The Costs of Hedging Disaster Risk and Home Prices in the Face of Climate Change

Shan Ge, Ammon Lam, Ryan Lewis [*]

Abstract

Climate change threatens to increase the damages of natural disasters and the cost of insuring against them. We study how the cost of hedging disaster risk changes home prices by using a 2012 law that mandated flood insurance premium increases for properties discontinuously around flood zone boundaries and based on the timing of construction. With a triple-difference design, we find that homes that experience the largest increase in premiums experience the largest decline in home values. While the effect is unrelated to current hazard risk, the estimate is three times larger for homes that are exposed to sea level rise than those not exposed, suggesting that insurance pricing can accelerate the incorporation of climate risk in asset markets.

JEL Codes: G1, G14, Q54, G28, G22

Keywords: Flood insurance, real estate, home prices, climate change

---

[*] Shan Ge, New York University, sg3634@stern.nyu.edu; Ammon Lam, New York University, asl664@stern.nyu.edu; Ryan Lewis, University of Colorado Boulder, Ryan.C.Lewis@colorado.edu. This research was funded in part by the NYU Stern Center for Sustainable Business Research Grant Program. We are grateful for the comments from Asaf Bernstein and Holger Mueller, as well as seminar participants at the London Business School, the University of Colorado at Boulder, Yale, University of Chicago, NYU, the Ohio State University, University of Iowa, Rutgers, Office of Financial Research of the Department of the Treasury, Office of the Comptroller of the Currency, and CEPR. Yiwen Lu provided excellent research assistance.

1 Introduction

The total cost of billion-dollar natural hazards has increased approximately fivefold between the 1980s and 2010s.[1] Researchers attribute this to climate change and migration to disaster-prone areas, among other causes. Insurance is the main tool for households to hedge against these risks, and can be a large proportional cost—homeowners in Louisiana pay approximately 2% of their home value annually for insurance. As climate change worsens, insurance rates for many hazards can increase. However, if households fail to take into consideration changing insurance premiums, home prices, and ultimately adaptation and migration efforts, may not fully incorporate natural disaster risks.

In this paper, we investigate home price response to changes in insurance rates using a plausibly exogenous shock to flood insurance pricing in the U.S., which arose from the Biggert-Waters Act. Discrete geographic and construction year cutoffs determined the extent of premium changes which allows for a triple-difference empirical design. We find that houses that faced the largest rate increase also experienced a relative decline in prices of around 2.5%. Flood risk is directly related to climate change as sea level rise (SLR) increases future flooding risks. The effect of flood insurance premiums on home prices is three times larger for homes with SLR risk indicating that changes in current insurance premiums can accelerate the pricing of future climate risks.

We use the setting of flood insurance for analyzing the impact of insurance premiums on home prices for multiple reasons. First, flooding is particularly acute in the U.S., where around 15 million homes are currently exposed to flooding risk. Floods make up 9 of the 10 most costly disasters.[2] Moreover, it is expected to exacerbate over time due to both migration patterns and climate change. SLR is projected to bring chronic tidal flooding to over 1 trillion dollars of homes by approximately 2080 and the number of people projected to live in high-risk areas by 2050 is 7.2 million.[3] In sum, flood risk is a widespread, salient, and growing risk which is relevant for many homeowners.

Second, while homeowners' insurance rates change frequently, these changes are inextricably linked to changes in risk. Thus, comparing changes in homeowners' insurance rates to that in house prices will confound the effect of risk and premiums. To separately identify the effect of

---

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

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

[3] See Wing et al. (2022) and https://www.zillow.com/research/ocean-at-the-door-21931/.

premiums on house prices, we narrow our analysis to the period around the implementation of the Biggert-Waters Act. The reform mandated that, starting in 2013, insurance rates increased most significantly for the most highly subsidized properties: homes built prior to the creation of the local Flood Insurance Rate Map (hereafter "Pre-Map"), located in areas designated as High-Risk by National Flood Insurance Program (NFIP).[4] Official documents related to the law changes emphasized that the rate increases were to phase out subsidies on heavily subsidized properties,[5] while not explicitly conveyed any changes in riskiness. However, it is possible that the rate changes can cause market participants to update their perception of the risks of affected properties. We consider this as one channel through which insurance premiums can affect house prices.

We use the rate reform and the variation in rate increases to identify the effect of flood insurance premiums on house prices, by combining administrative data from the National Flood Insurance Program and house transaction data from Zillow between 2009 and 2018. Our main sample includes 4.7 million house transactions. We estimate a triple-difference model, where the dependent variable is log house prices and the main independent variable is a triple interaction term, *Pre-Map* × *High-Risk* × *Post-Reform*, where *Post-Reform* is an indicator for 2013 and later. In addition, we also 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 latitude and longitude rounded to two decimal places (approximately 0.8 square miles), as well as zip code. The area-by-number of bedrooms-by-year fixed effects control for different trends for homes in different areas with different characteristics. Our identification strategy assumes that differences in house values between Pre-Map and Post-Map homes would have evolved similarly between High-Risk and Low-Risk areas around the reform, after controlling for home size and our fixed effects.

The coefficient estimates on the triple interaction term, *Pre-Map* × *High-Risk* × *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 two percentage points lower in High-Risk than Low-Risk zones. This is consistent with the fact that the reform caused a larger increase in flood insurance premiums for Pre-Map houses in High-Risk zones than other houses, and the larger

---

[4] High-Risk zones are defined as regions 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.

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

premium increase caused a larger relative decline in home values.

Our results suggest that a $1 increase in today's annual insurance premiums is associated with a decline in house value by $136–$250 for those exposed to 6-feet sea level rise, expected to happen in more than 80 years, and $24–$41 for houses not exposed. A pass-through of $136–$250 is larger than what we might infer from the average discount rate of 6% on housing assets in Giglio et al. (2021). We argue that the large effect could be because premium increases today induce people to update future flood risks due to sea level rise and the associated insurance premiums. We do not observe such stronger effects in areas with higher short-term flood risk. Our results suggest that insurance rate increases can trigger people to incorporate *long-term* climate risks in today's asset values.

We provide several pieces of evidence against potential alternative explanations. 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. Sea-level-rise risk is particularly relevant as several papers (e.g., Bernstein et al. (2019)) argue that this risk began to be priced in property values around 2012-2013. After absorbing the fixed effects analogous to those we control for in our main regression analyses, the difference between Pre- and Post-Map homes is not statistically significant in either High- or Low-Risk zones. The Pre- vs. Post-Map difference is also not statistically significantly different between High- and Low-Risk zones. These results indicate that it is unlikely that our results are driven by Pre-Map, High-Risk homes being exposed to more future or current flood risk, and such risks becoming priced in property values around 2013.

Second, we address the alternative explanation that relies on the assumption that expectations of flood damages may have increased more in High-Risk zones than Low-Risk zones around 2013. If Pre-Map homes are more vulnerable to flood damages than Post-Map homes, this alternative story could explain our results. In robustness tests, we restrict our sample to homes that are close to the boundary between High- and Low-Risk zones. This sample restriction shrinks the difference in flood risks between High- and Low-Risk zones since flood risks are likely to be continuous around the border. The estimated coefficients on *Pre-Map* × *High-Risk* × *Post-Reform* stay similar in these subsamples.

Third, we explicitly consider whether property age, rather than their Pre-Map status, drives the larger price decline for Pre-Map houses in High-Risk zones. In one of our tests related to this alternative explanation, we restrict our sample to houses that were built within the year before and the year after the year the local map was established. This sample restriction shrinks the difference in terms of property age between Pre- and Post-Map homes. Our results remain robust.

Fourth, one may be concerned that certain risks (e.g., see-level-rise and storm surge risks) are higher in High-Risk zones and became intensified or priced in around 2013, and Pre-Map houses are more vulnerable to such risks. If this is the case, when we control for *Exposed* × *Pre-Map* × *Post-Reform*, the coefficient on our main triple interaction term, *High-Risk* × *Pre-Map* × *Post-Reform*, should see its magnitude diminish towards zero, where *Exposed* proxies for properties' exposure to such risks. However, the estimate of our main coefficient remains similar to our main results.

Next, 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. Our results indicate that the 2012 flood insurance rate reform first had a negative effect on the transaction probabilities of affected homes in 2013 and 2014, which then disappeared between 2015 and 2018. These patterns are consistent with details in the Biggert-Waters 2012 reform and the subsequent Homeowner Flood Insurance Affordability Act of 2014. Between Oct 1, 2013 and May 1, 2014, new buyers of Pre-Map, High-Risk homes are supposed to experience a 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 Pre-Map, High-Risk house is transacted. This aspect of the reform may have lowered the liquidity of Pre-Map, High-Risk homes. Starting from May 1, 2014, new and current owners faced the same premiums, which can explain the reversal of the declining transaction probability starting from 2015. We discuss the details of the relevant law changes in Section 2.2.

Lastly, we explore whether homeowners are more likely to rebuild their property in response to increases in flood insurance premiums. There are at least there reasons to hypothesize that higher premiums can potentially incentivize homeowners to rebuild. First, if owners elevate the foundation of Pre-Map, High-Risk homes, they can qualify for a lower flood insurance rate. 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, it is possible that households will become increasingly likely to rebuild in a way that can better withstand flood damage. Third, if some of the effects on house prices are due to updating about risks, people are more likely to rebuild to increase the flood resilience of their properties. Our results suggest that Pre-Map, High-Risk homes exposed to sea level rise are more likely to be rebuilt in response to flood insurance rate increases. However, the effect is not statistically significant at traditional thresholds. We also examine other mitigation methods based on CoreLogic permit data. However, the number of permits related to flood mitigation based on their descriptions is very low.

Our results suggest that Pre-Map, High-Risk homes exposed to sea level rise are more likely to mitigate flood risk in response to flood insurance rate increases. However, the effect is not statistically significant at traditional thresholds, which is consistent with the idea that meaningful mitigation, such as raising the foundation of a house that costs around $50,000, is more expensive than the decline in house values due to premium increases. We find similar results when we examine whether homes are more likely to be rebuilt in response to the premium changes following rate increases due to the reform.

