Analyzing the impact of changes in flood risk on housing value: evidence from a coastal county

Travis LaHue

October 31, 2022

Abstract

How do consumers respond to changes in risk or perceived risk? This question is often difficult to answer because there are relatively few events that make the underlying risk salient. In this paper, I exploit a quasi-natural experiment with changes in FEMA's flood maps and estimate how a change in flood zone status affects housing prices in Miami-Dade County. Using newly digitized flood insurance maps and a newly created parcel-level dataset of the universe of single family home sales from 1995 - 2019, I find homes that were mapped into a flood zone experienced an average 14.7 percent decline in sales price, while homes that were mapped out of flood zone experienced an average 5.8 percent decline in sales price. Distance matters, the flood risk discount increases with distance to the old flood zone boundary for homes that were mapped into a flood zone. The effect is also long lasting; up to seven years after the map update, homes that were mapped into a flood zone continue to experience a significant decline in sales price.

1 Introduction

Climate change is a complex, dynamic phenomena that will continue to impact a variety of global interests for years. Existing climate models suggest that sea-levels will rise at least 12 inches above 2000 levels by 2100.[1] Sea level rise (SLR) will impact a broad range of economic outcomes, including: transportation infrastructure located on the coast (Dawson et al. (2016)), increase in storm surge risk and floods, and saltwater intrusion in coastal aquifers. Buchanan et al. (2017) argue that for many coastal communities, an increase in severity of flooding will be the most economically damaging component of climate change. While rising global sea levels is assuredly cause for concern, there are parts of the world that may be more susceptible to the negative side effects of SLR, such as Florida, where the average elevation is only six feet. Since 1950, sea levels have risen more than eight inches in Florida. Scientists project the sea level around Miami Beach will rise by approximately six inches within the next 15 years *Florida's Sea Level Rise - Sea Level Rise* (n.d.). With this forecast in mind, Florida's residents may soon experience an increase in negative side effects associated with its occurrence. If the sea level continues to rise at its current expected rate, Florida is projected to suffer a significant amount of economic damage. Under current estimates, one in eight homes in Florida will be underwater by the year 2100, causing property value losses over $400 billion, the highest in the country Rao (2017). Given Florida's exposure to current flood risk and future potential losses from SLR, it is important to study how its residents are responding to these dynamic conditions.

Flooding remains the most frequently occurring natural disaster in the United States. On average, flooding causes $10 billion in damages each year. Coastal communities are some of the most flood prone locations in the country, and over two-thirds of Florida's population lives in a coastal county. As of 2018, Floridians held approximately 34 percent of the total number of flood insurance policies issued.[2] Given Florida's large exposure to current and

[1] https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level This estimate is assuming future lower greenhouse gas emission.

[2] *Facts + Statistics: Flood insurance* (2019)

future flood risk, it is important that its residents have the most accurate and up-to-date information about the level of flood risk they face. They receive this information from the Federal Emergency Management Agency (FEMA) in the form of flood insurance rate maps (FIRMs).[3] These flood maps describe the parts of a community that are inside and outside of the 100-year floodplain. However, side effects from climate change (such as shoreline and soil erosion and changing hydrology), changes in levee classification, and new development can cause flood risk for a particular area to evolve over time. Because of dynamic nature of flood risk, Congress mandated FEMA to review and update flood maps at least once every five years. This Congressional mandate provides a quasi-natural experiment that generates plausibly random variation in flood zone status near the boundary of the 100-year floodplain when a new flood map is issued. The underlying flood risk is unchanged; however, due to the nature of flood map updates, the timing of the inclusion in the FIRM is quasi-random. This paper utilizes this to further explore the relationship between flood risk and housing outcomes.

There has been extensive research on the relationship between flood risk and housing values; the majority of the literature finds some evidence of a price discount when a house that is located in a flood zone is sold (Harrison et al. 2001, Hennighausen & Suter 2020, Beltran et al. 2018).[4] Most studies utilize some variety of the hedonic framework to test if the environmental (dis)amenity of location in a flood zone has been capitalized into the sale price. Over time, analyses started incorporating a difference-in-differences framework to examine the impact extreme weather events have on the housing market and the flood risk price discount. Following a flood or hurricane, home prices in a flood zone initially experienced a large increase in their flood risk price discount; however, the magnitude of this price discount decayed with time (Bin & Polasky 2004, Bin & Landry 2013, Zhang & Leonard 2019, Kousky 2010). The expansion of available inundation data for a community

[3]Throughout the remainder of the paper, I will use flood insurance rate maps and flood maps interchangeably.

