Homeowners Responses to the New Price of Flood Insurance

Jiyoung Lee*

Abstract

As climate risks intensify, the low demand for flood insurance has been a significant public policy concern. This study examines the demand for residential flood insurance following the implementation of a reform that adjusts pricing to more accurately reflect flood risk. Using a difference-in-differences analysis, we evaluate the impact of this pricing reform on flood insurance take-up rates. On average, a 1% increase in premiums reduces insurance take-up by 19%. We find that policyholders who experienced premium changes are more responsive in their take-up than those who did not. Lack of effect on renewal rates in high-risk areas may be attributed to mandatory insurance requirements. Renewal rates in low-risk areas are more responsive to premium changes than in high-risk areas. These insights into the price sensitivity of homeowners help better understand how to improve pricing strategies and maintain equity and accessibility in the flood insurance program, potentially encouraging higher participation.

Keywords: Climate Risk · Flood Insurance · Insurance Demand · Household Finance

JEL-Classifications: H31 · G52 · Q54 · Q58

*Risk, Actuarial Science, and Legal Studies, Fox School of Business, Temple University, Philadelphia, PA, E-mail: jiyoung-lee@temple.edu

1 Introduction

Flooding is one of the most economically damaging natural disasters, causing approximately $70 billion in damages across the United States over the past decade (adjusted in 2024 USD, NOAA, 2024). Projections indicate that flood-related losses in U.S. residential markets could increase by up to 60% over the next three decades (First Street Foundation, 2021). This growing risk underscores the importance of increasing insurance uptake. More accurate insurance pricing might reduce adverse selection and, as a result, increase participation in the insurance program. However, demand for flood insurance has been surprisingly low, and higher premiums on the high-risk properties may further reduce participation, especially among vulnerable households. The National Flood Insurance Program (NFIP), which has been the primary flood insurer for over 50 years, traditionally set premiums based on only a few basic property characteristics. This approach often resulted in premiums that did not accurately reflect actual flood risks (FEMA, 2022). To address this, the NFIP introduced a new pricing approach, Risk Rating 2.0, in 2021, which evaluates flood risk at the individual property level to ensure rates better reflect each property's true flood risk (FEMA, 2022).

We investigate how homeowners respond to changes in their flood insurance premiums following the implementation of the price reform, using a difference-in-differences analysis. We utilize premium change projection data for single-family homes, which was originally provided as monthly premium change projections, and we converted it to average annual premium adjustments at the ZIP code level. Additionally, we use a panel dataset of residential NFIP flood insurance policy data, which includes detailed policy-level information on all currently active policies. We also incorporate demographic information at the ZIP code level from the American Community Survey (ACS). Finally, we use data from the First Street Foundation to include the number of properties and the number of properties in high-risk areas at the ZIP code level.

Using these data, we estimate how changes in premiums affect insurance take-up rates across groups that experienced different price changes. To achieve this, we classify our dataset into three equally sized groups based on the percentage change in premiums they experienced. Our first treated group, ranging from -1% to 25%, is referred to as the "price increase group." The middle group, which serves as the control group, ranges from -18% to -1% and is referred to as "small premium decreases." Our second treated group, the "price decrease group," ranges from -100% to -18%. With these three groups, we assess changes in overall take-up rates, compare changes in new policy rates and renewal rates, and examine changes in renewal rates in high-risk areas and low-risk areas after the price reform.

We find that a 1% increase in premiums results in a 19% decrease in flood insurance take-up, on average. Specifically, the take-up rate decreases for the group with price increases and increases for the group with price decreases. The price reform led to a 4.7% decrease in the overall take-up rate for the price increase group and a 6.5% increase for the price decrease group, compared to the expected take-up rate without the reform. The reform did not have a statistically significant impact on new policies. However, for renewing policies, there was a 3.1% decrease in the renewal rate for the price increase group and a 3.5% increase for the price decrease group two years after the reform, relative to the expected take-up rate without the reform. One explanation for this pattern is that existing policyholders compare the new premium to their pre-reform payment, while new customers do not have this pre-reform reference. While the reform did not significantly impact renewal decisions in high-risk areas, it led to a 6.06% decrease in renewal rates in low-risk areas for the price increase group and a 12.2% increase for the price decrease group compared to the counterfactual outcomes without the reform. The lack of effect in high-risk areas could be due to mandatory insurance requirements.

We contribute to the broad literature on flood insurance as a primary risk transfer tool to manage growing climate risks. The literature has examined the factors affecting flood insurance purchasing decisions and found that the demand for flood insurance is price-inelastic (Kriesel and Landry, 2004; Landry and Jahan-Parvar, 2011; Atreya et al., 2015; Wagner, 2022). The literature has also examined the economic impacts of the past flood insurance reforms. Hennighausen et al. (2023) explore the effects of the Biggert-Waters Flood Insurance Reform Act of 2012 (Biggert-Waters) and the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA) on insurance premiums, demand, property prices, and property transaction volumes. Wagner (2022) and Collier et al. (2023) examine the impact of Biggert-Waters on insurance demand. Nance (2015) investigates how Biggert-Waters has affected the real estate markets in vulnerable communities. Frazier et al. (2020) examine the impact of floodplain revision on vulnerable communities.

Our setting is novel because it employs an exogenous natural experiment and difference-in-differences analysis design to find a causal relationship between premium changes and changes in flood insurance take-up rates. This is distinct from many earlier studies that were survey-based or examined correlations between various factors and demand for flood insurance. Moreover, while the Biggert-Waters involved uniform premium increases as a result of reduced subsidies, the RR2.0 introduces comprehensive price adjustments for all insured properties.

2 Institutional Background

In this section, we provide an overview of the National Flood Insurance Program (NFIP), including its primary goals and challenges. We then introduce the NFIP's new pricing strategy, Risk Rating 2.0 (RR2.0), and discuss its impact on premium rates and the implementation timeline.

2.1 National Flood Insurance Program

The NFIP was established in 1968 after all private insurers exited the residential flood insurance market following severe river floods in 1927 and 1928 (King, 2005). Since 1968, the NFIP has been the primary insurer of flood insurance, which covers about 95% of the residential flood insurance policies in the U.S. today (Kousky et al., 2018). As of early 2024, the NFIP had over 4.7 million policies in force, with total coverage exceeding $1.3 trillion. NFIP policies are available exclusively in communities that participate in the program, which requires them to adopt a flood map and enforce minimum floodplain standards.[1] Over 22,000 communities participated in the program as of early 2024. The program offers a maximum coverage of $100,000 for contents and $250,000 for building coverage for single-family residences (Horn and Webel, 2024).