We contribute to several strands of literature. First, our paper contributes to the literature on insurance rates and home prices, providing results in contrast with the literature. Gibson and Mullins (2020),[6] Bakkensen and Barrage (2021), and Hino and Burke (2021b) argue that the Biggert-Waters reform has no statistically significant impact on High-Risk relative to Low-Risk property values. However, since premiums only increased more for High-Risk than Low-Risk homes in the Pre-Map subsample (39% of our whole sample),[7] it is difficult to detect the effect on home prices in their difference-in-difference setting. Different from these papers, we exploit the fact that the reform instituted the largest premium increase for High-Risk, Pre-Map homes compared to High-Risk, Post-Map homes and Low-Risk homes. A recent paper by Georgic and Klaiber (2022) estimates the impact of flood insurance premium discounts on housing values and uses the Biggert-Waters reform as a robustness test for their main results. Relative to this paper, we add the new insight that exposure to climate change is closely linked to the impact of insurance premiums on house values. In addition, we argue that the effect of insurance premiums on house values can come from updating of future premiums or risks. Beyond flood insurance, Nyce et al. (2015) find a negative association between homeowners' insurance premiums rates and home value. However, homeowners' insur-

---

[6] They find a negative effect of rate increases on home prices, but the effect is not statistically significant.

[7] Figure A2 suggests that High-Risk houses on average did not experience a larger increase in premiums compared to Low-Risk houses in 2013-2015.

ance premiums rates 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.

Second, our paper is related to the literature that examines the relationship between being in a High-Risk zone and house prices. Papers in this literature find that prices of homes in High-Risk zones are between 75.5% lower and 61.0% higher than the comparison benchmark (see a literature review by Beltrán et al. (2018)). The price premiums of houses in High-Risk zones could be due to omitted amenities/characteristics associated with coastal properties. 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. We document the effect of increased premiums on home prices, which has its own important implications for the ongoing policy debate surrounding the pricing of flood insurance. By using the variation in risk zones, the prior literature also captures the effect of a few other channels, including FEMA's information on the riskiness of the property, mandatory insurance, etc. Our paper is also related to several recent papers in the flood insurance literature, including Wagner (2019), Sastry (2021), Mulder (2021), and Hu (2020). However, they do not study house prices as an outcome, which is our focus.

Third, we also contribute to the literature on climate change and real estate. With rising sea levels, flooding becomes a larger threat. The main financial tool households use to hedge against climate risk is insurance. Stroebel and Wurgler (2021) find that 42% of survey respondents think that the insurance market does not adequately price for climate risks. Our paper sheds light on how the risks of climate change can be incorporated into home values through the pricing of insurance. Relative to Bernstein et al. (2019) and Baldauf et al. (2020) that show a price discount for homes facing sea-level-rise risk, we offer evidence that insurance premiums can be an important channel through which long-term climate risks are incorporated in asset prices today.[8]

Fourth, our results have implications on the effect of other insurance premiums on home values, which have been and will likely continue to go up in areas and product lines most affected by climate change, e.g., fire insurance in California or homeowners' insurance in hurricane-exposed

---

[8] 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).

areas.[9] If climate change increases the systemic risk of disasters, insurance rates are likely to increase more widely. Our results suggest that homes more exposed to climate change can suffer significant price depreciation through rising insurance premiums.

Lastly, our setting provides a unique opportunity to examine how the cost of risk management affects the value of the underlying assets by exploiting an exogenous shock to the cost of hedging. In contrast to our paper, Ashcraft and Santos (2009) find that the cost of firms' debt did not change following the onset of credit default swaps (CDS) trading, which is not exogenous.[10] Consistent with our results, Pérez-González and Yun (2013) find that energy firms that are more exposed to weather shocks see value increase after weather derivatives became traded. The implication from our results is potentially generalizable: when the cost of hedging increases exogenously, the underlying assets can experience a value decline.

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.[11] 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. It is also responsible for floodplain management, as well as developing maps of flood hazard zones.

NFIP covers all 50 states and Puerto Rico, providing insurance to property owners, renters, and businesses. With the exception of 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 2009-2021, 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

---

[9] See, e.g., `https://www.nytimes.com/2020/09/16/climate/california-home-insurance-crisis.html` and `https://www.nytimes.com/2022/02/04/business/retirement-climate-change-homeowners-insurance.html`. Relatedly, several papers study how natural disasters and climate change affect insurance rates, including Oh et al. (2021), Froot and O'Connell (1999), and Ge (2022).

[10] Saretto and Tookes (2013) find that firms maintain higher leverage ratios and longer debt maturities after their CDS became traded, which could explain the lack of response in the observed cost of debt.

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

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.[12] Homeowners in High-Risk zones are required to purchase flood insurance if they have a federally backed mortgage. 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.[13]

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.[14] Most communities have their maps 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 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.[15]

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.[16] Higher house elevation corresponds to lower premiums.

---

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

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

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

[15] After the end of our sample period, in 2021, a new NFIP rating methodology, called "Risk Rating 2.0" started pricing using more granular levels of risk.

[16] 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."

Owners of Pre-Map houses can choose to obtain an elevation certificate and obtain 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.[17] 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 The Biggert-Waters Flood Insurance Reform Act and the Homeowner Flood Insurance Affordability Act

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.[18] 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 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. 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.

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, which depends on the elevation of the house relative to the Base Flood Elevation.[19] The subsequent 2014 reform revised the increase in premiums to be between 5% and 15% annually for all Pre-Map, High-Risk homes, including those not transacted.[20] Neither the laws nor the NFIP gave projections of how premiums would change in the future, beyond NFIP's

---

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

[18] 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`

[19] The law requires that premiums be set to the full-risk rate if a Pre-Map, High-Risk 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 Pre-Map, High-Risk 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`.

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

published rate tables for the upcoming policy year.

According to the NFIP rate tables (see Table 2), from 2012 to 2018, Pre-Map, High-Risk primary residence houses experienced an annual increase in premiums of 5.8% per year and saw a cumulative increase in premiums of $594 for $250,000 coverage. 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 for $250,000 coverage.

3 Data

3.1 Flood Insurance related 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.[21] The data are available starting in 2009 and ending in 2021 at the time of our download. There are about 4.5 million policies each year. It contains detailed information on both the policy type 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 and content coverage, 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,[22] 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.

---

[21] This product uses the Federal Emergency Management Agency's OpenFEMA API but is not endorsed by FEMA. The Federal Government or FEMA cannot vouch for the data or analyses derived from these data after the data have been retrieved from the Agency's website(s).

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

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.[23] 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 Column (3) of Table A1 using houses whose High-Risk designation did not change between 1996 and 2021. Our main result holds.

3.1.3 NFIP Community Status Book

The NFIP Community Status Book contains information about the NFIP status of a community (participating/non-participating/suspended/sanctioned), a community's initial flood map date, the date of the current effective map, and the CRS discount that the community currently receives. 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.[24] We focus on instances where a transaction references only a single parcel id.

The Zillow assessor data contain information on a broad set of property information including

---

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

[24] A single assessor parcel may have many transactions. Occasionally transactions will include multiple parcels under the same transaction ID.

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.

The assessor files also provide the geo-coded location of each property. We utilize the location data to provide a set of location-based risks and characteristics. First, we connect latitude and longitude to the property exposure to 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. Using the same data on SLR from NOAA, we identify the distance between a property and the current highest high tide (SLR=0). We run an analogous process to identify the property's exposure to NOAA storm surge risk (see Zachry et al. (2015)) and 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.

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 low- and high-risk properties exist within a particular geographic area as defined by our fixed effect structure. Finally, we only include properties with sufficient non-missing property information that we control for in the regression analyses. The final dataset has around 11 million transactions when including zip code level geographic effects, which reduces to 4.7 million when we condition on there being both High- and Low-Risk zones in each zip code by latitude and longitude rounded to two decimal places.

3.3 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 $290k, slightly higher than the national average for the time period. 16% of the properties in our sample are in High-Risk zones, and 39% are constructed prior to the flood map for their area. Property characteristics are otherwise in line with the housing stock in the U.S.

We match our sample with flood insurance premiums using latitude and longitude rounded to one decimal place, zip, and age. Though we have a premium for each observation in our sample, the premium data are averaged over the matched block and so are not property specific. Here 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 examine a number of property-specific flood factors. Exposure to 6-feet SRL risk is slightly lower than the number when just focusing on coastal counties (9% vs 11%). On average, our homes are 1.28 miles from the nearest high water mark. Lastly, about 13 percent of homes are exposed to storm-surge risk in the event of a level-3 hurricane.

4 Empirical 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 increase 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 from the estimated coefficient on the triple interaction term: *High-Risk* × *Pre-Map* × *Post-Reform*. We estimate the following regression using the period of 2009 to 2018:

$$\text{Log(Price)}_{i,t} = \beta_1 \times High\text{-}Risk_i \times Pre\text{-}Map_i \times Post\text{-}Reform_t + \beta_2 \times Pre\text{-}Map_i \times Post\text{-}Reform_t + \beta_3 \times High\text{-}Risk_i \times Post\text{-}Reform_t + \beta_4 \times High\text{-}Risk_i \times Pre\text{-}Map_t + \beta_5 \times High\text{-}Risk_i + \beta_6 \times Pre\text{-}Map_i + \beta_7 \times SquareFootage + FE_{zip \times age} + FE_{area \times \#bedrooms \times t} + \epsilon_{i,j,t}$$

In addition to the triple interaction term, we include the following terms: 1) *Pre-Map* × *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* × *Post-Reform*, whose coefficient captures the average change in Post-Map house prices for High-Risk regions relative to Low-Risk regions; 3) *High-Risk* × *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 relative to Post-Map houses in Low-Risk zones.

We also control for a set of highly saturated fixed effects. We include zip-by-property age fixed effects, and thereby compare transactions of houses of the same age within a zip code. At the same time, 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 and longitude rounded to two decimal places (approximately 0.8 square miles). Therefore, we are also comparing houses with the same number of bedrooms, in the same location, and transacted in the same year.

5 The Effect of Insurance Premium Reform on House Prices

Table 3 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. The estimated coefficient on the triple interaction term is -0.022, suggesting that Pre-Map homes in High-Risk zones trade at a 2.2% discount after the reform: Pre-Map minus Post-Map home values in High-Risk zones drop by 2.2% 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.

Our benchmark specification, Column (3), narrows down the property characteristic controls by including zip by rounded latitude/longitude by the number of bedrooms by year fixed effects. Here, we exploit variation across houses within the same zip code and are within the same latitude-longitude square, with the same number of bedrooms, and transacted in the same year. Throughout the paper, we use this specification as our primary analysis. In this model, the geographic controls are granular while we preserve the majority of our sample. We find a similar estimated coefficient on the triple interaction of -0.023. In Column (4), we repeat Column (3), with the dollar sales price as the dependent variable. Following the implementation of insurance price changes from the Biggert-Waters Act, we find that prices on Pre-Map, High-Risk homes fall relatively by approximately $13,000 dollars.

