk insurance: Regulatory frictions and cross-subsidies. *Available at SSRN 3762235*.

Piazzesi, M., M. Schneider, and J. Stroebel (2020). Segmented housing search. *American Economic Review 110*(3), 720–59.

Robinson, B. L. (2012). The performance of non-owner-occupied mortgages during the housing crisis. *FRB Richmond Economic Quarterly 98*(2), 111–138.

Sastry, P. (2021). Who bears flood risk? evidence from mortgage markets in florida. Technical report, Mimeo.

Shr, Y.-H. J. and K. Y. Zipp (2019). The aftermath of flood zone remapping: The asymmetric impact of flood maps on housing prices. *Land Economics 95*(2), 174–192.

Smith, M., O. M. Zidar, and E. Zwick (2021). Top wealth in america: New estimates and implications for taxing the rich. Technical report, National Bureau of Economic Research.

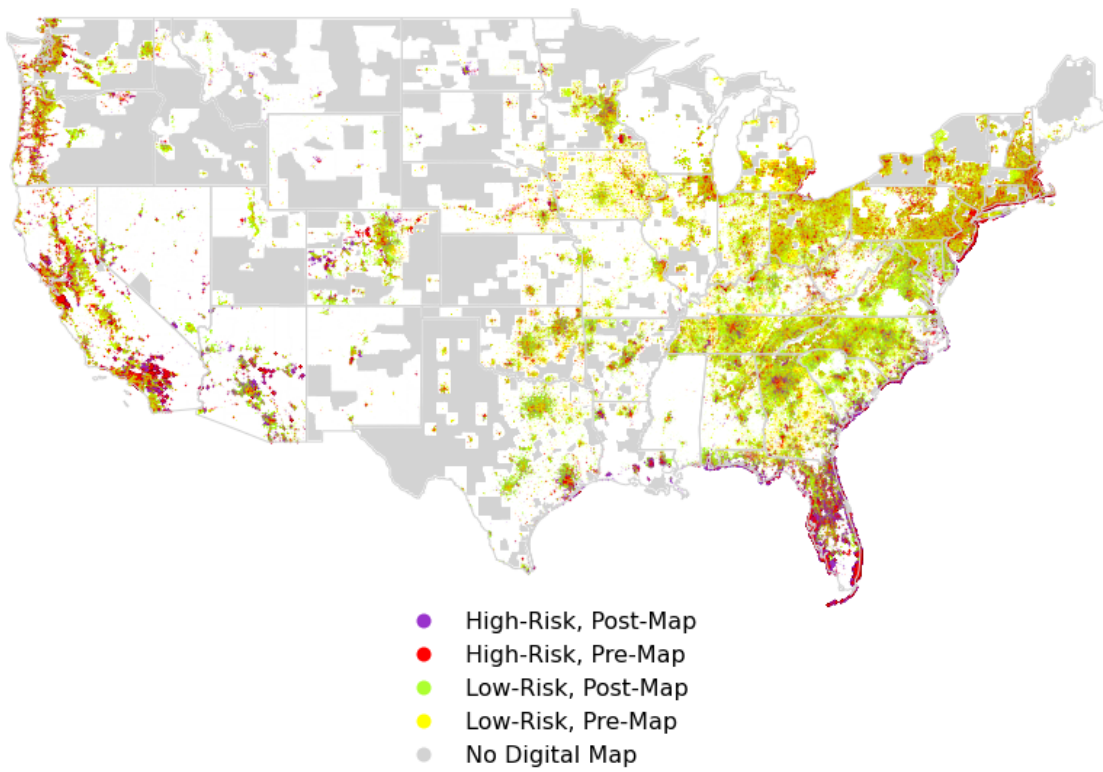
Stroebel, J. and J. Wurgler (2021). What do you think about climate finance?

Strother, L. (2018). The national flood insurance program: a case study in policy failure, reform, and retrenchment. *Policy Studies Journal 46*(2), 452–480.

Wagner, K. (2019). Adaptation and adverse selection in markets for natural disaster insurance. *Available at SSRN 3467329*.

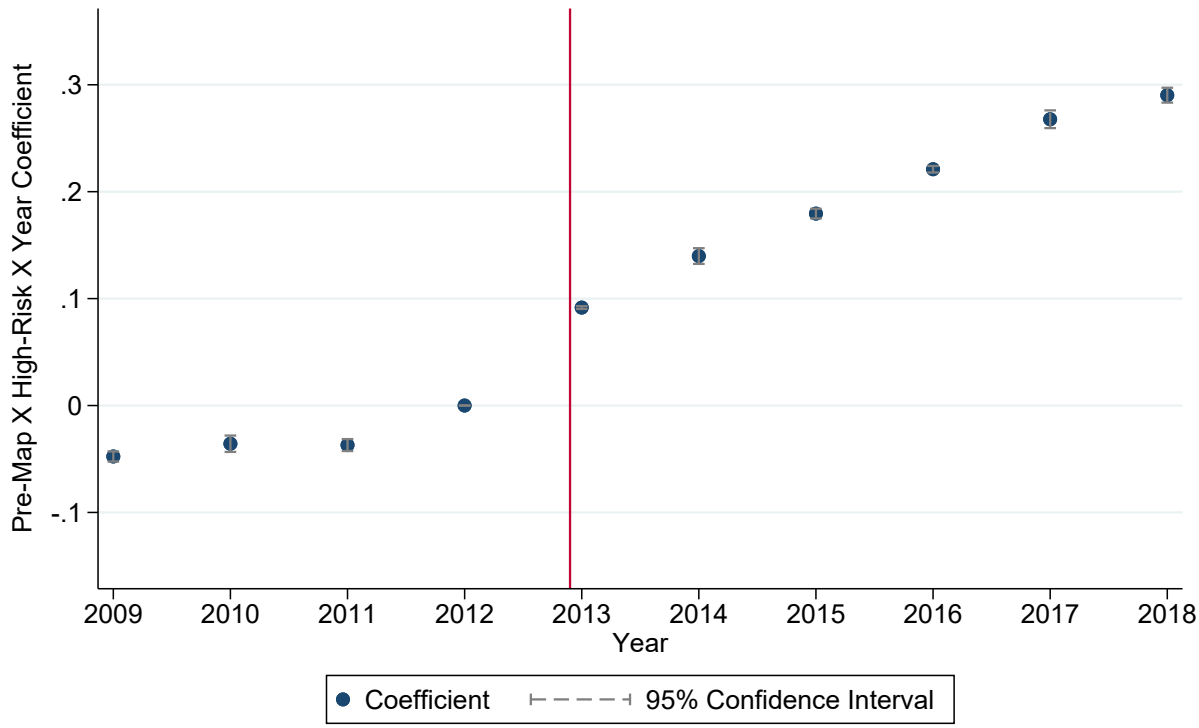
Zachry, B. C., W. J. Booth, J. R. Rhome, and T. M. Sharon (2015). A national view of storm surge risk and inundation. *Weather, Climate, and Society 7*(2), 109 – 117.