The long-standing goals of the NFIP have been to increase the number of insured properties and to offer reasonable premiums (National Research Council, 2015). However, the NFIP has encountered challenges in achieving these objectives. One major challenge has been the underpricing of risks, which has led to insufficient revenue to cover claims. Over the past 50 years, the NFIP has collected $60 billion in premiums but incurred $96 billion in costs, including losses, operating expenses, and interest. Consequently, the NFIP owes $20 billion to the U.S. Treasury, even after Congress canceled $16 billion of its debt. This lack of self-sufficiency negatively impacts policyholders, as premium revenues are used to pay the debt and interest (FEMA, 2021a; Horn and Webel, 2024). Another significant challenge was the inequity in the traditional rating system, which resulted in the cross-subsidization of high-risk properties at the expense of lower-risk properties. Under this system, flood insurance premiums were set using very limited information on individual property's flood risk or rebuilding costs. Premiums were based on the property's flood zone on the Flood Insurance Rate Map [2], along with factors such as occupancy type and its elevation relative to the Base Flood Elevation (Horn, 2024).[3] However, this system often resulted in policyholders with lower-value homes paying more than necessary, while those with higher-value homes paid less than their fair share of the risk (FEMA, 2021b).

2.2 Risk Rating 2.0

The NFIP introduced a new pricing methodology, Risk Rating 2.0 (RR2.0), to address those challenges. The new method reassesses flood risks of individual properties by considering a

[1] In most cases, a community is an incorporated city, town, township, borough, or village or an unincorporated area of a county or parish. (National Research Council, 2015)

[2] In this paper, we refer to the Flood Insurance Rate Map as the flood map.

[3] The Base Flood Elevation is the level to which water is expected to rise during a flood that has at least a 1% chance of occurring in any give year.

comprehensive set of factors to more accurately assess flood risk for each property. These factors include the likelihood of various flood-related perils, characteristics of the building, elevation and distance from flooding sources, replacement cost of the building, flood-proofing measures of the building, and the performance of levees in mitigating flood risks (FEMA, 2022).

Annual premium change. Under the previous rating system, policyholders faced average annual increases of $96. However, projections based on policies that were active in May 2020 estimated that with the new rating system, 23% of policyholders would immediately benefit from an average decreases of $1,032 in their annual premiums. About 73% of policyholders would see increases between $0 and $240, while approximately 4% would encounter increases exceeding $240 in their annual premiums (FEMA, 2021a). For policyholders whose premiums were previously below their risk-based rates, their premiums would gradually increase towards the full rate, with annual increases capped at 18% for primary residences and 25% for non-primary residences.[4]

Grandfathered rating discount. Grandfathering historically allowed policyholders to keep their existing flood insurance rates when flood maps changed their rating zones or Base Flood Elevations. However, fewer than 5% of single-family homes benefited from this option. As of March 2020, approximately 151,409 properties were grandfathered nationwide, representing 4.4% of the 3.5 million single-family, non-leveed properties insured by the NFIP. These grandfathered properties had an average annual premium of $1,077, which was about $800 less than the average for subsidized NFIP policies. With the implementation of RR2.0, which assesses individual property's flood risks, policies previously eligible for grandfathering shifted to their new full-risk premiums. These increases were phased in gradually, following the annual increase cap set by Congress.

Mandatory purchase requirement. Flood zones are classified by the annual chance of flooding in the area. Flood zones with at least a 1% annual chance of flooding are considered high-risk areas, and those with less than a 1% are considered low-risk areas. Although flood zones are no longer used to calculate a property's flood insurance premium, flood maps are still used for floodplain management and enforcing the mandatory purchase requirement. Under the Flood Disaster Protection Act of 1973, homeowners in high-risk areas are required to purchase flood insurance to qualify for any form of federal financial assistance, including loans, grants, subsidies, or disaster aid (National Research Council, 2015).[5]

[4] Upon renewal, policyholders may change their coverage or deductible selections (FEMA, 2021b).

[5] The NFIP designates regions with at least a 1% annual chance of flooding as Special Flood Hazard Areas (SFHAs), which include Zones A and V. Moderate flood hazard areas, with a 0.2% or greater annual chance of flooding, include Zones B and X. Minimal flood hazard areas, with less than a 0.2% annual chance of flooding, include Zones C and X. In this paper, we refer to SFHAs as high-risk areas or high-risk flood zones and all other zones outside SFHAs as low-risk areas or low-risk flood zones.

Timeline. The new pricing approach was progressively implemented from October 1, 2021, to March 31, 2023. The implementation schedule for RR2.0 was as follows:

- Phase I (Starting October 1, 2021): New policies issued on or after this date and existing policies up for renewal that would see a reduction in premiums were priced according to the new pricing methodology.
- Phase II (Starting April 1, 2022): All remaining policies, including those that might see an increase in premiums under the new method and those not yet transitioned in Phase I, were renewed under the new pricing approach.
- As of April 1, 2023, all existing policies were being priced under the new methodology.

3 Research Design

3.1 Data

We collect data from multiple sources. First, we utilize projections of monthly premium changes for single-family homes. These projections provide a detailed view of potential monthly premium adjustments at the ZIP code level for all existing policies as of May 2020. Premium changes are categorized into $10 increments, ranging from decreases of more than $100 to increases exceeding $100 per month. The dataset includes the total number of active policies within each ZIP code and provides a breakdown of how these anticipated premium changes are distributed among the policies. For privacy reasons, ZIP codes with fewer than five policyholders are grouped together, and such ZIP codes are excluded from our dataset. We convert these monthly premium changes into annual figures for our final dataset and arrange this dataset to reflect the average annual premium change projections at the ZIP code level.

Second, we use a panel dataset of residential NFIP flood insurance policies, sourced from the OpenFEMA Redacted Policies database. It includes policy-level information on policy characteristics, such as origination date, effective date, termination date, annual premium, and mandatory purchase indicator, and on the insured property characteristics, such as its ZIP code, primary residence indicator, flood zone category, building replacement cost, and occupancy type.

Table 1 outlines the sample selection process of our NFIP policy data. We focus on policies covering single-family residences in the contiguous United States and the District of Columbia, effective from October 1, 2018, to September 30, 2023. Due to the implementation schedule of RR2.0, we categorize the policy effective dates according to federal fiscal years instead of calendar years. For example, a policy effective between October 1, 2018, and September 30, 2019, is classified under fiscal year 2019. We exclude policies with invalid policy origination dates, such as missing dates or dates occurring after the policy's effective date.