In Table A1 of the Appendix, we conduct four robustness tests. In Column (1), we exclude the years 2013 and 2014, the period between the two reforms. Column (2) replaces fixed effects with Zip X Age X High-Risk fixed effects and Zip X Loc X Year X Beds X 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, frequent past floods, and whether the home has a basement. In Column (4), we only include houses, for which the High-Risk dummy did not change between 1996 and 2021. The results are all similar to those in Table 3.

Figure 3 illustrates the time series of the effect of the rate reforms by using our benchmark model from Column (3) of Table 3. Specifically, we replace the triple interaction term, *High-Risk* × *Pre-Map* × *Post-Reform*, with 10 interaction terms, each being *High-Risk* × *Pre-Map* × *Year Dummy*, where *Year Dummy* is an indicator for each of the years between 2009 and 2018. In the four years prior to the rate change, we observe larger confidence bands and no individual year with a coefficient that is different from zero. This indicates that there is no pre-trend in home prices prior to the reform taking effect. After the rate changes start in 2013, we begin to see the triple interaction taking on a negative and statistically significant coefficient, implying that prices of High-Risk, Pre-Map homes fall. They continue to fall throughout the same period, though the largest drop is in the year the reform takes effect.

House prices follow closely the evolution of insurance premiums. Figure 4 repeats Figure 3, plotting the coefficients on the triple interaction term *High-Risk* × *Pre-Map* × *Year Dummy*, with the dependent variable being flood insurance premiums (in $1,000s) for $250,000 building coverage. Figure 4 indicates that the difference in Pre-Map and Post-Map insurance premiums in High-Risk zones relative to Low-Risk zones increased drastically 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 increase in the coefficient on the triple interaction term from 2011 to 2012.

6 Heterogeneous Effects

6.1 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 inform buyers that they obtain flood insurance after buyers' offers have been accepted. States have different requirements on whether sellers need to disclose if the property is in a High-Risk zone. Figure 5 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 sellers to disclose such information because buyers are more likely to take flood insurance premiums into consideration in their valuation of the property.

Columns (1)-(3) of Table 4 test our hypothesis above. We repeat our main specification in Column (3) of Table 3, 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* × *Pre-Map* × *Post-Reform* is negative and statistically significant in both columns. The magnitude is twice as large in Column (2), -0.41, as in Column (1), -0.20. 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* × *Pre-Map* × *Post-Reform* × *Disclosure*. The estimated coefficient on this term is negative and statistically significant, suggesting that the difference between the two subsamples is statistically significant. Our results are 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.

6.2 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 2014 reform capped the increase in premiums for Pre-Map, High-Risk 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 4. 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* × *Pre-Map* × *Post-Reform* is negative and statistically significant in both columns. The magnitude using the sample of non-primary owners is much larger, -0.041, compared to -0.016 for the sample of primary owners. 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* × *Pre-Map* × *Post-Reform* × *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.

7 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* × *Pre-Map* × *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 perception 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.

7.1 Co-Variate Balance

One may be concerned that Pre-Map homes in High-Risk zones are more exposed to certain risks, which began to be priced into home values around the time of the reform. For example, Pre-Map homes may be more exposed to sea-level-rise risk than Post-Map homes, especially in High-Risk zones. Table 5 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.

In Table 5, we examine whether Pre-Map properties are exposed to (a) more future flood risk (proxied by sea-level-rise exposure),[25] (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, as well as by storm surge and distance to the highest-tide water;[26] (c) whether they are more likely to have a basement, which is usually associated with lower elevation and larger damages from floods. We compare Pre- and Post-Map properties in High- and Low-Risk areas, separately, in our main regression sample. We then compare the Pre-Map-vs-Post-Map difference between High- and Low-Risk Zones.

In Panel A, we do not control for any fixed effects. In High-Risk zones, we find that Pre-Map homes are exposed to higher levels of sea-level-rise risk but less storm-surge risk. In both high-risk and low-risk zones, Pre-Map homes are more exposed to 30-year flood risk, are closer to water relative to Post-Map homes, and are much more likely to have a basement.

In Panel B, we include fixed effects analogous to those we use in our main regression, Column (3) of Table 3, 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 difference between Pre-Map and Post-Map homes becomes much smaller and are all statistically indistinguishable from zero. As the last two rows of Panel B indicate, the difference between Pre-Map and Post-Map homes is also not statistically significantly different between High- and Low-Risk zones. Table 5 also illustrates the importance of the fixed effects we choose in our main analyses to narrow down the comparison set and remove unobserved

---

[25] SLR Exposure takes a value of one if a property will experience chronic tidal flooding after 6 feet of SLR risk according to NOAA, which is estimated to happen after the year 2100.

[26] 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.

differences between homes.

7.2 Control for Property Age and Basement

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, and older houses are more vulnerable, then older houses in High-Risk zones are likely to experience a larger price drop. We address this concern in Table 6.

In Column (1), we restrict our sample to houses that were built between the two years before and after the local map year. In Column (2), we narrow the window to between one year before and after the local map year. Restricting our sample this way shrinks the difference between Pre- and Post-Map houses in terms of age and other characteristics associated with age. Our sample size shrinks by 94% in Column (1) and by 97% in Column (2).[27] The estimates of the coefficients on the triple interaction term, *High-Risk* × *Pre-Map* × *Post-Reform*, remain negative and statistically significant although noisier. The magnitude of the estimates is around twice the size of our benchmark result.

In Column (3), we control for *High-Risk* × *Property Age* × *Post-Reform* and the associated lower-order terms.[28] If the estimated coefficient on *High-Risk* × *Pre-Map* × *Post-Reform* is driven by Pre-Map houses being older, we would expect the coefficient estimate to become smaller in absolute value after controlling for *High-Risk* × *Property Age* × *Post-Reform*. We would also expect the coefficient on *High-Risk* × *Property Age* × *Post-Reform* to be negative. However, the estimate of our main coefficient stays similar to our benchmark results, and the coefficient on *High-Risk* × *Property Age* × *Post-Reform* is estimated to be close to zero. The results in Columns (1)-(3) suggest that it is unlikely the age of the property rather than the Pre- versus Post-Map status drives our results.

One may also be concerned that Pre-Map houses are more likely to have basements, which could be driving our results rather than the Pre- versus Post-Map status of the house. The results in

---

[27] 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.

[28] 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 by rounded latitude/longitude, there is little variation left in *High-Risk* × *Pre-Map* × *Post-Reform* after controlling for *High-Risk* × *Property Age* × *Post-Reform*. Hence, we replace the area-by-year-by-number of bedrooms fixed effects with zip-by-year-by-number of bedrooms fixed effects.

Panel B of Table 5 suggest that controlling for our fixed effects, Pre-Map houses are not more likely to have basements. Nonetheless, we provide additional evidence that having a basement does not drive our results. In Columns (4) and (5), we control for *High-Risk* × *Has Basement* × *Post-Reform* and all the associated lower-order terms. *Has Basement* is an indicator that equals one if the house has a basement based on Zillow data.

If the estimated coefficient on *High-Risk* × *Pre-Map* × *Post-Reform* is driven by Pre-Map houses' higher likelihood of having basements, we would expect the coefficient estimate to become smaller in absolute value after controlling for *High-Risk* × *Property Age* × *Post-Reform*. However, the estimate of our main coefficient stays similar to our benchmark results. These results suggest that it is unlikely that having a basement rather than the Pre- versus Post-Map status drives our results.

7.3 Restricting to Close-to-Border Sample

More generally, Pre-Map homes could be more vulnerable than Post-Map homes to flooding for reasons other than being older or having a basement. 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.

We repeat our main analyses using homes that are close to the boundary of High- and Low-Risk zones. Since flood (and other) risks are most likely continuous rather than being a dichotomy for houses near the flood zone borders, restricting to such a subsample should at least shrink the difference in the trend between the High- and Low-Risk zones.

Table 7 presents the results. We restrict our analysis to properties within 1000 feet of the border in Column (1), 750 feet in (2), 500 feet in (3), and 250 feet in (4). The coefficient estimates on our main variable, the triple interaction term, are stable across the four columns and remain similar to our benchmark result. This suggests that a differential time trend in a present-day flood or sea-level-rise risk is unlikely to drive our results.

7.4 Control for Other Risk Exposure

We provide another piece of evidence against the alternative hypothesis raised at the beginning of Section 7.3. 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 8.

$$\begin{aligned} Log(Price)_{i,t} = &\beta_1 \times High\text{-}Risk_i \times Pre\text{-}Map_i \times Post\text{-}Reform_t \\ &+ \beta_2 \times Hazard \times Pre\text{-}Map_i \times Post\text{-}Reform_t \\ &+ \textit{lower-order Terms} + Exposed_i + FE_{zip \times age} + FE_{area \times \#bedrooms \times t} + \epsilon_{i,j,t}. \end{aligned}$$

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 6 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); decile buckets (standardized) 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).

These four different measures reflect future (in 80+ years) flood risk related to sea level rise in Column (1), and current or medium-term flood risk in Columns (2)-(5). Houses that are more exposed to sea-level-rise risk are likely to experience worse flooding in the future, both through nuisance flooding and because sea level rise amplifies the risk of hurricane- and storm-related flooding.

If one is concerned about present-day and future flood risks, captured by *Exposed*, being correlated with High-Risk, then controlling for *Exposed* × *Pre-Map* × *Post-Reform* should address the concern. The coefficient on *Exposed* × *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 3. 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.

8 Sea-Level-Rise Exposure and Home Price Response to Insurance Rate Reform

Our main results suggest a large effect of the flood insurance rate reforms on the prices of Pre-Map, High-Risk homes: an average 2% or $13,000 relative price drop. This large effect could be driven by rate increases inducing people to update their perception of properties' risk exposure to flooding events and the associated costs of hedging this risk, which may at least partially drive our results.

To test the mechanism, we turn to variations in both current and future flood risk to examine whether the change in rates acts as a catalyst for risk updating. We examine two potential hypotheses. First, if the shock to rates prompts buyers to gather more information about the increased future risk of flooding or the associated cost, the effect is likely to be larger in places that face higher future flood exposure (e.g. those exposed to sea-level-rise risk). Alternatively, if the insurance rate change causes buyers to update the current flood risk, then the effect is likely to be larger where the current risk is higher.