Figure 1: Distribution of Pre- vs Post-Map, High- vs Low-Risk Houses in the United States



Note: This figure plots the transacted Zillow properties in the United States. Properties are colored according to their *High-Risk* and *Pre-Map* status . The darker colors (Red and Purple) represent *Pre-Map* and *Post-Map* properties in high-risk zones. The brighter colors (yellow and lime green) represent *Pre-Map* and *Post-Map* properties in low-risk zones. Grey areas are those for which digital flood maps are not available.

Figure 2: Relative Effect of Flood Insurance Rate Reform on Premiums

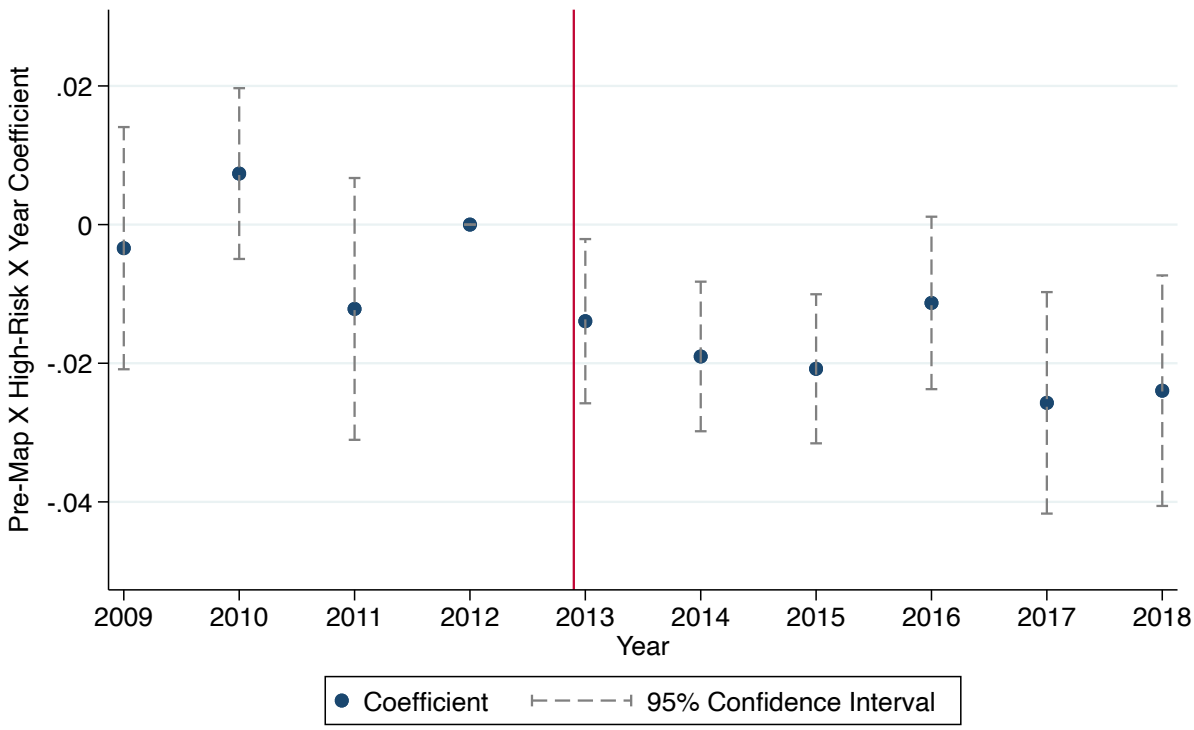


Note: Using the FEMA policies dataset, this figure plots the yearly estimates for *High-Risk*, *Pre-Map* homes (Blue Line) and the 95% confidence interval from the following regression

$$Premium_{i,t} = \sum_{y=2009}^{2019} \beta_y \times High\text{-}Risk_i \times Pre\text{-}Map_i \times \mathbf{1}_t^y + \mathbf{LOT} + FE_{zip \times age} + FE_{zip \times Loc \times t} + \epsilon_{i,j,t} \quad (1)$$

where *Premium* is the premium from a 250k coverage policy in \$1,000, $\mathbf{1}_t^y$ is an indicator that takes a value of one if t is in year y. *Loc* is defined by longitude and latitude rounded to one decimal place. Note that this is the finest longitude and latitude that NFIP data provide. **LOT** includes all lower-order interactions between *High-Risk*, *Pre-Map*, and the year indicators, as well as standalone terms that are not absorbed by fixed effects. Standard errors are two-way clustered by quarter and zip code.