Table 1: Sample Selection Process

Steps	**Description**	**Policies**
1	All policies in the contiguous U.S. from fiscal years 2019 to 2023	20,077,392
2	Keep if single family home	17,049,312
3	Keep if valid *Policy Origination Date*	16,514,922
4	Keep if ZIP code premium change projections are available	16,375,614

Notes: This table outlines our sample selection process, showing the sequential steps and the number of policies remaining after each step.

New policies and renewed policies. In the NFIP policy data, nearly all policies are annual. With these annual policies, we differentiate between new policies and renewed policies to compare their insurance take-up rate changes following the insurance price reform. A policy is classified as a "new policy" if its origination date coincides with its effective date. Conversely, a policy is considered as a "renewed policy" if its origination date precedes its effective date. In our dataset, 11% of the policies are new policies and 89% are renewed policies.

High-risk flood zones and low-risk flood zones. To assess the impacts of premium changes on policyholder decisions in different risk areas, we classify the policies based on the flood zone of the insured property on the flood map. Flood zones A and V denote high-risk areas, which have a greater than 1% annual chance of significant flooding, mudflows, or flood-related erosion hazards. Zones B, C, D, and X are classified as low-risk areas. Properties in zones with missing data are also considered low-risk. In our dataset, 46% of the insured properties are in high-risk areas and 54% are in low-risk areas.

We aggregate this residential policy-level dataset to the ZIP code level. This dataset includes information on the share of insured properties, the proportions of new policies and renewed policies, as well as the shares of renewals in high-risk areas and low-risk areas within each ZIP code.

Third, we incorporate data from the American Community Survey (ACS), conducted by the U.S. Census Bureau, which provides detailed demographic information at the ZIP code level. This includes data on racial composition, educational attainment, and median income levels. We specifically use the 2019 5-year estimate data. This dataset allows us to examine how insurance demand changes across different demographic groups following the reform.

Lastly, we use a ZIP code level flood risk summary dataset provided by First Street Foundation. This dataset includes the total number of properties and the number of properties in high-risk areas within each ZIP code.

These datasets are merged at the ZIP code level to create a balanced panel dataset spanning fiscal years 2019 to 2023, comprising 17,022 ZIP codes.

3.2 Empirical Strategy

First, we investigate the impact of the price reform on flood insurance take-up rates across different price change groups, categorized by the percentage change in premiums. We use a two-way fixed effects difference-in-differences approach.

To classify control and treated groups, we divide our sample into terciles, creating three equally sized groups, based on the percentage change in premiums. The upper tercile, ranging from -1% to 25%, consists of ZIP codes where 95% experienced premium increases and only 5% saw decreases of less than 1%. This group, referred to as the "price increase group," serves as our first treated group. The middle tercile, ranging from -18% to -1%, includes ZIP codes with relatively small premium decreases. We refer to this group as the "small change group" and it serves as our control group. The lower tercile, ranging from -100% to -18%, represents ZIP codes that experienced significant premium decreases. This group is our second treated group, referred to as the "price decrease group."

With these two treated groups and a control group, we estimate the following equation:

$$Takeup_{zt} = \sum_{t=2019, t\neq 2021}^{2023} \beta_1 \cdot Increase_z \times Year_t + \sum_{t=2019, t\neq 2021}^{2023} \beta_2 \cdot Decrease_z \times Year_t + \zeta_z + \tau_t + \epsilon_{zt}, \tag{1}$$

where $Takeup_{zt}$ represents the insurance take-up in ZIP code z in fiscal year t, which is calculated as $\frac{\text{number of policies}}{\text{number of properties}} \times 100$. $Increase_z$ refers to our first treated group, which experienced a premium increase. $Decrease_z$ represents our second treated group, which experienced a premium decrease of more than 18%. $Year_t$ indicates fiscal years rather than calendar years. We use fiscal year 2021 as the reference year. We include ZIP code fixed effects (ζ_z) and fiscal year fixed effects (τ_t) in our analysis to control for time-invariant characteristics of ZIP codes and time-specific shocks affecting the ZIP codes. Standard errors are clustered at the ZIP code level.

Additionally, we examine how different demographic populations respond to the price change. We estimate the following equation:

$$Takeup_{zt} = \beta \cdot PremiumChange(\%)_z \times Post_t + \zeta_z + \tau_t + \epsilon_{zt}, \tag{2}$$

where $Takeup_{zt}$ represents insurance take-up in ZIP code z in fiscal year t, which is calculated as $\frac{\text{number of policies}}{\text{number of properties}} \times 100$. $PremiumChange(\%)_z$ is the percentage change in premiums compared to the period before the reform, ranging from -100% to 25%. The upper limit is due to the annual increase cap on premiums. $Post_t$ is a binary variable that equals one for fiscal years 2022 and later, and zero otherwise. We include ZIP code fixed effects (ζ_z) and fiscal year fixed effects (τ_t) to control for unobserved heterogeneity across ZIP codes and time-specific factors.

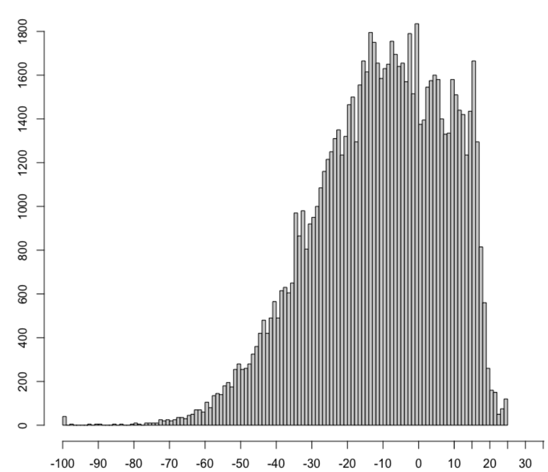
We anticipate a negative coefficient estimate on the interaction term for all groups ($\beta < 0$) because an increase in price typically leads to a decrease in demand, resulting in a downward-sloping demand curve. Moreover, previous studies have shown that higher flood insurance prices reduce demand (Browne and Hoyt, 2000; Kriesel and Landry, 2004; Dixon et al., 2006; Landry and Jahan-Parvar, 2011; Atreya et al., 2015; Wagner, 2022). Specifically, in our estimation, β indicates that a 1 percentage point increase in premium results in a β percentage point change in the insurance take-up rate relative to before the reform.