In Table 9, we examine whether the geographic variation in future and current 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 to long-horizon flood risk related to sea level rise. In Column (1), we include the interaction between *Exposed* × *Pre-Map* × *Post-Reform* and an indicator for whether the property is exposed to a 6-feet sea level rise. In Columns (2)-(5), we replace the sea level rise exposure indicator with proxies of short-term flood exposure, the same ones as we used in the previous table. In Column (6), we include all of the quadruple interaction terms. For presentation, we suppress the lower-order terms.

Among all the quadruple interaction terms, only the estimated coefficients on *Exposed* × *Pre-Map* × *Post-Reform* ×*Sea Level Rise* are statistically significant both with and without other quadruple terms. The estimated coefficients are negative. The results suggest that, in response to increases in flood insurance rates, people likely update climate-related *long-run* flood risk or its associated future premium increases. 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. Our findings support our earlier argument that the observed change in premiums is not the sole driver of house price responses. The effect we estimate is likely at least partially due to updating about future flood risk and the associated costs of hedging that risk.

One may be concerned that when insurance premiums increase for Pre-Map, High-Risk homes, some of these homes will drop or decrease their flood insurance coverage. In the event of a flood, homes with no or less coverage are less likely to be repaired to a high standard, causing a decrease in home value due to owners' potential liquidity constraints. We address this concern in Table A2. We replace the ">3 Historic Floods" indicator in Columns (5) and (6) of Table 9 with an indicator "Prior-Year Flood". This variable equals one if there is a flood that FEMA declares as a disaster in the same county the year before the house transaction. The estimated quadruple interaction term involving this indicator is not statistically significant in either column, suggesting that potential recent flood damage does not drive our results.

To better understand how the house price response to insurance premium changes varies with exposure to sea level rise, in Table A3, 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 6 feet of sea level rise, prices of the Pre-Map, High-Risk homes drop by $5,378 more following the flood insurance rate reforms. The magnitude for homes exposed to sea level rise is much larger, $26,764.

Next, to understand how much house prices respond to $1 of increase in flood insurance, we want to match the premium information from NFIP to our Zillow data. Because the insurance policy data only provide 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 each year as follows.

First, we calculate the annual average premium rate (total premium divided by building plus content coverage) and the average 2009 building plus content coverage for houses within a group that shares the same characteristics as follows: NFIP latitude and longitude (rounded to one decimal place), zip code, flood zone, year built, and policy year. Then we multiply the annual average premium rate and the average 2009 coverage to obtain the average total premium. We use the coverage in 2009 so that the total premium does not change due to changing coverage as a response to changing premium rates. Second, we match the average premium rate and 2009 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.

We estimate the effect of the insurance reform on insurance premiums in Columns (2) and (5). The estimates suggest that premiums increased by $84 more for the most treated homes in the not exposed sample 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 premium per dollar of coverage is slightly larger for non-exposed homes.

The reforms stipulate that premiums will grow every year for the Pre-Map, High-Risk homes until reaching "full-risk" rates. However, households cannot observe the future rates. Columns (3) and (6) of Table A3 repeat Columns (2) and (5), using premium rates in 2018 to match home transactions between 2013 and 2018. This exercise can help us understand the magnitude of the effects if people expect the rates to be what they end up being in 2018 after the reform. The estimates suggest that premiums increased by $124 more for the most treated homes in the not exposed sample and by $165 more for these homes in the exposed sample.

Based on Columns (1) and (3), for one dollar of premium increase in 2018, house prices fall by $43 (=5.378/0.124) in the not exposed sample. If we assume that people expect the premiums to stay the same as in 2018, this result implies a discount rate of 2.3% if the average premium differential post reform stays fixed permanently. This implied discount rate is very close to the 2.6% long-run discount rate calculated by Giglio et al. (2015).

Based on Columns (4) and (6), for one dollar of premium increase in 2018, house prices fall by $162 (=26.764/0.165) in the sample exposed to sea level rise. If the premium differentials were to stay fixed, the magnitudes imply a discount rate that is too low. However, the reforms specifically provided a pathway to eventually charge "actuarially fair" rates. Indeed, the reform specified that rates can increase up to 15% per year until they reflect the underlying risk for Pre-Map, High-Risk homes, which had previously been heavily subsidized. Thus, the estimated price impact of premium changes likely embeds the expectation of future premium increases. If we take the discount rate of 2.6% in Giglio et al. (2015) as given, it is possible that people expect that the Pre-Map relative to Post-Map premium differential will cumulatively increase by \$696 (=\$26,764×2.6%) in High-Risk zones to reach steady state. It is also possible that people expect that the difference in Pre-Map and Post-Map premiums in High-Risk zones will grow by 2.0% perpetually (=2.6%-\$165/\$26,764). Our results are consistent with our earlier argument that the insurance rate reform triggers people to update their expectations of the costs associated with long-run flooding risks.

Our cross-sectional findings, combined with the relatively large pass-through from rate changes to house prices, reflect a consistent narrative. Some portion of the home price effect is directly attributable to the premium cash flows observed in our sample, but the majority of the average effect is driven by re-evaluation of the risk exposure of the property or the associated costs. In particular, buyers demand a larger sea-level-rise-related discount after an increase in insurance rates. These findings highlight that insurance markets are an important channel through which future sea-level-rise risk information becomes embedded in current prices.[29]

8.1 Climate Opinion and the Effect of Insurance Rate Reforms on House Prices

Our findings above suggest that the effect of long-term climate risk plays a role in the house price response to flood insurance premium changes. This could be due to people updating future flood risks or the associated insurance costs. Climate-change believers' expectations of future flood insurance rates without subsidies are likely higher than non-believers'. This could be the case for an average home as climate change will bring more rainfall and more flooding, and especially so for homes exposed to sea level rise. When the reforms signal that subsidies will phase out for Pre-Map, High-Risk homes, believers will make larger updates on the expected premiums for these homes than non-believers. Thus, for believers, the difference in premiums for Pre-Map relative to Post-Map homes in High-Risk zones is likely to increase by more in the future (from a negative number to

---

[29] Prior research has focused on the dissemination of scientific information as well as the role of lenders and commercial investors in driving house price response to climate risk.

zero) for climate-change believers than non-believers. Therefore, we argue that the effect of flood insurance premiums should have a larger effect in places where more people believe in climate change.

We test this hypothesis using the climate opinion survey data from the Yale Program on Climate Change. We split counties into two samples based on the percentage of adults who are worried about global warming in 2014, the earliest year for which county-level data are available. We use the median as the cutoff. A county is classified as "More Worried" if its percentage of climate change believers is higher than the median across counties and "Less Worried" otherwise.

The results are presented in Table 11. Columns (1) and (2) use the sample of less worried counties. Columns (3) and (4) use the sample of more worried counties. The coefficient on the triple interaction term, *Exposed* × *Pre-Map* × *Post-Reform* is -0.018 for the less worried counties in Column (1) and -0.031 for the more worried counties in Column (3), suggesting a larger house price effect among the more worried counties. In Columns (2) and (4), we include the quadruple interaction term, *Exposed* × *Pre-Map* × *Post-Reform* ×*Sea Level Rise*. The coefficients on the triple and quadruple interaction terms are both larger in magnitude and more statistically significant in the more worried counties than the less worried counties. This result is consistent with our hypothesis above. However, all the estimated coefficients are not statistically significantly different between the two subsamples.

9 Insurance Rate Reforms 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* × *Pre-Map* × a dummy variable for each year, as well as all lower-order (interaction) terms and the fixed effects as in Column (3) of Table 3, our benchmark regression on the price effect.

Figure 6 plots the coefficients on *Exposed* × *Pre-Map* × *year dummies*. The results indicate that the 2012 reform first had a negative effect on the transaction probabilities of Pre-Map, High-Risk 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. Between Oct 1, 2013 and May 1, 2014, new buyers of Pre-Map, High-Risk homes are supposed to experience a larger premium increase than current owners according to the 2012 reform. This would make a potential new owner's valuation of such a home lower than the current owner, lowering the probability that a Pre-Map, High-Risk house is transacted. The subsequent 2014 reform revised the increase in premiums to be between 5% and 15% annually for all Pre-Map, High-Risk homes, including those not transacted. This can explain the reversal of the declining transaction probability starting from 2015.

10 Insurance Rate Reforms and Rebuilding Activity

Lastly, we examine whether the larger rate increases for Pre-Map, High-Risk homes induce more rebuilding activities of such homes. There are at least there reasons to hypothesize that higher premiums can potentially incentivize homeowners to rebuild. First, if owners elevate the foundation of Pre-Map, High-Risk homes, they can qualify for a lower flood insurance rate. 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, it is possible that households will become increasingly likely to rebuild in a way that can better withstand flood damage. Third, if some of the effects of flood insurance premiums on house prices are due to updating about risks, people are more likely to rebuild to increase the flood resilience of their properties. Our results suggest that Pre-Map, High-Risk homes exposed to sea level rise are more likely to be rebuilt in response to flood insurance rate increases. However, the effect is not statistically significant at traditional thresholds. We also examine other mitigation methods based on CoreLogic permit data. However, the number of permits related to flood mitigation based on the permit description is very low.

Table 12 repeats Column 3 of Table 3, replacing the dependent variable with an indicator for whether a house is rebuilt in a certain year multiplied by one thousand. Observations are at the parcel-year level, not conditional on transaction. We consider a house as rebuilt in year t if the effective year built in Zillow's assessor data is t, later than the original year built. One caveat is that we only observe the latest assessor data from Zillow, so we can only observe up to one rebuilding activity for each house. If a house is rebuilt in year t, we remove later observations of the house from the sample since the house cannot be rebuilt again in our data. In Table 12, we modify the definition of Pre-Map. It takes a value of one if a house was originally built prior to flood maps being released for the area.

The estimated coefficients on the triple interaction term are negative for the entire sample, as well as the sample not exposed to sea level rise, but not statistically significant in either. The estimated coefficients are positive for the sample exposed to sea level rise, suggesting that Pre-Map, High-Risk homes are more likely to be rebuilt after the reform. In Column (3), the estimate suggests that after the reform, Pre-Map, High-Risk homes see an increase in the likelihood of being rebuilt by 15% of the mean (=0.897/5.822). However, the coefficients are not statistically significant at traditional levels, with the t-statistic being 1.49.