Figure 3: Relative Effect of Flood Insurance Rate Reform on House Prices

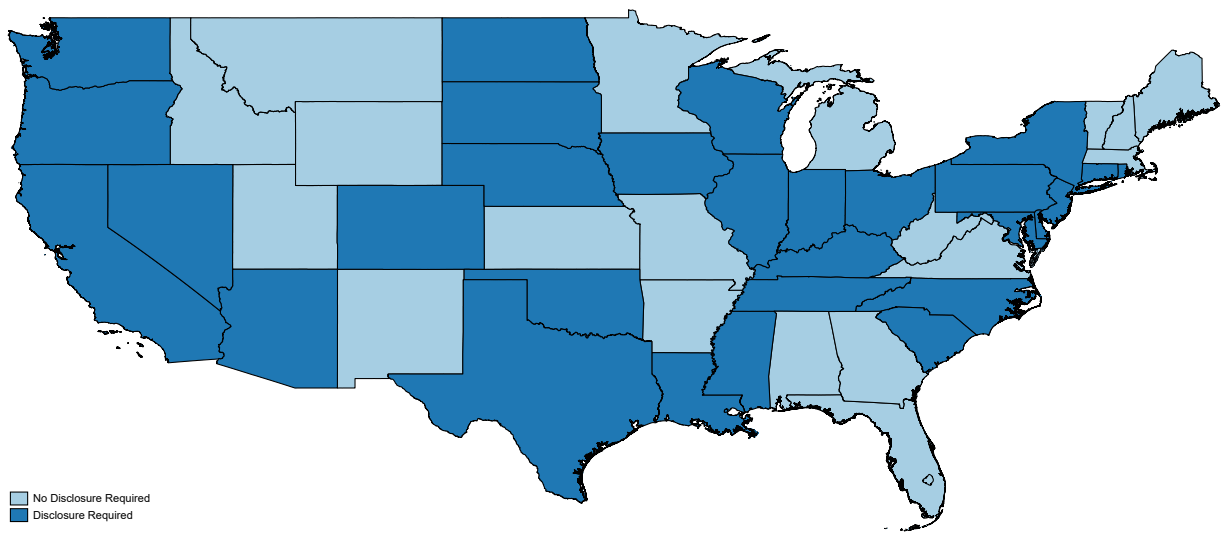


Note: This figure plots the yearly estimates for *High-Risk*, *Pre-Map* homes (blue dots) and the 95% confidence interval from the following regression

$$Log(Price)_{i,t} = \sum_{y=2009}^{2018} \beta_y \times High\text{-}Risk_i \times Pre\text{-}Map_{it} \times \mathbf{1}_t^y + \mathbf{LOT} + FE_{zip \times age} + FE_{zip \times loc \times \#bedrooms \times t} + \epsilon_{i,j,t}$$

where $\mathbf{1}_t^y$ is an indicator that takes a value of one if t is in year y. **LOT** includes all lower-order interactions between *High-Risk*, *Pre-Map*, and the year indicators, as well as standalone terms that are not absorbed by fixed effects. Fixed Effects are as described in 5.1 and correspond to the benchmark model of Column (3) of Table 2. Standard errors are two-way clustered by quarter and zip code.

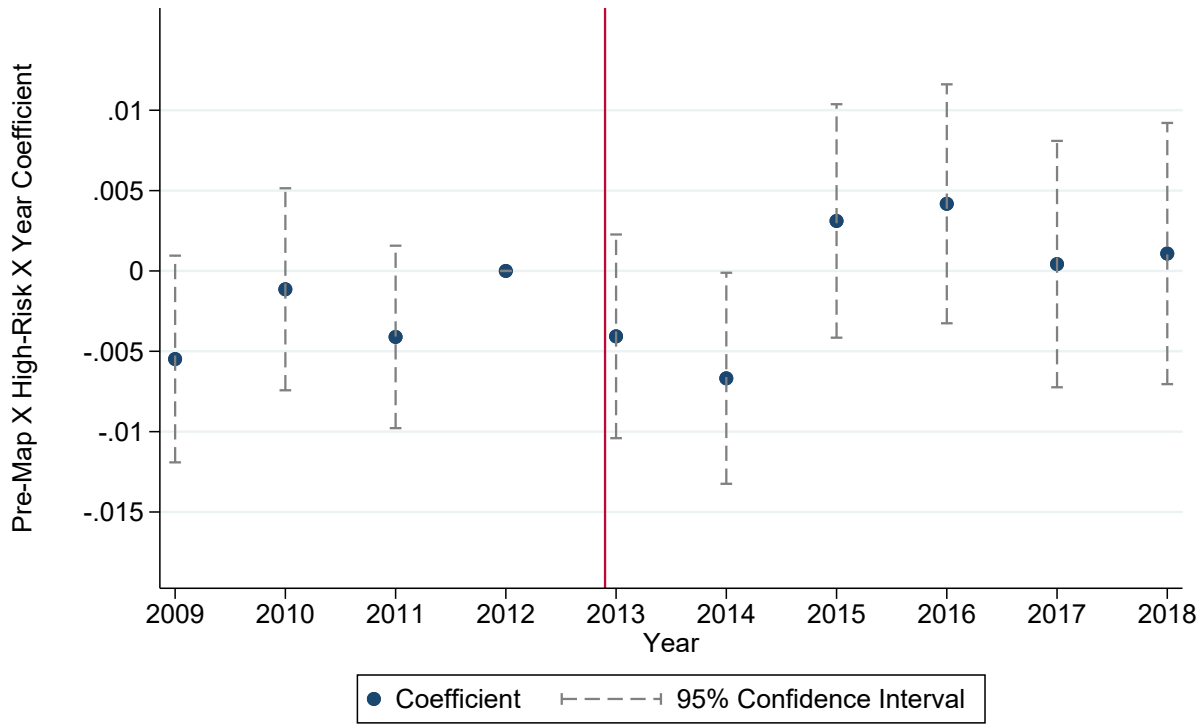
Figure 4: Requirements on Flood Zone Disclosure Across States



Note: This figure plots the state-level requirements on flood zone disclosure by propoerty sellers, based on a FEMA 2022 Report.[a] The lighter shade indicates no disclosure. The darker shade indicates that the seller is required to disclose whether the house is located in a High-Risk zone.

[a] See, `https://www.fema.gov/sites/default/files/documents/fema_state-flood-risk-disclosure-best-practices_07142022.pdf`. Tennessee requires sellers to disclose whether flood insurance is required to property buyers (but not renters). We classify Tennessee as requiring disclosure.

Figure 5: Relative Effect of Flood Insurance Rate Reform on House Transaction Probability



Note: This figure plots the yearly estimates for *High-Risk*, *Pre-Map* homes (blue dots) and the 95% confidence interval from the following regression

$$\mathbf{1}_{i,y}^{Transacted} = \sum_{y=2009}^{2018} \beta_y \times High\text{-}Risk_i \times Pre\text{-}Map_{it} \times \mathbf{1}_t^y + \mathbf{LOT} + FE_{zip \times age} + FE_{zip \times loc \times \#bedrooms \times t} + \epsilon_{i,j,t}$$

LOT includes all lower-order interactions between *High-Risk*, *Pre-Map*, *Post-Reform* and the year dummies, as well as standalone terms that are not absorbed by fixed effects. Fixed Effects are as described in Section 5.1 and correspond to the benchmark model of Column (3) of Table 2. Standard errors are two-way clustered by quarter and zip code.