We are particularly interested in identifying which groups respond more sensitively to changes in their premiums. Understanding price sensitivity helps ensure that premium changes do not disproportionately impact vulnerable populations, thereby maintaining equity and accessibility. Pricing strategies and coverage offerings can be adjusted to improve insurance uptake and more effectively address the needs of price-sensitive homeowners. Overall, these insights support the creation of a more resilient and equitable flood insurance system, encouraging higher participation and providing better protection for the participating communities.

3.3 Descriptive Statistics

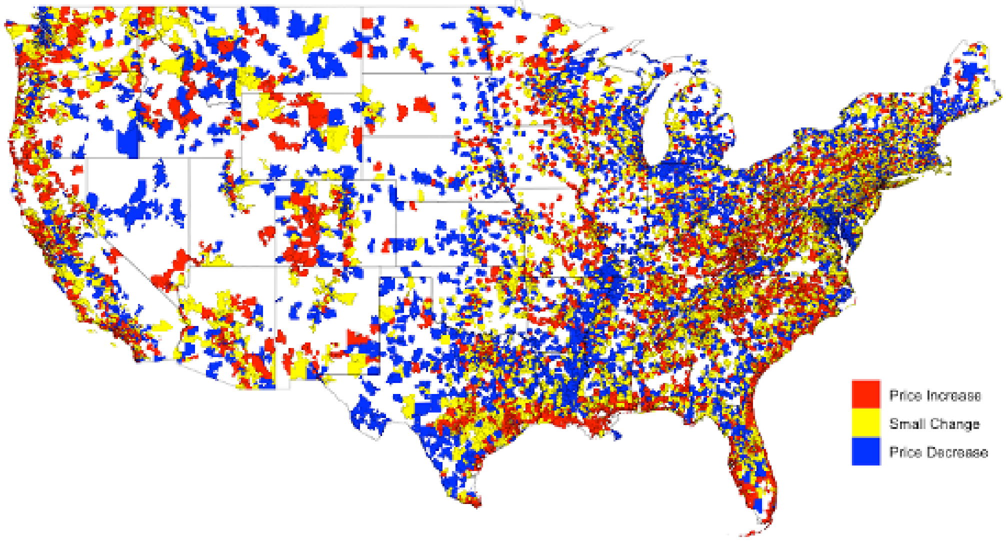
Figure 1 shows the distribution of percentage changes in annual premiums for single family homes across ZIP codes. The percentage changes in premiums range from -100% to 25%, reflecting the annual increase cap of 18% for primary residences and 25% for non-primary residences. In our dataset, about 83% of the policies are for primary residences, and 17% are for non-primary residences.

Figure 1: Percentage Changes in Annual Premiums of Single Family Homes



Notes: This histogram shows the distribution of the projected percentage changes in annual premiums, ranging from -100% to 25%. To mitigate the impact of outliers, we replace values below -100% and above 25% with the 1st and the 99th percentile values, respectively.

Figure 2: Geographic Distribution of Different Price Change Groups

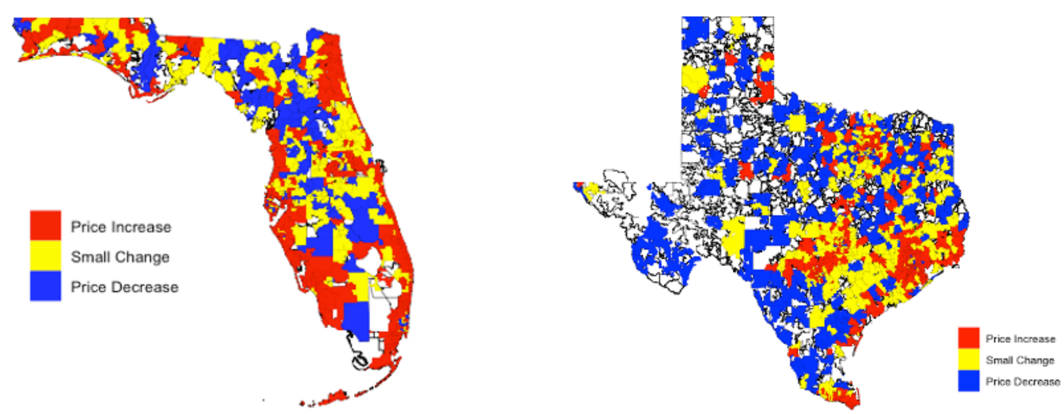


Notes: This map of the contiguous United States and the District of Columbia displays the geographic distribution of ZIP codes in our sample, using distinct colors to highlight different price change groups. The Price Increase group, our first treated group, is colored red. The Price Decrease group, our second treated group, is colored blue. The Price Small Change group, our control group, is colored yellow. ZIP codes not included in our sample are shown in white.

Figure 3: Florida and Texas

Panel A: Florida

Panel B: Texas



Notes: This figure provides a detailed view of the geographical distribution of the different price change groups within Florida and Texas. The Price Increase group is shown in red, the Price Small Change group in yellow, and the Price Decrease group in blue. ZIP codes not included in our sample are shown in white.

Figure 2 illustrates the geographic distribution of our two treated groups and a control group across the contiguous United States, highlighted in distinct colors. Notably, price increases and decreases are not concentrated in specific states but occur in every state. In Figure 3, we provide a detailed view of Florida and Texas, which are disaster-prone and represent a large share of all NFIP policies. The map of Florida shows that price increases are most concentrated in coastal areas (Panel A). In Texas, price increases are not limited to coastal areas, suggesting that the new pricing system takes various factors into account to more accurately assess flood risk for individual properties (Panel B).

Table 2: Summary Statistics in Fiscal Year 2020

	Price Decrease Group		Small Change Group		Price Increase Group	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
New Policies (N = 42,653)						
In High-risk Area	0.55	0.38	0.46	0.37	0.35	0.38
Is Mandatory Purchase	0.43	0.35	0.35	0.33	0.28	0.32
Is Primary Residence	0.84	0.26	0.83	0.26	0.85	0.24
Renewed Policies (N = 422,431)						
In High-risk Area	0.58	0.26	0.48	0.28	0.36	0.31
Is Mandatory Purchase	0.19	0.13	0.15	0.12	0.11	0.13
Is Primary Residence	0.82	0.16	0.82	0.17	0.84	0.16
Annual Premium ($)	890	356	781	379	563	257
Premium Change (%)	-32	11	-9	5	9	6
Number of Properties	6,582	5,472	7,371	6,245	7,159	6,030
Total Population	15,503	15,431	16,969	16,314	18,027	18,264
Proportion of White Population	0.81	0.20	0.82	0.19	0.80	0.20
Proportion of Black Population	0.10	0.18	0.09	0.16	0.09	0.16
Proportion of Bachelor's Degree Holders	0.12	0.06	0.13	0.07	0.13	0.07
Median Household Income ($)	64,148	27,485	68,816	29,902	67,070	27,768

Notes: This table provides summary statistics for three different price change groups in fiscal year 2020. Each price change group consists of 5,674 ZIP codes.