11 Conclusion

The Biggert-Waters Flood Reform Act of 2012 and the subsequent reform of 2014 mandated higher flood insurance premiums, a shock that increased flood insurance premiums the most for homes built prior to local flood map availability in High-Risk areas. We exploit the differential premium rate changes for different types of homes to identify the impact of flood insurance prices on house prices. We find a statistically and economically meaningful negative effect of flood insurance premiums on house values.

We also find that the negative effect of insurance premiums on house values is much larger in areas that are most likely to be impacted by climate change. Our findings suggest that the insurance premium change updates the housing market's expectation of long-run flooding risk associated with sea level rise and the costs associated with it. Insurance is therefore an important channel through which sea-level-rise risk can be incorporated into asset prices.

Our findings have implications for policies with regard to flood insurance rate setting and other insurance rate regulations (e.g., fire). While prior studies have documented little effect of flood insurance on house prices, this paper highlights that insurance premium increases will likely pass through to housing markets. Simultaneously, flood policy can be effective in changing awareness of future risks, which may not yet be fully impounded in asset prices.

References

Ashcraft, A. B. and J. A. Santos (2009). Has the cds market lowered the cost of corporate debt? *Journal of Monetary Economics 56*(4), 514–523.

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.

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.

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.

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*.

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.

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*.

Pérez-González, F. and H. Yun (2013). Risk management and firm value: Evidence from weather derivatives. *The Journal of Finance 68*(5), 2143–2176.

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.

Saretto, A. and H. E. Tookes (2013). Corporate leverage, debt maturity, and credit supply: The role of credit default swaps. *The Review of Financial Studies 26*(5), 1190–1247.

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.

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

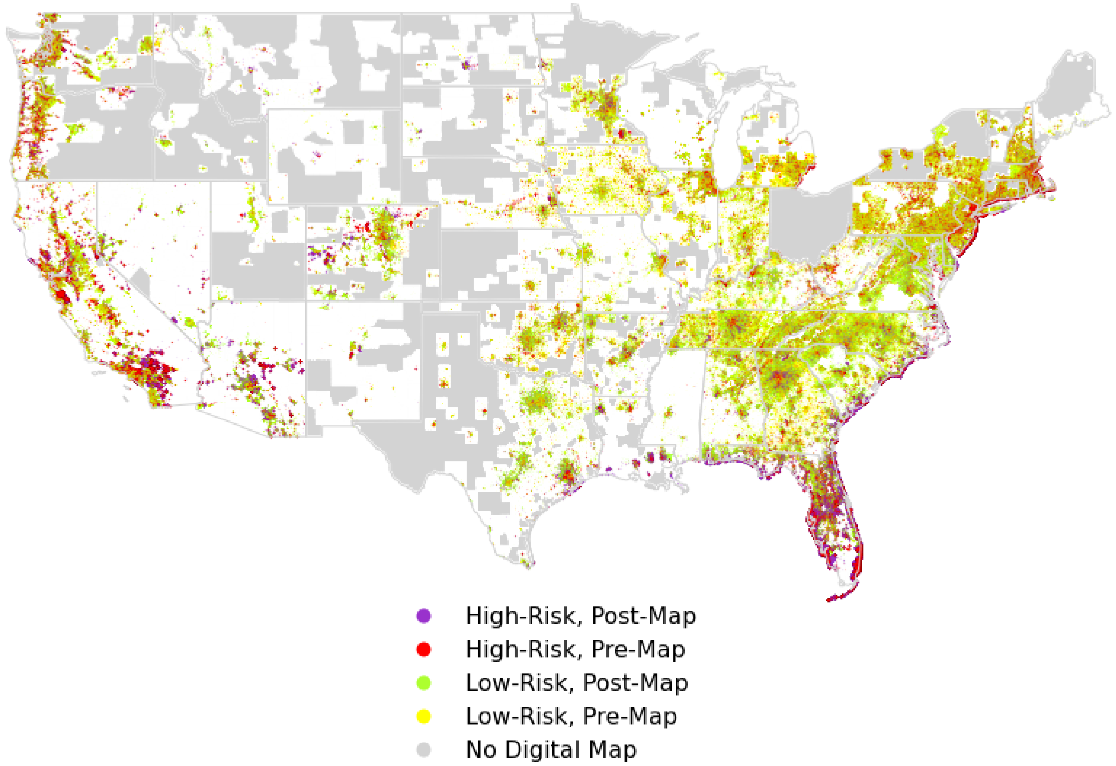
Strother, L. (2018). The national flood insurance program: a case study in policy failure, reform, and retrenchment. *Policy Studies Journal 46*(2), 452–480.

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

Wing, O. E., W. Lehman, P. D. Bates, C. C. Sampson, N. Quinn, A. M. Smith, J. C. Neal, J. R. Porter, and C. Kousky (2022). Inequitable patterns of us flood risk in the anthropocene. *Nature Climate Change 12*(2), 156–162.

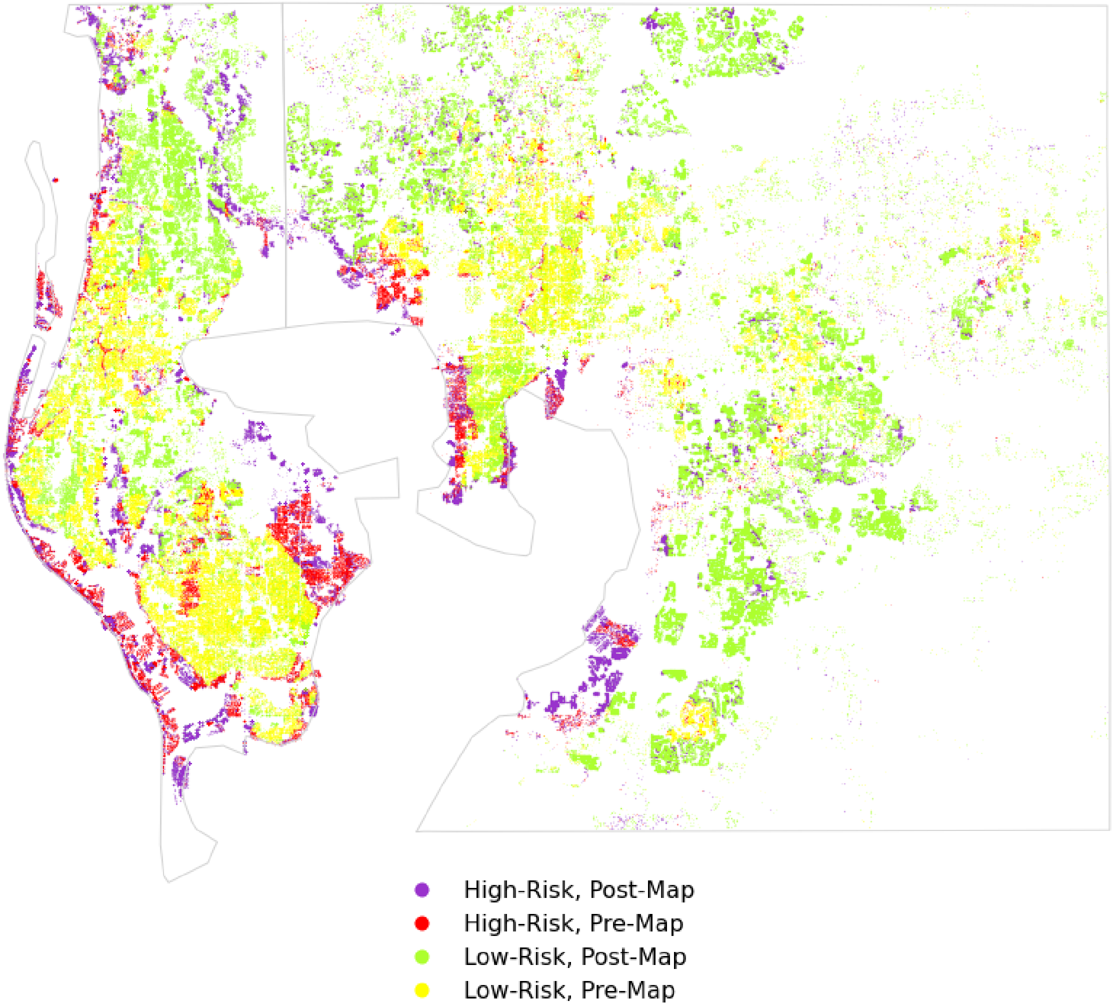
Zachry, B. C., W. J. Booth, J. R. Rhome, and T. M. Sharon (2015). A national view of storm surge risk and inundation. *Weather, Climate, and Society 7*(2), 109 – 117.

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



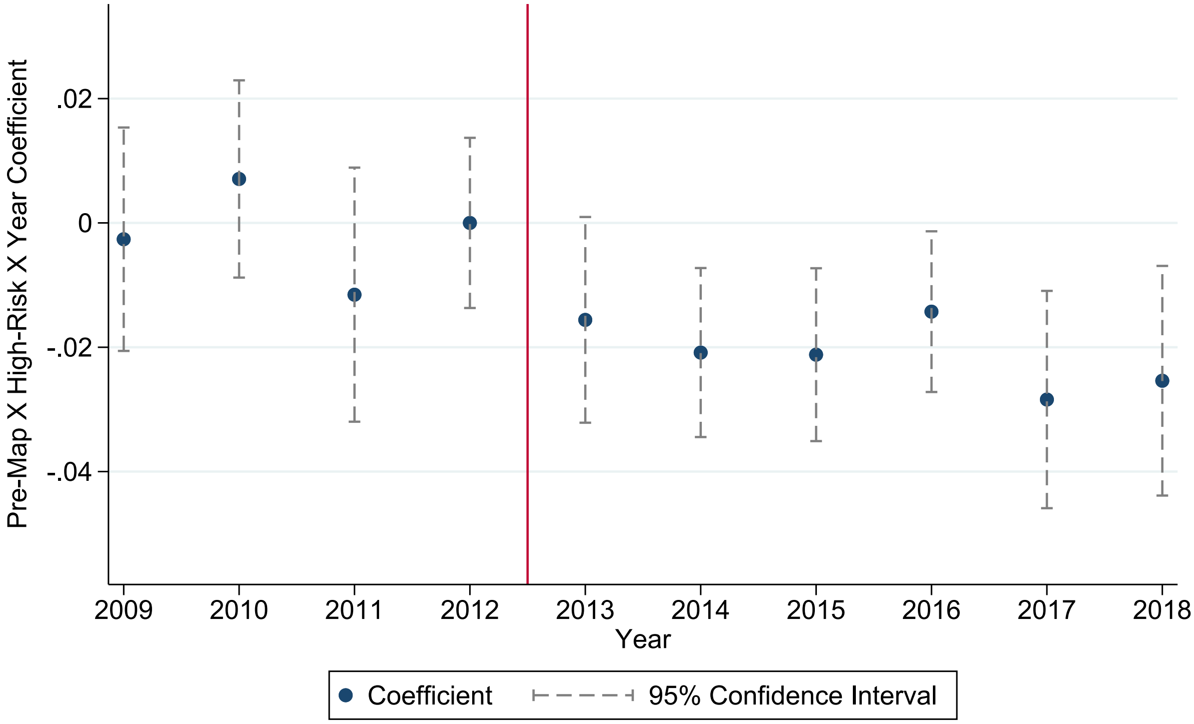
Note: This figure plots the transacted Zillow properties in the United States. Properties are colored according to their *High-Risk* and *Pre-Map* status . The darker colors (Red and Purple) represent *Pre-Map* and *Post-Map* properties in high-risk zones. The brighter colors (yellow and lime green) 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: Distribution of Pre- vs Post-Map, High- vs Low-Risk Houses in Sample County



Note: This figure the transacted properties in Pinellas county and Hillsborough county, Florida. 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.