Table 1: Summary statistics

	N	Mean	SD	25 Pctl	Median	75 Pctl
Sales Price($1000s)	11,106,255	301.29	321.58	136.00	219.00	351.14
High-Risk	11,106,255	0.10	0.30	0.00	0.00	0.00
Pre-Map	11,106,255	0.37	0.48	0.00	0.00	1.00
High-Risk&Pre-Map	11,106,255	0.04	0.20	0.00	0.00	0.00
Sales Year	11,106,255	2,013.81	2.84	2,011.00	2,014.00	2,016.00
Built Year	11,106,255	1,985.46	22.92	1,971.00	1,990.00	2,004.00
Property Age	11,106,255	28.41	23.13	10.00	23.00	43.00
# Bedrooms	11,106,255	2.47	1.56	2.00	3.00	3.00
Building Sq. Ft.	11,106,255	2,022.32	2,535.78	1,347.00	1,777.00	2,392.00
Dist. to Risk Zone Border (miles)	10,869,922	0.45	0.66	0.09	0.26	0.57
Ave. Premium ($1000s)	11,106,255	0.44	0.42	0.27	0.30	0.40
Storm Surge	11,106,255	0.08	0.27	0.00	0.00	0.00
Sea Level Rise	11,106,255	0.06	0.23	0.00	0.00	0.00
Dist. to coast (miles)	3,472,921	1.45	1.38	0.29	0.98	2.31
Dist. to coast (11 Bins)	11,106,255	9.21	3.09	8.00	11.00	11.00
Has Basement	11,106,255	0.12	0.33	0.00	0.00	0.00
Storm-Surge	7,220,657	0.13	0.33	0.00	0.00	0.00
Buyer Morgage	10,266,471	0.53	0.50	0.00	1.00	1.00

Note: This table presents summary statistics of variables used in the analyses.

Table 2: The Effect of Flood Insurance Rate Reform on House Prices

	Log(Price)			Price ($1000s)
	(1)	(2)	(3)	(4)
High-Risk × Pre-Map × Post-Reform	-0.023***	-0.018**	-0.021***	-12.292***
	(-3.69)	(-2.46)	(-3.92)	(-4.52)
High-Risk × Post-Reform	-0.002	-0.005	0.004	6.674***
	(-0.36)	(-0.71)	(1.13)	(3.55)
Pre-Map × Post-Reform	-0.009*	-0.019	-0.008	-12.805***
	(-1.77)	(-1.11)	(-1.25)	(-4.11)
High-Risk × Pre-Map	-0.015	1.598***	0.002	-0.445
	(-1.29)	(9.71)	(0.31)	(-0.14)
High-Risk	0.100***		0.036***	11.880***
	(8.51)		(6.20)	(4.57)
Pre-Map	0.003	-0.052	-0.004	10.565***
	(0.37)	(-0.30)	(-0.63)	(4.13)
Sq Ft	0.044***		0.057***	24.708***
	(4.93)		(4.11)	(4.26)
Zip X Age FE	Y	Y	Y	Y
Zip X Year X Beds FE	Y	Y	N	N
Property FE	N	Y	N	N
Zip X Loc X Year X Beds FE	N	N	Y	Y
Outcome Mean	12.320	12.240	12.256	282.320
Outcome SD	0.724	0.696	0.719	308.617
Observations	11,106,255	5,030,670	4,294,716	4,294,716

Note: This table presents OLS regressions where the dependent variable is log house prices. The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 3: Effect of Rate Reform on House Prices by Insurance Coverage

	Price ($1000s)		
Sample	High Coverage	Low Coverage	All
High-Risk × Pre-Map × Post-Reform	-17.714***	-4.747**	-5.493**
	(-3.62)	(-2.27)	(-2.62)
High-Risk × Pre-Map × Post-Reform × High Coverage			-11.333**
			(-2.28)
Sample	High Coverage	Low Coverage	All
Lower-Order Terms & Sq Ft	Y	Y	Y
Zip X Age FE	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y
Outcome Mean	368.023	193.896	282.136
Outcome SD	363.583	205.762	308.905
Observations	2,162,319	2,107,008	4,275,932

Note: This table presents OLS regressions where the dependent variable is dollar house prices. We repeat our main specification from Column (4) of Table 2, using houses with below-median coverage amount in Column (1) and those with above-median coverage amount in Column (2). In Column (3), we include all houses. The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 4: Heterogeneous Effects of Rate Reform on House Prices across Different Flood Risks

	Log(Sales Price)	
	(1)	(2)
High-Risk × Pre-Map × Post-Reform	-0.012**	-0.013**
	(-2.18)	(-2.11)
High-Risk × Pre-Map × Post-Reform × Sea Level Rise	-0.029**	-0.021*
	(-2.45)	(-1.81)
High-Risk × Pre-Map × Post-Reform × 1st St Flood Factor		-0.003
		(-0.65)
High-Risk × Pre-Map × Post-Reform × Storm-Surge		0.013
		(1.49)
High-Risk × Pre-Map × Post-Reform × > 3 Historic Floods		0.009
		(0.76)
High-Risk × Pre-Map × Post-Reform × Distance to Water		0.004
		(0.92)
Sample	All	All
Lower-Order Terms & Sq Ft	Y	Y
Zip X Age FE	Y	Y
Zip X Loc X Year X Beds FE	Y	Y
Outcome Mean	12.256	12.256
Outcome SD	0.719	0.719
Observations	4,294,716	4,294,716

Note: This table presents OLS regressions similar to Column (3) of Table 2 where the dependent variable is log house prices. The main independent variables include *High-Risk* × *Pre-Map* × *Post-Reform*, and its interaction with another measure of flood hazard. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 5: The Effect of Rate Reform on House Prices and Exposure to Sea Level Rise

Sample	Not Exposed to Sea Level Rise			Exposed to Sea Level Rise		
Dependent Variable	Price	Same-Yr Premium	2018 Premium	Price	Same-Yr Premium	2018 Premium
	(1)	(2)	(3)	(4)	(5)	(6)
High-Risk × Pre-Map × Post-Reform	-4.823**	0.085***	0.128***	-25.845***	0.116***	0.168***
	(-2.19)	(5.53)	(7.19)	(-3.64)	(6.05)	(7.78)
Lower-Order Terms & Sq Ft	Y	Y	Y	Y	Y	Y
Zip X Age FE	Y	Y	Y	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y	Y	Y	Y
Outcome Mean	275.208	0.447	0.433	336.604	0.767	0.764
Outcome SD	295.978	0.312	0.297	383.973	0.544	0.547
Observations	3,874,700	2,993,725	2,909,157	375,424	325,498	321,579