Table 2 presents summary statistics for the three price change groups. In fiscal year 2020, 9% of the policies were new, and 91% were renewals. For new policies, the mean of "In High-risk Area" was calculated as the average proportion of insured properties in high-risk areas out of the number of new policies. The mean of "Is Mandatory Purchase" represents the average proportion of mandated policies among the new policies. The mean of "Is Primary Residence" is the average proportion of policies insuring primary residences among the new policies. These variables were calculated similarly for renewed policies.

The price decrease group has the highest proportion of policies in high-risk areas and the highest proportion of mandatory policies for both new and renewed policies. Before the reform, this group, despite having the lowest household income, paid the highest annual premiums. Across all three groups, the proportions of White population, Black population, and Bachelor's degree holders were similar.

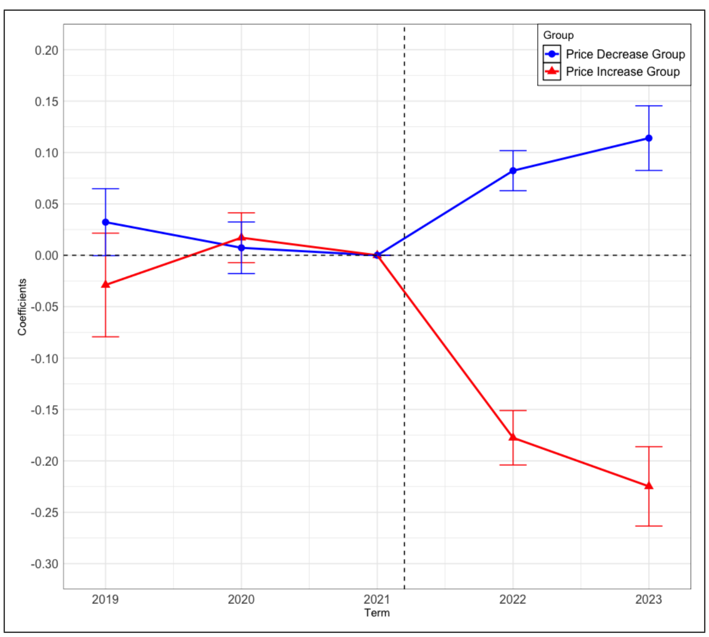
4 Effect of Reform on Insurance Take-up

In this section, we present event-study style difference-in-differences estimates of Equation 1. First, we estimate the average effect of the reform on overall insurance take-up rates. Next, we compare the reform's effects on new policy rates and renewal rates. Lastly, we compare the effects of the reform on renewal rates between high-risk areas and low-risk areas.

4.1 Total policies in force

The overall insurance take-up rate is defined as the percentage of active policies relative to the number of properties. Figure 4 illustrates that the reform decreased flood insurance take-up for the price increase group and increased it for the price decrease group. In fiscal year 2023, the estimated effect of the reform is a decrease of 0.225 percentage points for the price increase group and an increase of 0.114 percentage points for the price decrease group (Table 5 in the Appendix). These effects correspond to 4.7% for the price increase group and 6.5% for the price decrease group to their respective pre-reform take-up rates in fiscal year 2020. The results show that the estimated effects before the price change were not statistically different from zero, supporting that the changes in flood insurance take-up after fiscal year 2021 can be attributed to the premium change.

Figure 4: Effect of Price Reform on Overall Insurance Take-up



Notes: This figure shows the results of estimating Equation 1 with overall insurance take-up rates as the dependent variable, using fiscal year 2021 as the reference year. The coefficients β_1 and β_2, along with their 95% confidence intervals, are illustrated. ZIP code fixed effects and fiscal year fixed effects are included, with standard errors clustered at the ZIP code level.

4.2 New Policies versus Renewals

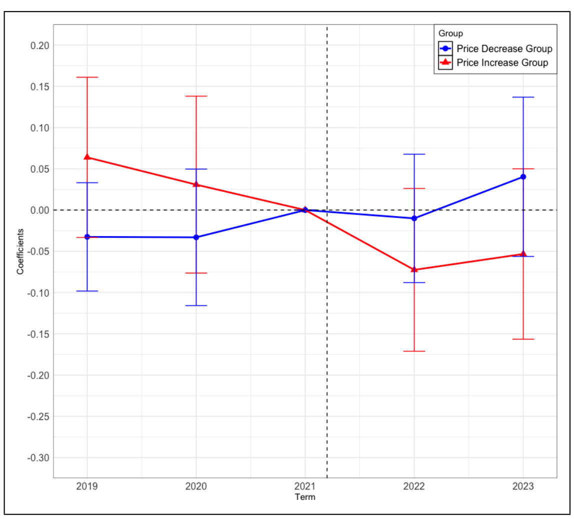
To understand household responses to premium changes, we further estimate the percentages of new policies and renewed policies, each relative to the number of properties. Households that purchased new policies after the reform did not experience premium changes, whereas those that renewed their policies did. Therefore, we are particularly interested in comparing the insurance take-up rates between these two groups.

Figure 5 shows how the price reform affected demand for new policies and renewals separately. Panel A of Figure 5 indicates that the reform did not affect new policy take-up rates for either the price increase group or the price decrease group. The estimated effects are statistically not different from zero for all period. In our dataset, about 46% of the new policies cover properties located in high-risk areas, and about 19% of the new policies are for properties where flood insurance is mandatory.

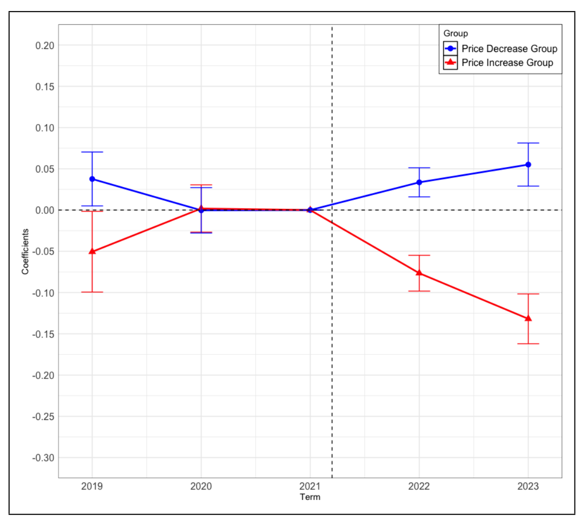
Panel B of Figure 5 presents the effects of the price reform on policy renewal rates for the price increase group and the price decrease group. Two years after the reform, the renewal rate for the price increase group dropped by 0.132 percentage points, while the renewal rate for the price decrease group rose by 0.055 percentage points (Table 6 in the Appendix). These effects represent a 3.1% of the pre-reform renewal rate for the price increase group and a 3.5% of the pre-reform renewal rate for the price decrease group.