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

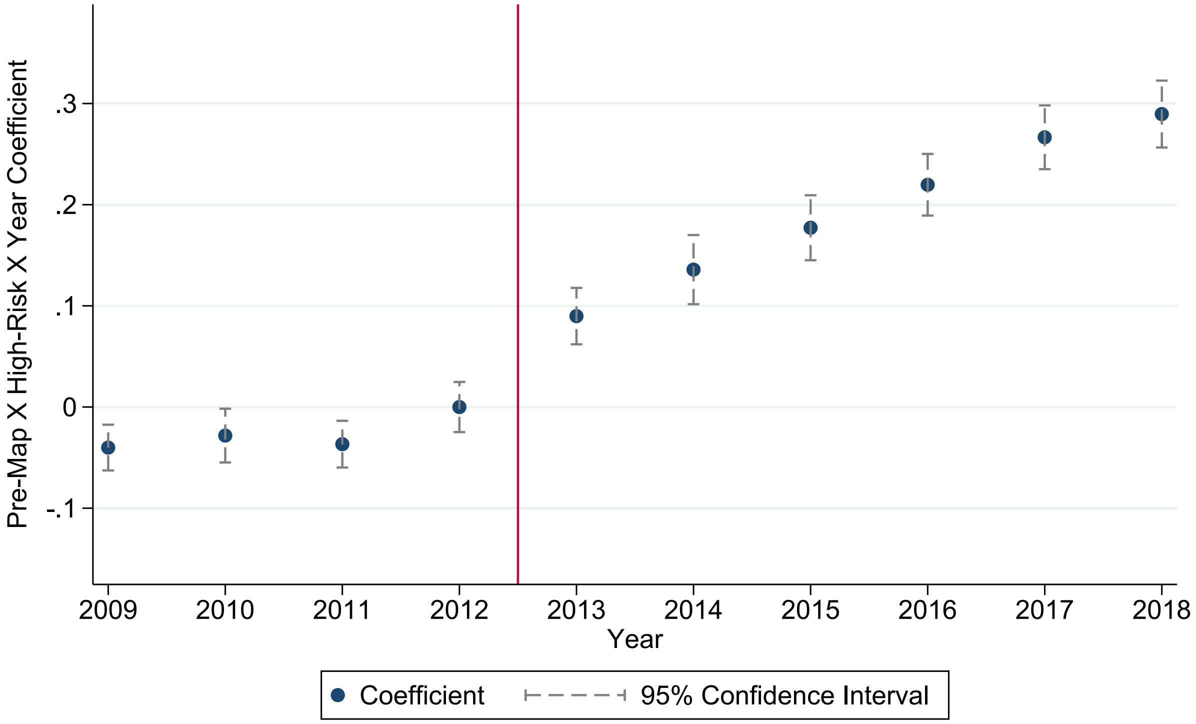


Note: This figure plots the yearly estimates for *High-Risk*, *Pre-Map* homes (blue dots) and the 95% confidence interval from the following regression

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

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 4 and correspond to the benchmark model of Column (3) of Table 3. Standard errors are two-way clustered by quarter and zip code.

Figure 4: Relative Effect of Flood Insurance Rate Reform on Premiums

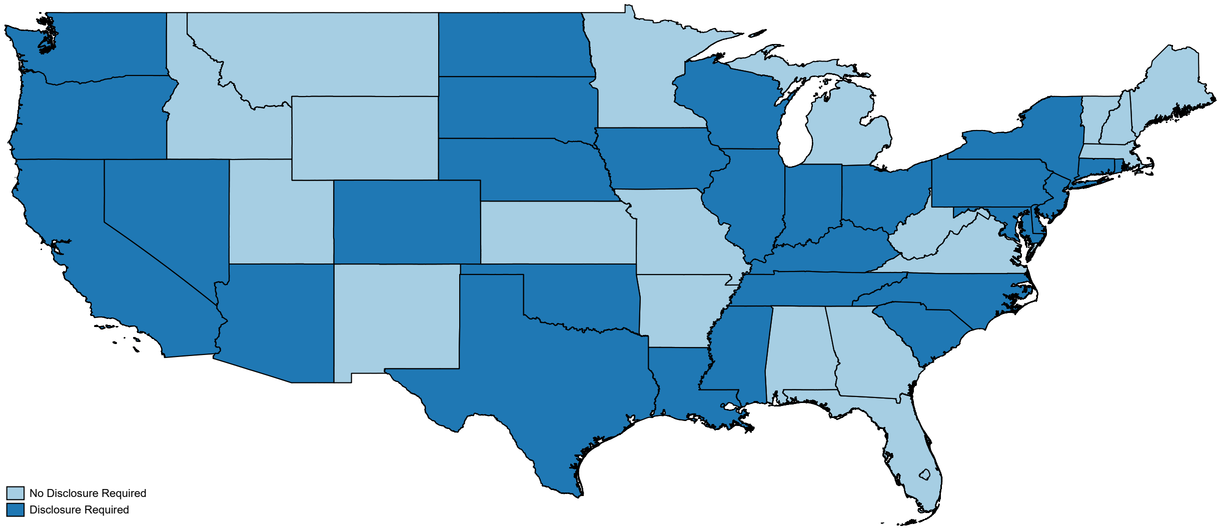


Note: Using the FEMA policies dataset, this figure plots the yearly estimates for *High-Risk*, *Pre-Map* homes (Blue Line) and the 95% confidence interval from the following regression

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

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 5: Requirements on Flood Zone Disclosure Across States

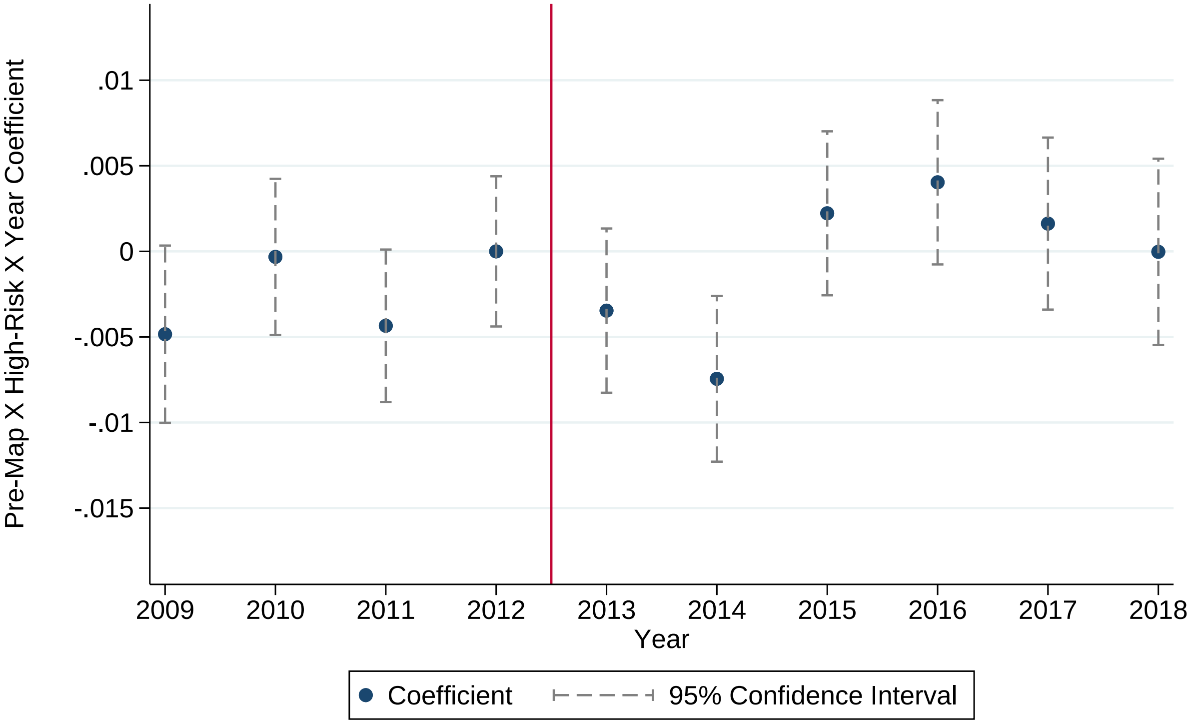


Note: This figure plots the state-level requirements on flood zone disclosure by propoerty sellers, based on a FEMA 2022 Report.[a] The lighter shade indicates no disclosure. The darker shade indicates that the seller is required to disclose whether the house is located in a High-Risk zone.

---

[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 6: 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

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

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 4 and correspond to the benchmark model of Column (3) of Table 3. Standard errors are two-way clustered by quarter and zip code.