[4]"Price discount" refers to the negative cost that is associated with a house being located in a flood zone. This has also been referred to as a "price penalty", or a "risk premium."

after a flood has allowed researches to further examine heterogeneous effects of extreme weather events on the flood risk discount. Results have been mixed; most studies find evidence of a significant price discount for inundated homes in the floodplain, but not all find evidence of a price discount for non-inundated homes in a floodplain (Ortega & Taspinar 2018, Hennighausen & Suter 2020, Atreya & Ferreira 2015). In an analysis of the New York City housing market after Hurricane Sandy, Ortega & Taspinar (2018) find that properties that were located in a flood zone and did not suffer damage from hurricane Sandy experienced a permanent price discount of approximately eight percent. Atreya & Ferreira (2015) and Hennighausen & Suter (2020) do not find any significant effect on the sales price of non-inundated homes in the floodplain; Hennighausen & Suter (2020) actually finds evidence of a small positive premium for non-inundated homes in the floodplain.

The saliency of flood risk is difficult to measure; the standard 100-year floodplain carries a stated risk of a one percent (or greater) probability of a major flooding event in any given year. Thus, over the course of a 30-year mortgage, there is a 26 percent probability that a house in the 100-year floodplain will flood at least one time. Flood insurance take-up rates provide one possible proxy measure of how salient the flood risk is in a given area. Using a nationwide dataset of flood insurance policies and flooding disasters, Gallagher (2014) demonstrates that following a flood, there is a large increase in insurance take-up rates, but this declines over time to the baseline. Gallagher's findings highlight the difficulties economic agents face in accurately assigning risk to infrequent events, such as floods. This outcome contributes to a developing narrative of increased awareness of flood risk after a major flooding event, followed by a return to a baseline flood risk discount. Another possible measure of flood risk saliency is to measure the responsiveness of the flood risk discount after an information update, such as the publication of updated flood maps. However, it is challenging to disentangle the proportion of the flood risk discount that is attributable to the cost of the subsidy over the life of the mortgage from any saliency effects.

Little empirical work has been done analyzing how new flood maps and the resultant changes in flood zone status impact housing outcomes. This is largely due to data limitations; FEMA does not archive old versions of their digital flood maps. Thus, analyzing how flood zone status changes over time is challenging due to limited availability of historic flood maps. In the first study to use flood zone remapping as a quasi-natural experiment, Shr & Zipp (2019) investigate how new flood maps impacted housing prices in Centre county, Pennsylvania. Their preferred hedonic model, a screened repeat sales sample which includes parcel fixed effects, finds evidence of a large price discount (-11.6%) associated with being mapped into a flood zone. The associated discount from the average sales price is almost the same as the net present value of the average insurance payment in perpetuity, $19,981 and $20,000, respectively.[5] This suggests the effect can be attributed to the flood insurance mandate. Shr and Zipp discover this outcome is asymmetric; there is no statistically significant effect on property value when a home is mapped out of a flood zone. This supports their finding that the flood risk discount is being driven by the insurance mandate. Shr and Zipp's study is an important contribution to the flood risk literature; they are the first to measure the flood risk discount using the remapping approach and the first to identify the asymmetric impact of getting mapped into a flood zone. This suggests the previously used method of identifying flood zone status is not the most optimal. However, their sample size is extremely small, limiting the potential external validity of the study. In my paper, I utilize the universe of data from the Florida Department of Revenue. The larger sample size allows me to expand efforts to estimate the price discount associated with flood risk more precisely and to analyze additional components, such as heterogeneous effects of new flood maps and investigating the possibility of a lasting stigma effect on houses that are mapped out of flood zones.

This study is more broadly related to the extensive literature analyzing how environmental amenities affect local housing markets. These studies cover a wide range of environmental amenities, including shale gas fracking and shale gas fracking licenses (Muehlenbachs et al.

[5]The NPV is calculated using a 5% discount rate and the average flood insurance premium in Centre County, PA ($1,000 per year).