Note: This table repeats Columns (3) of Table 2 with two subsamples separately. In Columns (1)-(3), we use the sample of homes not exposed to sea level rise at six feet. In Columns (4)-(6), we use the sample of homes exposed to sea level rise. The dependent variable is house prices in thousands of dollars in Columns (1) and (3) and is the flood insurance premium for $250,000 building coverage in thousands of dollars in Columns (2) and (4). Panel A matches premiums from policy year t with house transactions that take place in policy year t. Panel B replaces premiums for transactions that take place between 2013 and 2018 using premiums from 2018. The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. t-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 6: Effect of Rate Reform on House Prices and Sea Level Rise by Insurance Coverage

	Price ($1000s)	
Sample	High Coverage	Low Coverage
High-Risk × Pre-Map × Post-Reform	-8.223*	-3.992*
	(-1.91)	(-1.84)
High-Risk × Pre-Map × Post-Reform × Sea Level Rise	-19.467*	-10.575
	(-1.71)	(-1.53)
Sample	High Coverage	Low Coverage
Lower-Order Terms & Sq Ft	Y	Y
Zip X Age FE	Y	Y
Zip X Loc X Year X Beds FE	Y	Y
Outcome Mean	368.023	193.896
Outcome SD	363.583	205.762
Observations	2,162,319	2,107,008

Note: This table presents OLS regressions where the dependent variable is dollar house prices. We repeat our main specification from Column (4) of Table 2, using houses with below-median coverage amount in Column (1) and those with above-median coverage amount in Column (2). *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 7: The Effect of Rate Reform on Buyers' Mortgage Take-up

	Buyer Takes Out Mortgage		
	(1)	(2)	(3)
High-Risk × Pre-Map × Post-Reform	-0.014***	-0.016**	-0.010**
	(-3.82)	(-2.39)	(-2.41)
Lower-Order Terms & Sq Ft	Y	Y	Y
Zip X Age FE	Y	Y	Y
Zip X Year X Beds FE	Y	Y	N
Property FE	N	Y	N
Zip X Loc X Year X Beds FE	N	N	Y
Outcome Mean	0.491	0.431	0.471
Outcome SD	0.500	0.495	0.499
Observations	9,761,848	4,545,663	3,918,114

Note: This table repeats Columns (1)-(3) of Table 2, replacing the dependent variable with an indicator for whether the buyer uses a mortgage at the time of the property transaction. The observations are at the house-transaction level. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. Pre-Map (Orig) is an indicator that takes a value of one if a house was *originally* built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 8: Effect of Rate Reform on House Prices by State Disclosure Requirement and Buyer Type

	Log(Price)					
Sample	No Disclosure (1)	Disclosure (2)	All (3)	Primary (4)	Non-Primary (5)	All (6)
High-Risk × Pre-Map × Post-Reform	-0.021***	-0.034***	-0.017**	-0.017***	-0.035***	-0.012**
	(-3.07)	(-4.22)	(-2.67)	(-3.54)	(-2.88)	(-2.55)
High-Risk × Pre-Map × Post-Reform × Disclosure			-0.013			
			(-1.24)			
High-Risk × Pre-Map × Post-Reform × Non-Primary						-0.014*
						(-1.85)
Sample	No Disclosure	Disclosure	All	Primary	Non-Primary	All
Lower-Order Terms & Sq Ft	Y	Y	Y	Y	Y	Y
Zip X Age FE	Y	Y	Y	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y	Y	Y	Y
Outcome Mean	12.135	12.419	12.256	12.309	12.102	12.256
Outcome SD	0.685	0.731	0.719	0.677	0.784	0.719
Observations	2,475,082	1,819,634	4,294,716	2,989,069	1,068,273	4,294,716

Note: This table presents OLS regressions where the dependent variable is log house prices. We repeat our main specification from Column (3) of Table 2, using the transactions in states that do not require any disclosure in Column (1) and using states that require disclosure in Column (2). We use the sample of houses sold to primary owners in Column (4) and those sold to non-primary owners in Column (5). The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table 9: The Effect of Rate Reform on Rebuilding Activities

	1(Demolished)*1M	1(Rebuilt)*1M	1(Demolished or Rebuilt)*1M
High-Risk × Pre-Map (Orig) × Post-Reform	51.397***	86.763*	138.112***
	(3.81)	(1.88)	(2.87)
Lower-Order Terms & Sq Ft	Y	Y	Y
Zip X Age FE	Y	Y	Y
Zip X Year X Beds FE	Y	Y	Y
Outcome Mean	23.986	302.047	326.025
Observations	240,260,377	240,260,377	240,260,377

Note: This table repeats Column (1) of Table 2, replacing the dependent variable with an indicator for whether a house is rebuilt in a year, multiplied by one million. In Column (1), the dependent variable is one if the house in that year is matched to a permit that is of the type "New Building", where the permit year is after the initial year built of the property. The dependent variable also equals one if the year equals a built year that is later than the built year based on the property from tax assessor data. In Column (2), the dependent variable is one if the house in that year is matched to a permit that is of the type "Demolition", where the permit year is after the initial year built of the property. In Column (3), the dependent variable equals one if either the dependent variable for column (1) or (2) is one. The observations are at the property-year level, not conditional on a house being transacted. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. Pre-Map (Orig) is an indicator that takes a value of one if a house was *originally* built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and year. ***p<0.01, **p<0.05, *p<0.1.

Table 10: The Effect of Rate Reform on House Prices — Built Around Map Year or Boundary

	Log(Sales Price)	
	(1)	(2)
High-Risk × Pre-Map × Post-Reform	-0.037**	-0.016***
	(-2.47)	(-2.76)
Sample	MapYr+-3	250ft
Lower-Order Terms & Sq Ft	Y	N
Zip X Age FE	Y	Y
Zip X Year X Beds FE	Y	Y
Zip X Loc X Year X Beds FE	N	Y
Outcome Mean	12.039	12.231
Outcome SD	0.688	0.717
Observations	397,835	1,202,817

Note: This table presents OLS regressions similar to Columns (1) and (3) of Table 2. We restrict our sample to houses that were built within three years of the local map establishment in Column (1). We restrict our analysis to properties within 250 feet of the border in Column (2). The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