Table 1: Summary statistics

	N	Mean	SD	25 Pctl	Median	75 Pctl
Property Variables						
Sales Price($1000s)	4,787,988	290.92	326.78	129.00	207.00	335.00
High-Risk	4,787,988	0.16	0.36	0.00	0.00	0.00
Pre-Map	4,787,988	0.39	0.49	0.00	0.00	1.00
Sales Year	4,787,988	2,013.87	2.82	2,012.00	2,014.00	2,016.00
Built Year	4,787,988	1,983.72	23.08	1,970.00	1,987.00	2,003.00
Property Age	4,787,988	30.19	23.28	11.00	26.00	45.00
# Bedrooms	4,787,988	2.44	1.56	2.00	3.00	3.00
Building Sq. Ft.	4,787,988	1,982.39	2,158.56	1,319.00	1,746.00	2,348.00
Dist. to Risk Zone Border (miles)	4,787,988	0.14	0.24	0.03	0.09	0.19
Flood Insurance Policy Variables						
Ave. Premium ($1000s)	4,787,988	0.48	0.51	0.28	0.31	0.44
Ave. Coverage ($1000s)	4,787,988	287.34	68.43	252.40	306.25	350.00
Other Risk Variables						
Exposed to 6-feet SLR	4,787,988	0.09	0.29	0.00	0.00	0.00
Storm Surge	4,787,988	0.13	0.33	0.00	0.00	0.00
Miles to Water	1,856,059	1.28	1.35	0.20	0.69	2.07
Has Basement	4,787,988	0.09	0.28	0.00	0.00	0.00

Table 2: 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 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.

Table 3: The Effect of Flood Insurance Rate Reform on House Prices

	Log(Price)			Price (1000s)
	(1)	(2)	(3)	(4)
High-Risk × Pre-Map × Post-Reform	-0.022***	-0.016**	-0.023***	-13.045***
	(-3.49)	(-2.29)	(-4.22)	(-4.76)
High-Risk × Post-Reform	-0.003	-0.006	0.005	7.174***
	(-0.44)	(-1.03)	(1.37)	(3.85)
Pre-Map × Post-Reform	-0.009*	-0.021	-0.009	-13.368***
	(-1.77)	(-1.10)	(-1.39)	(-4.11)
High-Risk × Pre-Map	-0.016		0.002	-1.219
	(-1.35)		(0.22)	(-0.37)
High-Risk	0.101***		0.036***	12.348***
	(8.63)		(6.40)	(4.85)
Pre-Map	0.004		0.001	11.423***
	(0.54)		(0.10)	(4.20)
Sq Ft	0.044***		0.058***	25.373***
	(4.94)		(4.16)	(4.31)
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	12.325	12.245	12.258	282.653
Outcome SD	0.724	0.695	0.718	307.859
Observations	11,058,391	4,538,625	4,787,988	4,787,988

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 4: 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	-0.020***	-0.042***	-0.017**	-0.016***	-0.041***	-0.013**
	(-2.97)	(-5.03)	(-2.59)	(-3.25)	(-3.39)	(-2.68)
High-Risk × Pre-Map × Post-Reform × Disclosure			-0.021*			
			(-2.02)			
High-Risk × Pre-Map × Post-Reform × Non-Primary						-0.017**
						(-2.28)
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	12.432	12.258	12.314	12.099	12.258
Outcome SD	0.685	0.728	0.718	0.675	0.784	0.718
Observations	2,741,857	2,046,131	4,787,988	3,404,274	1,383,714	4,787,988

Note: This table presents OLS regressions where the dependent variable is log house prices. We repeat our main specification from Column (3) of Table 3, 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 5: Co-variate Balance

Panel A: Without 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)	6.73*** (3.49)	0.54 (1.01)	0.66*** (5.56)	0.12*** (3.31)	-5.73*** (-3.27)	-0.84 (-1.32)	-12.02** (-2.06)	-25.36*** (-3.88)	5.14*** (8.38)	5.91*** (9.03)
Outcome Mean	37.27	3.43	5.16	10.68	36.56	8.90	0.75	1.46	5.16	10.68
Outcome SD	48.35	18.21	22.12	30.89	48.16	28.47	1.11	1.39	22.12	30.89
Observations	712,913	3,797,986	712,913	3,797,986	712,913	3,797,986	433,118	1,320,951	712,913	3,797,986
Diff btwn High & Low Risk	6.19*** (3.34)		0.55*** (4.72)		-4.89*** (-3.21)		13.34** (2.24)		-0.77 (-1.15)	

Panel B: 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)	1.14 (0.34)	-0.31 (-0.89)	-0.20 (-1.44)	-0.00 (-0.04)	1.19 (0.70)	-0.04 (-0.07)	0.47 (0.63)	0.41 (0.25)	0.21 (0.56)	-0.09 (-0.22)
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	674,181	3,665,740	674,181	3,665,740	674,181	3,665,740	402,630	1,257,342	674,181	3,665,740
Diff btwn High & Low Risk	1.45 (0.43)		-0.20 (-1.25)		1.23 (0.68)		0.06 (0.03)		0.30 (0.55)	

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 Pre-Map, High-Risk, 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 x High-Risk. *t*-statistics are reported in parentheses. Standard errors are double clustered by zip code. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table 6: The Effect of Rate Reform on House Prices — Control for Property Age and Basement

	Log(Sales Price)				
Year Built	MapYr+-2 (1)	MapYr+-1 (2)	All (3)	All (4)	All (5)
High-Risk × Pre-Map × Post-Reform	-0.041**	-0.048*	-0.019*	-0.022***	-0.018***
	(-2.08)	(-1.84)	(-1.86)	(-3.54)	(-3.61)
High-Risk × Property Age × Post-Reform			-0.000		
			(-0.30)		
High-Risk × 1(Basement) × Post-Reform				-0.007	-0.018**
				(-0.83)	(-2.09)
Lower-Order Terms & Sq Ft	Y	Y	Y	Y	Y
Zip X Age FE	Y	Y	Y	Y	Y
Zip X Year X Beds FE	Y	Y	Y	Y	N
Zip X Loc X Year X Beds FE	N	N	N	N	Y
Outcome Mean	12.020	12.009	12.271	12.271	12.258
Outcome SD	0.682	0.684	0.729	0.729	0.718
Observations	290,451	157,350	4,787,988	4,787,988	4,787,988

Note: This table presents OLS regressions similar to Columns (1) and (2) of Table 3. 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 7: The Effect of Rate Reform on House Prices — Restricting to Near Border

	Log(Sales Price)			
Distance to Border	1000ft (1)	750ft (2)	500ft (3)	250ft (4)
High-Risk × Pre-Map × Post-Reform	-0.022*** (-4.16)	-0.021*** (-4.08)	-0.019*** (-3.69)	-0.016** (-2.59)
Lower-Order Terms & Sq Ft	Y	Y	Y	Y
Zip X Age FE	Y	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y	Y
Outcome Mean	12.237	12.233	12.230	12.230
Outcome SD	0.710	0.711	0.713	0.718
Observations	3,567,819	3,100,067	2,456,190	1,529,907

Note: This table presents OLS regressions similar to Column (3) of Table 3. 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 8: The Effect of Rate Reform on House Prices — Additional Flood Risk Controls

	Log(Sales Price)				
Hazard	Sea Level Rise (1)	1st St Flood Factor (2)	Storm Surge (3)	Dist to Water (4)	>3 Floods (5)
High-Risk × Pre-Map × Post-Reform	-0.018***	-0.016***	-0.019***	-0.019***	-0.019***
	(-3.51)	(-3.11)	(-3.97)	(-3.84)	(-3.73)
Hazard × Pre-Map × Post-Reform	-0.006	-0.003	-0.001	0.001	-0.005
	(-0.64)	(-1.16)	(-0.24)	(0.34)	(-0.58)
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	12.258	12.258	12.258	12.258	12.258
Outcome SD	0.718	0.718	0.718	0.718	0.718
Observations	4,787,988	4,787,988	4,787,988	4,787,988	4,787,988

Note: This table presents OLS regressions similar to Column (3) of Table 3. On top of the fixed effects used in Column (3) of Table 3, an additional Hazard Measure is added as control variable. 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: Heterogeneous Effects of Rate Reform on House Prices across Different Flood Risks

	Log(Sales Price)					
	(1)	(2)	(3)	(4)	(5)	(6)
High-Risk × Pre-Map × Post-Reform	-0.011**	-0.011*	-0.017***	-0.016***	-0.021***	-0.011*
	(-2.10)	(-1.76)	(-3.11)	(-3.11)	(-3.76)	(-1.70)
High-Risk × Pre-Map × Post-Reform × Sea Level Rise	-0.036***					-0.029**
	(-2.86)					(-2.39)
High-Risk × Pre-Map × Post-Reform × 1st St Flood Factor		-0.007				-0.003
		(-1.68)				(-0.59)
High-Risk × Pre-Map × Post-Reform × Storm-Surge			-0.007			0.007
			(-0.73)			(0.75)
High-Risk × Pre-Map × Post-Reform × Distance to Water				0.008*		0.004
				(1.91)		(0.82)
High-Risk × Pre-Map × Post-Reform × > 3 Historic Floods					-0.002	-0.001
					(-0.14)	(-0.10)
Lower-Order Terms & Sq Ft	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	12.258	12.258	12.258	12.258	12.258	12.258
Outcome SD	0.718	0.718	0.718	0.718	0.718	0.718
Observations	4,787,988	4,787,988	4,787,988	4,787,988	4,787,988	4,787,988

Note: This table presents OLS regressions similar to Column (3) of Table 3 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 10: 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	-5.378**	0.084***	0.124***	-26.764***	0.116***	0.165***
	(-2.42)	(5.45)	(6.88)	(-3.53)	(5.81)	(6.94)
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	275.632	0.445	0.431	336.232	0.771	0.768
Outcome SD	295.081	0.309	0.295	384.612	0.547	0.551
Observations	4,351,226	3,395,423	3,300,096	436,762	380,078	375,393

Note: This table repeats Columns (3) of Table 3 with two subsamples separately. In Columns (1)-(3), we use the sample of homes not exposed to sea level rise at 6 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 11: Less vs More Worried and the Effect of Rate Reform on House Prices

Dependent Variable:	Log(Price)			
Sample:	Less Worried		More Worried	
	(1)	(2)	(3)	(4)
High-Risk × Pre-Map × Post-Reform	-0.018**	-0.008	-0.031***	-0.015*
	(-2.23)	(-1.00)	(-4.31)	(-1.79)
High-Risk × Pre-Map × Post-Reform × Sea Level Rise		-0.025		-0.043**
		(-1.23)		(-2.32)
Lower-Order Terms & Sq Ft	Y	Y	Y	Y
Zip X Age FE	Y	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y	Y
Observations	2,535,218	2,535,218	2,252,770	2,252,770