Figure 5: Effect of Price Reform on New policy Rates and Renewal Rates

Panel A: New Policies



Panel B: Renewed Policies



Notes: This figure shows the results of estimating Equation 1 with new policy rates and renewal rates as the dependent variables. Fiscal year 2021 is used as the reference year. The coefficients β_1 and β_2 along with their 95% confidence intervals are illustrated. ZIP code fixed effects and fiscal year fixed effects are included. Standard errors are clustered at the ZIP code level.

4.3 Renewal Rates by Flood Zones

We further differentiate renewed policies by classifying them into high-risk flood zones and low-risk flood zones based on the flood map. Although flood maps are no longer used for pricing a property's premium, they are still used to enforce the mandatory purchase requirement. Homeowners in high-risk areas are also required to purchase flood insurance to be eligible for federal disaster assistance. We examine how the price reform affects policy renewal rates in these different risk areas.

Figure 6 compares the policy renewal rates in high-risk areas and low-risk areas. Panel A of Figure 6 shows that the reform did not significantly affect policyholders' insurance purchase behavior in high-risk areas, as the renewal rates for both price change groups remained relatively unchanged compared to the reference group. This lack of effect of the reform in high-risk areas may be attributed to the mandatory purchase requirement, which obligates homeowners in these areas to maintain flood insurance to qualify for federal financial assistance. Alternatively, it could be that demand for flood insurance in high-risk areas is inherently less sensitive to premium changes.[6]

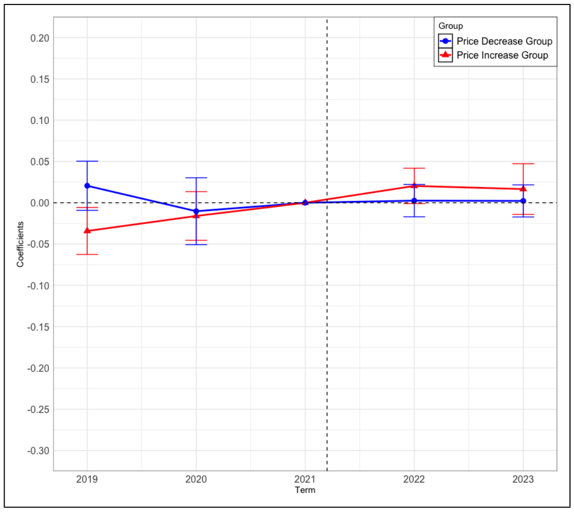
Panel B of Figure 6 shows that the reform decreased policy renewal rates in low-risk areas for the price increase group and increased renewal rates for the price decrease group. Two years after the reform, homeowners with price increases are 0.141 percentage points less likely to renew their policies, while those with price decreases are 0.070 percentage points more likely to renew (Table 7 in the Appendix). These changes correspond to 6.06% of the pre-reform renewal rate in low-risk areas for the price increase group and 12.2% for the price decrease group.

These results suggest that there is a risk information gap between the NFIP and homeowners regarding updated risk assessments, as emphasized in Mulder and Kousky (2023). An increase in premiums signals that the property's flood risk is higher under the new assessment system than previously understood. However, homeowners in low-risk areas are likely to cancel their policies if the new premium exceeds their willingness to pay. This behavior may be due to continued reliance on the flood map as the primary source of risk information and unupdated risk perception, resulting in asymmetric risk information between the NFIP and homeowners regarding the updated flood risk.

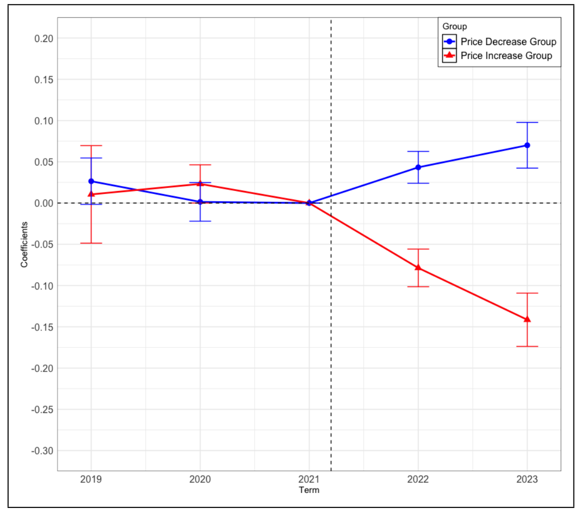
[6] Although several studies (Kunreuther, 1996; Tobin and Calfee, 2005; Landry and Jahan-Parvar, 2011) have noted that this requirement was poorly enforced, enforcement may have improved.

Figure 6: Effect of Price Reform on Renewal Rates in High-risk Areas and Low-risk Areas

Panel A: High-risk Area Renewal Rates



Panel B: Low-risk Area Renewal Rates



Notes: This figure shows the results of estimating Equation 1 with insurance renewal rates for high-risk areas and for low-risk areas as the dependent variables. Fiscal year 2021 is used as the reference year. The coefficients β_1 and β_2 along with their 95% confidence intervals are illustrated. ZIP code fixed effects and fiscal year fixed effects are included. Standard errors are clustered at the ZIP code level.

5 Demand for Insurance

In this section, we analyze how the overall take-up rate for flood insurance changed after the reform and compare it with take-up rate changes across different demographic groups. Using the estimated effects of the reform, we calculate the elasticity of demand for flood insurance for each group.