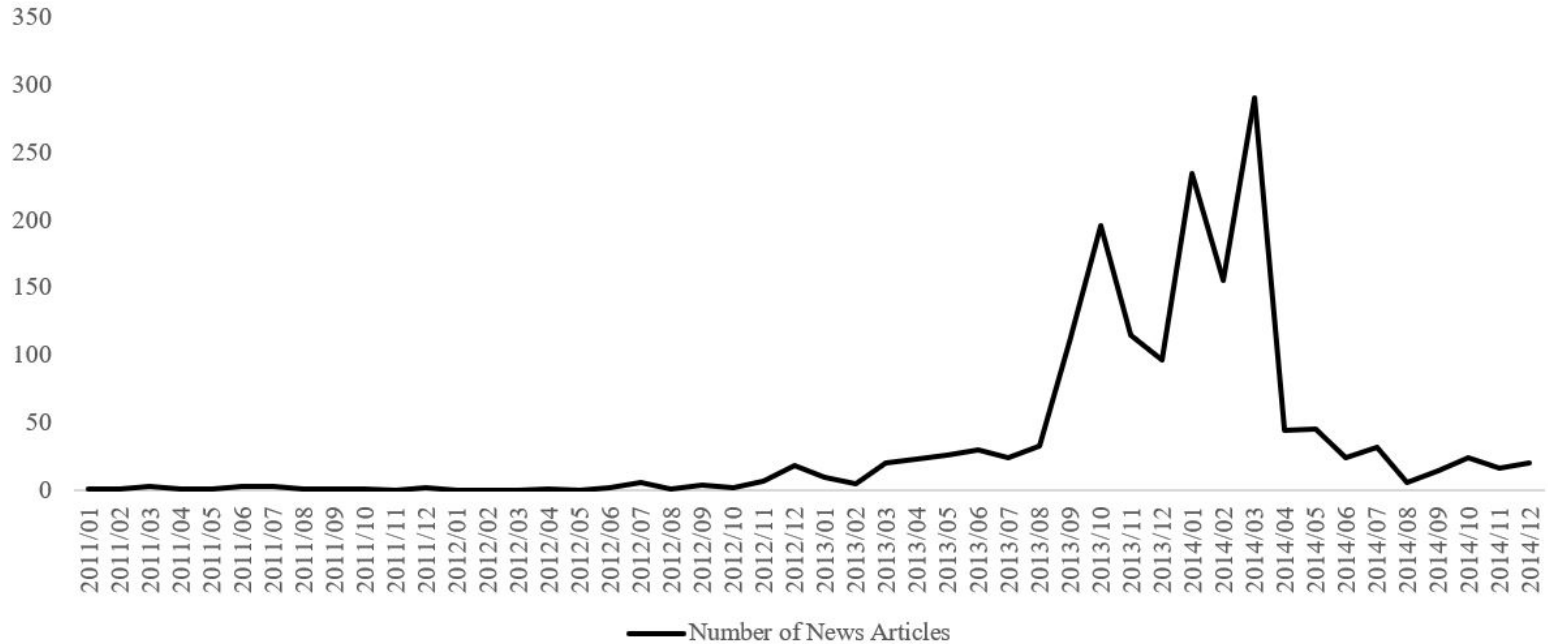
Table 11: The Effect of Rate Reform on House Prices — Additional Flood Risk Controls

	Log(Sales Price)				
	(1)	(2)	(3)	(4)	(5)
High-Risk × Pre-Map × Post-Reform	-0.017***	-0.013**	-0.017***	-0.017***	-0.017***
	(-3.27)	(-2.59)	(-3.61)	(-3.51)	(-3.41)
Hazard Measure × Pre-Map × Post-Reform	-0.003	-0.003	-0.002	0.002	-0.003
	(-0.34)	(-1.49)	(-0.35)	(0.42)	(-0.37)
Hazard Measure	Sea Level Rise	1st St Flood Factor	Storm Surge	Dist to Water	>3 Floods
Lower-Order Terms & Sq Ft	Y	Y	Y	Y	Y
Zip X Age FE	Y	Y	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y	Y	Y
Outcome Mean	12.256	12.256	12.256	12.256	12.256
Outcome SD	0.719	0.719	0.719	0.719	0.719
Observations	4,294,716	4,294,716	4,294,716	4,294,716	4,294,716

Note: This table presents OLS regressions similar to Column (3) of Table 2. On top of the fixed effects used in Column (3) of Table 2, additional lower-order terms involving Hazard measures is added as a control variable. *Hazard* is an indicator for whether or not the house is exposed to six feet of sea level rise in Column (1); the standardized value of First Street Foundation's flood factor in Column (2); an indicator for whether or not the house is exposed to storm surge in the case of a category-3 hurricane in Column (3); standardized buckets of distance to highest-tide water in Column (4); whether or not the county experienced a flood declared by FEMA as a disaster in more than three years since 1950 in Column (5). The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

A Appendix

Figure A1: Number of News Articles Related to the Reform



Note: This figure plots the number of unique news articles with the following keywords: "Biggert-Waters", "Grimm-Waters", "Homeowner Flood Insurance Affordability", or "HFIAA".

Table A1: Example Premium for Primary Residence, Single Family Home without Basement, $250k Coverage Policy

	High-Risk, Pre-Map	High-Risk, Post-Map			Low-Risk, Pre-/Post-Map
		Elev. Relative to Flood			
		+1	0	-1	
Effective Year	Premium for $250k coverage				
2008	1300	495	855	4075	735
2009	1460	530	940	4680	810
2010	1539	585	1067	4921	867
2011	1596	628	1188	4955	953
2012	1710	640	1315	4730	1002
2013	1919	616	1315	4483	1051
2014	2009	616	1315	4255	1088
2015	1992	616	1315	4255	1088
2016	2073	646	1414	3471	1113
2017	2179	756	1598	3643	1181
2018	2304	769	1592	3631	1187
2012-2018 Δ	594	129	277	-1099	185
Avg Annual Δ	5.8%	3.4%	3.5%	-3.9%	3.1%

Note: This table shows the insurance premium for a primary residence, single family home without a basement from 2008-2018. The premium is calculated assuming the policy includes $250k building coverage and $0 content coverage, and include no other adjustments that lead to rate discount. The premium rates for each year are taken from the semi-annually published NFIP Flood Insurance Manual. "Elev. Relative to Flood" refers to the elevation of the lowest floor of the house above base flood elevation. From 2014 to 2015, the premium for High-Risk, Pre-Map policies did not increase, contrary to the mandate of the law. NFIP's then chief actuary, Andy Neal, explained that "it is a combination of implementing the reserve fund and HFIAA as well as the timing of the law compared to what changes we had made."