Note: Columns (1) and (3) repeat Column (3) of Table 3. Columns (2) and (4) repeat Column (1) of Table 9. Columns (1)-(2) use the sample of counties, where the percentage of climate change believers is higher than the median across counties in the 2014 climate opinion survey by the Yale Program on Climate Change. *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 12: The Effect of Rate Reform on Rebuilding Activities

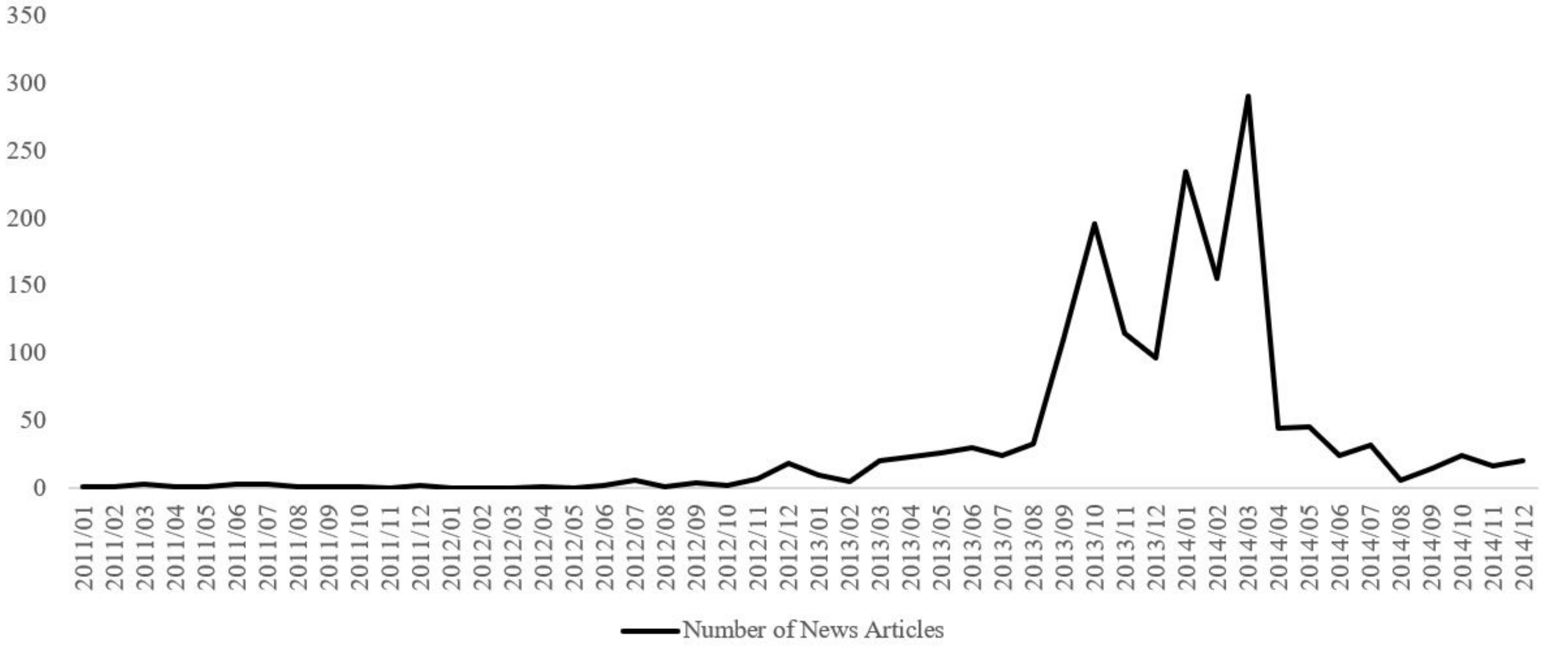
	1(Rebuilt)*1,000		
Sample:	All (1)	Not Exposed (2)	Exposed to Sea Level Rise (3)
High-Risk × Pre-Map (Orig) × Post2013	-0.105 (-0.71)	-0.215 (-1.29)	0.897 (1.49)
Lower-Order Terms & Sq Ft	Y	Y	Y
Zip X Age FE	Y	Y	Y
Zip X Loc X Year X Beds FE	Y	Y	Y
Outcome Mean	5.153	5.086	5.822
Outcome SD	71.599	71.137	76.079
Observations	31718932	29598023	2120909

Note: This table repeats Column (3) of Table 3, replacing the dependent variable with an indicator for whether a house is rebuilt in a year, multiplied by one thousand. The observations are at the house-year level, not conditional on a house being transacted. We consider a house as rebuilt in year *t* if the effective year built in Zillow's assessor data is *t*, which is later than the year built variable. If a house is rebuilt in year *t*, we remove later observations of the house from the sample. *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.

Online Appendices

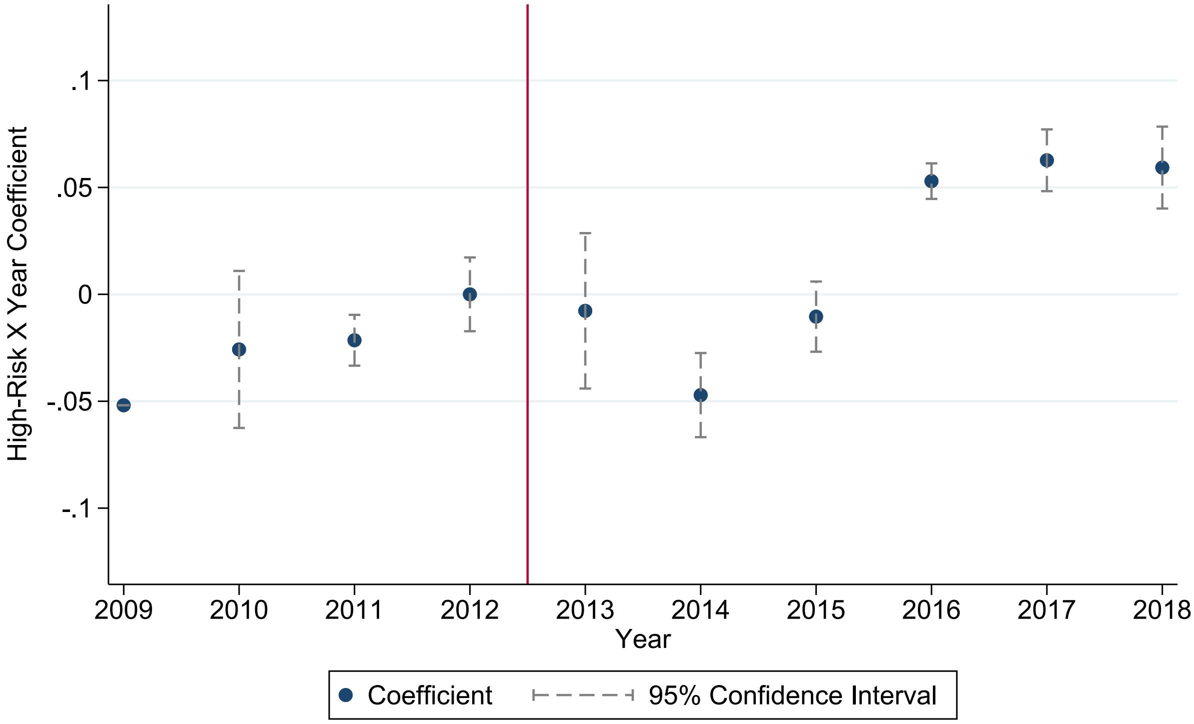
A Additional Figures and Tables

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".

Figure A2: 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 A1: Additional Robustness Tests for Flood Insurance Rate Reform and House Prices

	Log(Sales Price)			
	Excluding 2013-2014 (1)	FE ×High-Risk (2)	Additional Controls (3)	Risk Zone No Change (4)
High-Risk × Pre-Map × Post-Reform	-0.022*** (-3.38)	-0.038*** (-3.52)	-0.035*** (-4.91)	-0.021** (-2.70)
Lower-Order Terms & Sq Ft	Y	Y	Y	Y
Zip X Age FE	Y	N	Y	Y
Zip X Loc X Year X Beds FE	Y	N	Y	Y
Zip X Age X High-Risk FE	N	Y	N	N
Zip X Loc X Year X Beds X High-Risk FE	N	Y	N	N
Outcome Mean	12.325	12.254	12.377	12.246
Outcome SD	0.713	0.715	0.786	0.709
Observations	3,793,239	4,787,988	3,210,937	3,415,313

Note: This table presents OLS regressions similar to Column (3) of Table 3 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 A2: 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 9, replacing the "> 3 Historic 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 A3: Effect on House Prices and Exposure to Sea Level Rise

Sample:	Not Exposed to Sea Level Rise			Exposed to Sea Level Rise		
	OLS	1st Stage	2nd Stage	OLS	1st Stage	2nd Stage
Dependent Variable:	Price ($1000s) (1)	Premium ($1000s) (2)	Price ($1000s) (3)	Price ($1000s) (4)	Premium ($1000s) (5)	Price ($1000s) (6)
High-Risk × Pre-Map × Post-Reform	-5.378**	0.132***		-26.764***	0.107***	
	(-2.42)	(4.17)		(-3.53)	(3.98)	
Premium - Instrumented			-40.850**			-250.796**
			(-2.12)			(-2.64)
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	275.632	0.438	275.632	336.232	0.798	336.232
Outcome SD	295.081	0.438	295.081	384.612	0.735	384.612
Observations	4,351,226	4,351,226	4,351,226	436,762	436,762	436,762
Cragg-Donald F stat			3,002.3			227.3

Note: This table repeats Columns (3)-(5) of Table 3 with two subsamples separately. In Columns (1)-(3), we use the sample of homes not exposed to sea level rise at 6 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), (3), (4), and (6) and is the flood insurance premium for $250,000 building coverage in thousands of dollars in Columns (2) and (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 that was built prior to flood maps being released in a particular area, and Post-Reform is an indicator for whether the transaction happened after the insurance rate reform. All variables are defined in Table 3. Reported *t*-statistics in parentheses are heteroscedasticity-robust and double clustered by zip code and quarter. ***p<0.01, **p<0.05, *p<0.1.

B Data Appendix

B.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, X zones are classified as non-SFHA (i.e. Low-Risk flood zone).[30] 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

---

[30] 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.

B.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.

B.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.