5.1 Effect of Reform on Take-up by Groups

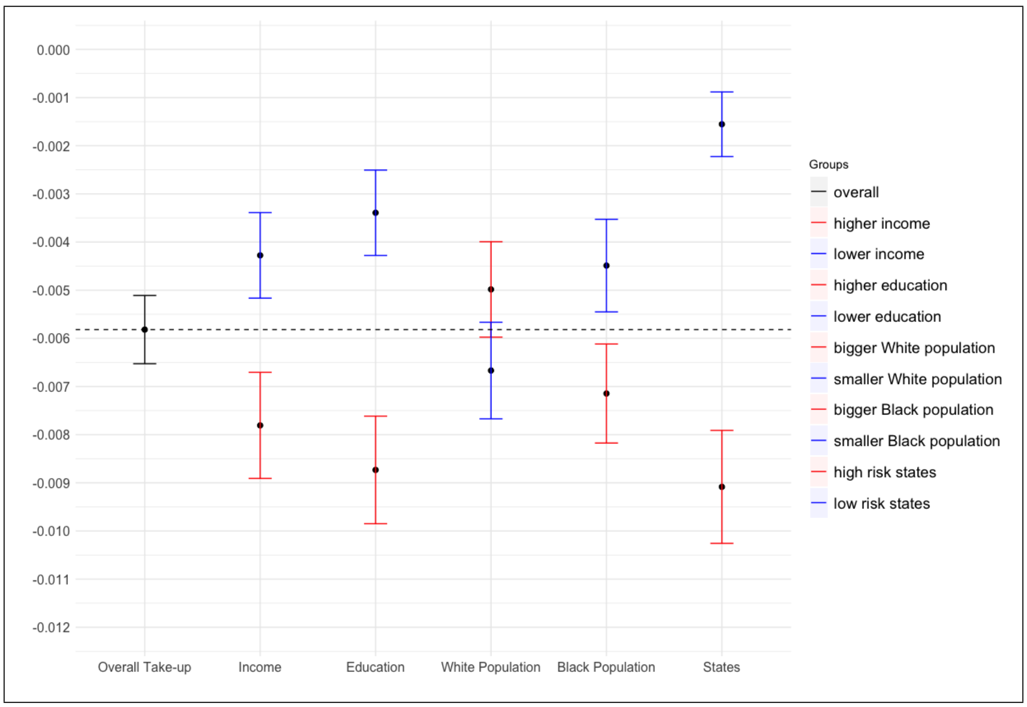
First, we estimate the effect of the reform on the overall insurance take-up rate, defined as the percentage of insured properties relative to the total number of properties. Using the 2019 5-year estimate data from the ACS, we then analyze changes in take-up rates across various demographic groups, including racial composition, household income, education attainment, and property locations, to understand their responses to premium changes. To achieve this, we divide our sample into two groups based on the median value of each demographic characteristic. For example, to differentiate between groups with larger and smaller populations of White individuals, we split our sample at the median proportion of White population. For property locations, we identify the 12 states with the most properties in high-risk areas, which are Florida, Texas, Louisiana, California, New Jersey, North Carolina, New York, Mississippi, South Carolina, Ohio, Pennsylvania, and Illinois. These states account for about 50% of such properties in the United States and are referred to as "high-risk states." We then compare the insurance take-up rate changes in each group following the reform. Table 3 details the distribution of demographic values at the ZIP code level, presenting the ranges and median values for each group.

Table 3: Overview of the Demographic Data: Median Values and Ranges

	Min.	Median	Max.	Total ZIPs
Household Income ($)	12,676	60,024	250,001	16,850
Bachelor's Degree Holders (%)	0	11	100	16,997
White Population (%)	0	88	100	16,997
Black Population (%)	0	3	100	16,997

Notes: This table presents an overview of the demographic data, listing the median values and the ranges of the data for each demographic variable.

Figure 7: Insurance Take-up Rate Changes by Group



Notes: This figure shows the results of estimating Equation 2 with insurance take-up of different population groups as the dependent variables. Fiscal years 2019, 2020, and 2021 are considered as the pre-period and used as the reference period. The coefficients β for each group along with their 95% confidence intervals are illustrated. ZIP code fixed effects and fiscal year fixed effects are included. Standard errors are clustered at the ZIP code level.

Figure 7 illustrates the changes in insurance take-up rates across different demographic groups following the implementation of the reform, compared to their rates before the reform. These changes range from -0.0016 to -0.0091. Low-risk states, which have fewer properties in high-risk areas compared to high-risk states, show the least impact from the reform. In contrast, high-risk states are the most sensitive to price changes relative to any other group in our analysis. The more-educated group is more sensitive to price changes than less-educated group. Additionally, the larger White population group is less sensitive to price changes than the smaller White population group, although the changes in their take-up rates are not statistically different. On the other hand, the larger Black population group is more sensitive to price changes than the smaller Black population group. Interestingly, the higher-income group is more sensitive to price changes than the lower-income group.

5.2 Price Elasticity of Demand by Group

Using the changes in take-up rates obtained in Section 5.1, we calculate the price elasticity of demand for each group. In our analysis, the price elasticity of demand for flood insurance can be written as

$$Elasticity = \frac{\partial Takeup / Takeup}{\partial PremiumChange / PremiumChange},$$

where $Takeup$ represents the pre-reform insurance take-up rate, $\partial Takeup$ is the change in the insurance take-up rate, $PremiumChange$ is the pre-reform insurance premium, and $\partial PremiumChange$ is the change in premium. Since $PremiumChange$ represents the baseline value for the premium change, it is set at 100. The elasticity can be rewritten as

$$Elasticity = \frac{PremiumChange}{Takeup} \cdot \frac{\partial Takeup}{\partial PremiumChange}.$$

We know the values of $\frac{\partial Takeup}{\partial PremiumChange}$ for each group from Section 5.1. Table 4 shows the price elasticity for each group.

The price elasticity of demand for flood insurance is -0.19, which means that a 1 percentage increase in premium reduces flood insurance take-up by 19%. The price elasticity of demand for renewals in low-risk areas is -0.28. Table 4 illustrates price elasticities of different demographic groups. They range from -0.09 to -0.24, indicating that the demand for flood insurance is inelastic to price, consistent with findings of the literature (Kriesel and Landry, 2004; Landry and Jahan-Parvar, 2011; Atreya et al., 2015; Wagner, 2022). The results show that the more-educated group and the higher income group are the most sensitive to changes in insurance premiums. Specifically, a 1 percentage increase in premiums results in a 24% decrease in insurance purchases among these groups. Interestingly, policyholders living in states with more high-risk properties are more sensitive to price increases than those in states with relatively low-risk properties. In addition, the high-income group is more responsive to price changes compared to the low-income group.