Table A2: Additional Robustness Tests for Flood Insurance Rate Reform and House Prices

	Log(Sales Price)		
	Excluding 2013-2014	FE ×High-Risk	Additional Controls
	(1)	(2)	(3)
High-Risk × Pre-Map × Post-Reform	-0.019***	-0.027**	-0.022***
	(-3.13)	(-2.47)	(-4.19)
Lower-Order Terms & Sq Ft	Y	Y	Y
Additional Risk Controls	N	N	Y
Zip X Age FE	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y
Outcome Mean	12.267	12.252	12.256
Outcome SD	0.719	0.716	0.719
Observations	3,389,537	4,172,729	4,294,716

Note: This table presents OLS regressions similar to Column (3) of Table 2 where the dependent variable is log house prices. In Column (1), we exclude the years 2013 and 2014, the period between the two reforms. In Column (2), we include additional controls: exposure to sea level rise, First Street Foundation flood factor, exposure to storm surge, distance to highest-tide water, frequent past floods, and whether the home has a basement. In Column (3), we only include houses, for which the High-Risk dummy did not change between 1996 and 2021. The main variable of interest is the triple interaction term *High-Risk* × *Pre-Map* × *Post-Reform*. *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table A3: Co-variate Balance, with Controls

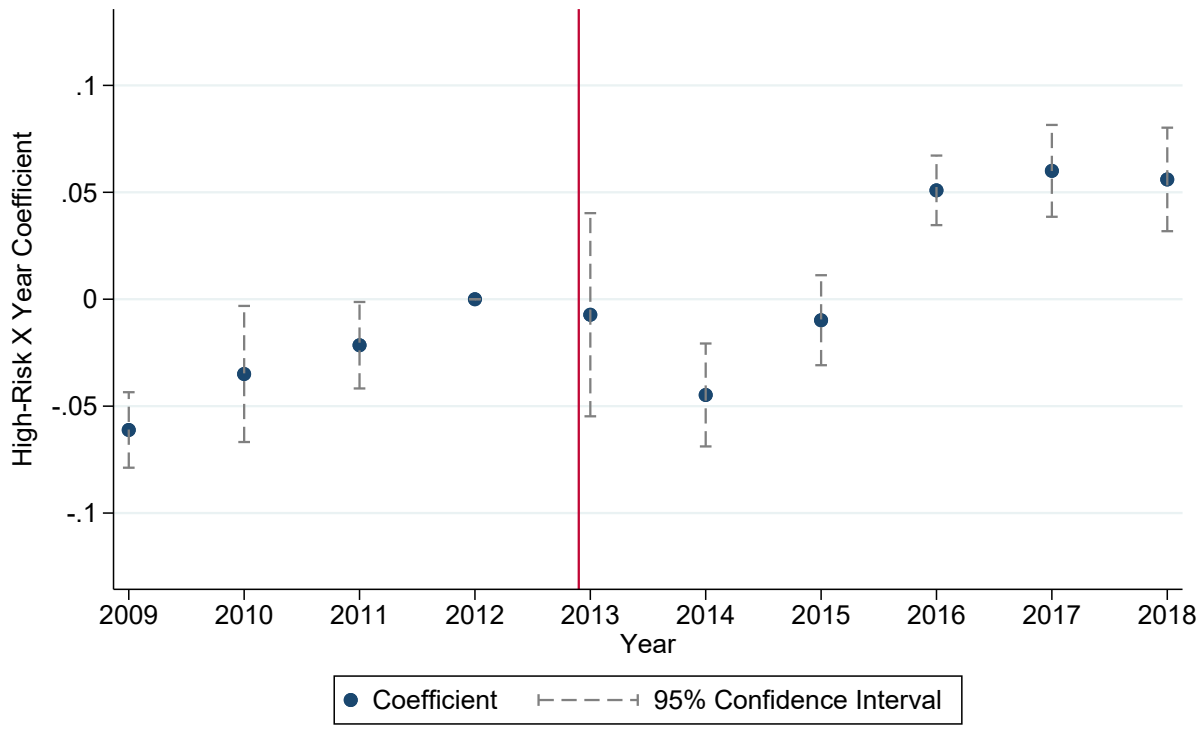
	Sea Level Rise x 100		1st St. Flood Factor		Storm-Surge x 100		Miles to Water		Basement x 100	
Risk Zone	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)	High (7)	Low (8)	High (9)	Low (10)
Pre-Map (relative to Post-Map)	1.77	-0.11	-0.12	-0.01	0.47	-0.15	-2.36	0.58	0.14	0.06
	(0.67)	(-0.30)	(-1.07)	(-0.10)	(0.32)	(-0.27)	(-0.67)	(0.31)	(0.44)	(0.15)
Risk Level	High	Low	High	Low	High	Low	High	Low	High	Low
Sq Ft	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Zip X Year Built FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Zip X Loc X Beds FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	595,382	3,542,191	595,382	3,542,191	595,382	3,542,191	595,382	3,542,191	595,382	3,542,191
Diff btwn High & Low Risk	1.88		-0.12		0.62		-2.94		0.08	
	(0.71)		(-0.90)		(0.40)		(-0.76)		(0.15)	

Note: This table presents OLS regressions using different property characteristics as the dependent variable. Observations are at the property level. First, the main variable of interest is *Pre-Map*. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. Panel A and B report the coefficient estimates on Pre-Map. Panel A does not include any controls or fixed effects. Panel B includes square footage, zip by year built fixed effects and zip by longitude/latitude (rounded to two decimal places) by number of bedrooms fixed effects. Odd-numbered columns only include High-Risk houses in the sample whereas even-numbered columns only include Low-Risk houses in the sample. At the bottom of each panel, we report the difference between the coefficients between the High-Risk and Low-Risk samples. This difference in difference is estimated by regressing the Hazard measures on High-Risk, Pre-Map, and the interaction between the two. In Panel B, for the difference in difference we also including controls and fixed effects, both interacted with the High-Risk dummy. We report the estimated coefficients on the interaction term, Pre-Map $\times$ High-Risk. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code. ***p<0.01, **p<0.05, *p<0.1.

Internet Appendices

IA Additional Figures and Tables

Figure IA.1: Relative Effect of Flood Insurance Rate Reform on Premiums, High-Risk vs Low-Risk



Note: Using the FEMA policies dataset, this figure plots the yearly estimates for β_y (blue dots) and the 95% confidence interval from the following regression

$$Premium_{i,t} = \sum_{y=2009}^{2018} \beta_y \times High\text{-}Risk_i \times \mathbf{1}_t^y + \lambda \times High\text{-}Risk_i + FE_{zip \times age} + FE_{zip \times Loc \times t} + \epsilon_{i,j,t}$$

where *Premium* is the premium from a \$250,000 coverage policy in \$1,000, $\mathbf{1}_t^y$ is an indicator that takes a value of one if *t* is in year *y*. *Loc* is defined by longitude and latitude rounded to one decimal place. Note that this is the finest longitude and latitude that NFIP data provide. Standard errors are two-way clustered by quarter and zip code.

Table IA.1: The Effect of Rate Reform on House Prices and Prior-Year Flood

	Log(Sales Price)	
High-Risk × Pre-Map × Post-Reform	-0.019***	-0.007
	(-3.66)	(-1.11)
High-Risk × Pre-Map × Post-Reform × Sea Level Rise		-0.030**
		(-2.43)
High-Risk × Pre-Map × Post-Reform × 1st St Flood Factor		-0.003
		(-0.70)
High-Risk × Pre-Map × Post-Reform × Storm-Surge		0.007
		(0.72)
High-Risk × Pre-Map × Post-Reform × Distance to Water		-0.000
		(-0.14)
High-Risk × Pre-Map × Post-Reform × Prior-Year Flood	-0.045	-0.026
	(-0.51)	(-0.29)
Lower-Order Terms & Sq Ft	Y	Y
Zip X Age FE FE	Y	Y
Zip X Loc X Year X Beds FE	Y	Y
Observations	4,787,988	4,787,988

Note: This table repeats Columns (5) and (6) of Table 4, replacing the "> 3 Past Floods" with "Prior-Year Flood", which equals one if there was a FEMA disaster declaration for a flood in the previous year. T *High-Risk* is an indicator that takes a value of one if a house is in a high-risk flood zone. *Pre-Map* is an indicator that takes a value of one if a house was built prior to flood maps being released for the area. *Post-Reform* is an indicator of whether the transaction happened after the insurance rate reform. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

Table IA.2: Book Rate for High-Risk, Pre-Map Properties

Manual Publish Year	Basic Limit ($)	Basic Rate ($ per $ of Basic Coverage)	Additional Rate ($ per $ of Additional Coverage)
2008	50000	0.76	0.54
2009	60000	0.76	0.57
2010	60000	0.76	0.6
2011	60000	0.76	0.66
2012	60000	0.76	0.77
2013	60000	0.91	0.77
2014	60000	0.85	0.78
2015	60000	0.89	0.81
2016	60000	0.94	0.95
2017	60000	0.99	0.9

Note: This table tabulates the book rate of flood insurance premiums according to FEMA's rate manuals. The second column tabulates the basic coverage limit, for which the basic rate for each dollar of coverage (third column) applies. The last column tabulates the addition rate, which is the per dollar cost of insurance for each dollar of additional coverage.

IA Data Appendix

IA.1 Construction of the NFIP policies dataset

We start with The NFIP policies dataset with a total of 60 million observations, covering the years 2009-2021. We limit our sample to only single-family housing, which is 85% of all written policies. While the Biggert-Waters Act led to changes in premium rates for all types of occupancy, the differential effect on the rate is most prominent for single-family housing, thus we focus our study on single-family housing. Furthermore, we limit our policy sample to primary residences only, which composes 80% of all policies. We drop the 1% of the policies with the property's original date of construction missing, since the original construction date is necessary for classifying whether a house is pre- or post-Map, which in turn decides whether a house is in the treatment or control group. We exclude the 4% of policies for which the coverage is less than or equal to 0. We exclude policies with premia that are smaller than the first or greater than the ninety-ninth percentile. We drop the policies with missing zip code (less than 0.01%). The NFIP dataset made an error when recording the building construction year and we fix the error whenever it is detected.

Flood zones: The NFIP policies dataset provides a granular classification for the flood zones. The A, numbered A (e.g. A1-30, except for A99), V, numbered V, and D zones are classified under the Special Flood Hazard Area (SFHA) (i.e. High-Risk flood zones), whereas A99, B, C, $\times$ zones are classified as non-SFHA (i.e. Low-Risk flood zone).[33] The rate schedules are set according to whether a property is in a High- or Low-Risk flood zone.

Premium rate: Premium rate is calculated by taking the total insurance premium of the policy, divided by the sum of building coverage and content coverage of the policy. While several other factors that could impact the premium rate (deductible amount, Community Rating System (CRS) discount, etc.), the premium rate is primarily impacted by the basic limit rates and the additional limit rates specified in the rate schedule. Holding other variables fixed, an increase in the basic limit rates and the additional limit rates would directly reflect in an increase in the overall premium rate.

Elevation difference: Elevation difference is a key metric in determining the policy premium for the post-Map properties in High-Risk zones, as well as any other properties that are self-selected

[33] Technically, A99 (areas with a 1% annual chance of flooding protected by a Federal flood control system) are also SFHA in FEMA's terminology. But for the purpose of setting insurance premium rate, A99 rate follows the same rate schedule as low-risk zones B, C and X.

to be rated as a High-Risk post-Map property. It is calculated by subtracting the property's lowest floor elevation (the elevation of the lowest floor, basement included) by the base flood elevation (the elevation, in feet, at which there is a 1% chance per year of flooding). The elevation difference is then rounded to an integer, and then the integer elevation difference is used to determine the policy premium for post-Map properties in a High-Risk zone.

IA.2 Construction of the Zillow dataset

We filter the data as follows. First, we retain only transactions of residential properties for which the price of the transaction is between $50,000 and $5,000,000. In addition, we only include transactions where both low- and high-risk properties exist within a particular geographic area as defined by our fixed effect structure. Third, we only include properties with sufficient non- missing property information.

IA.3 Merging flood insurance policies to Zillow properties

The policies dataset has been anonymized to protect the privacy of individuals; therefore, we only have latitude and longitude coordinates up to one decimal place. In order to match the policy rate data to the Zillow home transaction data, we utilized a few additional characteristics of the house. An insurance policy in the NFIP policies dataset is matched to a Zillow transacted property if (i) the latitude and longitude (rounded to one decimal place) are the same; (ii) the zip code is the same; (iii) the policy year is the same as the sale year; and (iv) the year built on the NIFP record and the Zillow record are within a three- year difference. We first aggregate the policy dataset to obtain an average premium rate, average coverage, and average claim amount for such grouping, then we merge them to properties in the Zillow dataset.