Table 4: Price Elasticity by Group

	$\frac{PremiumChange}{Takeup}$	$\frac{\partial Takeup}{\partial PremiumChange}$	Elasticity
Overall Take-up	100/3.05	-0.0058	-0.19
New Policies	100/0.44	-0.0023	-0.52
Renewed Policies	100/2.75	-0.0022	-0.08
Renewed Policies in High-risk Areas	100/1.59	0.0012	0.08
Renewed Policies in Low-risk Areas	100/1.33	-0.0037	-0.28
Higher Household Income	100/3.29	-0.0078	-0.24
Lower Household Income	100/2.72	-0.0043	-0.16
More Bachelor's Degree Holders	100/3.70	-0.0087	-0.24
Less Bachelor's Degree Holders	100/2.39	-0.0034	-0.14
Bigger White Population	100/2.91	-0.0050	-0.17
Smaller White Population	100/3.18	-0.0067	-0.21
Bigger Black Population	100/3.41	-0.0072	-0.21
Smaller Black Population	100/2.68	-0.0045	-0.17
Higher-risk States	100/4.45	-0.0091	-0.20
Lower-risk States	100/1.69	-0.0016	-0.09

Notes: This table shows the elasticity of demand for flood insurance across various demographic groups. The elasticity is calculated by multiplying $\frac{PremiumChange}{Takeup}$ with $\frac{\partial Takeup}{\partial PremiumChange}$. $\frac{\partial Takeup}{\partial PremiumChange}$ was estimated from Equation 2.

6 Conclusion

We examine how changes in flood insurance premiums impact demand across different price change groups. We find that those who experienced a price increase are less likely to renew their flood insurance, while those with a price decrease are more likely to renew. In high-risk areas, the renewal rates are not significantly affected by the reform. However, in low-risk areas, the reform led to a reduced renewal rate for the price increase group and an increased renewal rate for the price decrease group. One explanation could be that homeowners may reply on outdated risk information and tend to cancel their policies if premiums rise. Other possible explanations include liquidity constraints, reference-dependent preferences, and relocation.

Furthermore, we calculate the elasticity of demand for flood insurance. Consistent with the literature (Kriesel and Landry, 2004; Landry and Jahan-Parvar, 2011; Atreya et al., 2015), we find that the demand for flood insurance is inelastic to price. The average elasticity is -0.19, indicating that a 1% increase in premiums leads to a 19% reduction in flood insurance take-up. We also calculate elasticities for several demographic groups. The results show that the more-educated group and the higher-income group exibit the greatest sensitivity to premium changes, with an elasticity of -0.24.

These insights into the price sensitivity of homeowners help better understand how to adjust pricing strategies and coverage offerings. They also help maintain equity and accessibility in the flood insurance program, potentially encouraging higher participation.

A Appendix

Table 5: Effect of Price Reform on Overall Insurance Take-up

	Takeup
$Year_{t=2019} \times Increase$	-0.029
	(0.026)
$Year_{t=2020} \times Increase$	0.017
	(0.012)
$Year_{t=2022} \times Increase$	-0.178***
	(0.014)
$Year_{t=2023} \times Increase$	-0.225***
	(0.020)
$Year_{t=2019} \times Decrease$	0.032
	(0.017)
$Year_{t=2020} \times Decrease$	0.007
	(0.013)
$Year_{t=2022} \times Decrease$	0.082***
	(0.010)
$Year_{t=2023} \times Decrease$	0.114***
	(0.016)
Controls	No
ZIP FE	Yes
Year FE	Yes
Clustered SE	ZIP code
Adjusted R-Squared	0.9924
Within R-Squared	0.0078
Observations	84,655

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05
This table shows the results of estimating Equation 1 with overall insurance take-up rates as the dependent variable, calculated as the percentage of the total number of insured properties. Fiscal year 2021 is used as the reference year. ZIP code and fiscal year fixed effects are included. Standard errors clustered at the ZIP code level are in parentheses.

Table 6: Effect of Price Reform on New policy Rates and Renewal Rates

	New Policy Rates	*Renewal Rates*
$Year_{t=2019} \times Increase$	0.064	-0.051*
	(0.050)	(0.025)
$Year_{t=2020} \times Increase$	0.031	0.002
	(0.055)	(0.015)
$Year_{t=2022} \times Increase$	-0.073	-0.077***
	(0.050)	(0.011)
$Year_{t=2023} \times Increase$	-0.053	-0.132***
	(0.053)	(0.015)
$Year_{t=2019} \times Decrease$	-0.032	0.038*
	(0.033)	(0.017)
$Year_{t=2020} \times Decrease$	-0.033	-0.000
	(0.042)	(0.014)
$Year_{t=2022} \times Decrease$	-0.010	0.0034***
	(0.040)	(0.009)
$Year_{t=2023} \times Decrease$	0.040	0.055***
	(0.049)	(0.013)
Controls	No	No
ZIP FE	Yes	Yes
Year FE	Yes	Yes
Clustered SE	ZIP code	ZIP code
Adjusted R-Squared	0.8148	0.9919
Within R-Squared	0.0005	0.0022
Observations	84,655	84,655

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05
This table shows the results of estimating Equation 1 with new policy rates and renewal rates as the dependent variables. New policy rate is calculated as the percentage of new policies to the number of properties. Renewal rate is calculated as the percentage of renewed policies to the number of properties. Fiscal year 2021 is used as the reference year. ZIP code fixed effects and fiscal year fixed effects are included. Standard errors clustered at the ZIP code level are shown in parentheses.

Table 7: Effect of Price Reform on Renewal Rates in High-risk Areas and Low-risk Areas

	Renewal Rates High-risk Areas	*Renewal Rates Low-risk Areas*
$Year_{t=2019} \times Increase$	-0.034*	0.011
	(0.015)	(0.030)
$Year_{t=2020} \times Increase$	-0.016	0.023*
	(0.015)	(0.012)
$Year_{t=2022} \times Increase$	0.020	-0.079***
	(0.011)	(0.012)
$Year_{t=2023} \times Increase$	0.017	-0.141***
	(0.016)	(0.016)
$Year_{t=2019} \times Decrease$	0.021	0.026
	(0.015)	(0.014)
$Year_{t=2020} \times Decrease$	-0.010	0.001
	(0.021)	(0.012)
$Year_{t=2022} \times Decrease$	0.003	0.043***
	(0.010)	(0.010)
$Year_{t=2023} \times Decrease$	0.002	0.070***
	(0.010)	(0.014)
Controls	No	No
ZIP FE	Yes	Yes
Year FE	Yes	Yes
Clustered SE	ZIP code	ZIP code
Adjusted R-Squared	0.9868	0.9838
Within R-Squared	0.0003	0.0035
Observations	84,655	84,655

Notes: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05
This table shows the results of estimating Equation 1 with insurance renewal rates for high-risk areas and for low-risk areas as the dependent variables. Fiscal year 2021 is used as the reference year. ZIP code fixed effects and fiscal year fixed effects are included. Standard errors clustered at the ZIP code level are shown in parentheses.

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