2015, Gibbons et al. 2021), power plant openings and nuclear power plant closures (Davis 2011, Bauer et al. 2017), and hazardous waste sites (Greenstone & Gallagher 2008, Ihlanfeldt & Taylor 2004). These papers highlight the difficulty of credibly identifying a causal effect of these environmental (dis)amentities on housing values, and illustrate the importance of controlling for any possible omitted variable bias when the environmental externalities are extremely localized.

This research project further examines the relationship between flood risk and housing prices in Miami-Dade county. Utilizing tax rolls from the Florida Department of Revenue, FEMA's historical and current flood maps, and multiple decennial censuses, I create a unique parcel-level dataset containing the universe of single-family home sales and their flood zone status in Miami-Dade county from 1990 - 2019. The tax roll data cover a long period of time, allowing me to use a repeat sales approach and include parcel level fixed effects. The inclusion of parcel level fixed effects is an important feature of the study, as they control for any possible effects from unobserved and time-invariant property and neighborhood characteristics. Results indicate homes that were mapped into a flood zone experienced a flood risk discount of 14.85 percent, while homes that were mapped out of a flood zone had a flood risk discount of 5.81 percent. Using the study's average indexed sales price of $310,791, this implies a discount of $45,779 and $18,056, respectively. Assuming a $1,000 annual flood insurance premium, the insurance effect explains 44 percent of the total effect, while the "saliency effect" explains approximately 56 percent of the overall effect. This is the first study to estimate an effect larger than the net present value of all future flood insurance premiums, and a statistically significant effect of being mapped out of a flood zone on housing value. Proximity to old flood zone boundaries matters as well, homes that were closer in proximity to the old flood zone boundary experienced a smaller decline in value compared to homes that were further away. The effect is long lasting; up to seven years after the map update, homes that were mapped into a flood zone continue to experience a significant decline in sales price. Lastly, estimates suggest the effect is most prominent in neighborhoods where the minority population levels are above average.

The rest of the paper is organized as follows: Section 2 provides background information on FEMA's flood insurance rate maps, a brief history of reforms to the National Flood Insurance Program, and reviews the flood map revision process. Section 3 describes the data used and highlights key summary statistics. Section 4 discusses a brief theoretical framework and the empirical strategy. Section 5 details the primary results, while Section 6 covers the robustness checks. Section 7 discusses implications of the results and concludes.

2 Background: FEMA's Flood Zones

2.1 National Flood Insurance Program

In 1968, Congress passed legislation that created the National Flood Insurance Program (NFIP). The goal was to to help reduce the impact of flooding on private and public properties by providing affordable flood insurance (prior to the creation of the program, it was difficult to obtain private flood insurance).[6] However, due to several loopholes, participation in the program was originally quite low. To address these shortcomings, Congress first passed the Flood Disaster Protection Act of 1973, followed by the National Flood Insurance Reform Act of 1994. The 1973 Act instituted the mandatory purchasing requirement of flood insurance for all real estate properties secured with a federally backed mortgage that are located inside of the special flood hazard area. The 1994 Act introduced several key reforms, including enhanced enforcement of the mandatory purchasing requirement, increased the limit of maximum coverage available to structures, and introduced a mandate to review and update flood insurance rate maps at least once every five years.

Facing increasing amounts of debt in the aftermath of several catastrophic natural disasters, Congress once again enacted more reforms to the NFIP. Congress first passed the

[6] According to Harrison et al. (2001), private flood insurance was "virtually unavailable" prior to the passage of NFIP. This is primarily due to losses incurred following the Great Mississippi Flood of 1927.

Biggert-Waters Flood Insurance Reform Act of 2012, and after facing backlash to the Act, passed an additional reform in 2014.[7] FEMA oversees the NFIP, and they developed flood insurance rate maps (FIRMs) to help implement the program's requirements. The flood maps define the location and boundaries of the different flood zones, as well as the flood risk associated with each zone. FEMA incorporates all of the most recently updated flood maps into the National Flood Hazard Layer, which assists people in determining if their property is located in a flood zone and what kind of flood insurance they should buy (if necessary).

One section of the 1994 Congressional reform to the NFIP instituted a mandate for FEMA to review and update a community's flood maps at least once every five years. However, over 20,000 communities across the United States participate in the NFIP, and it is difficult for FEMA to keep all of their flood maps up-to-date; it is common for communities to have outdated flood maps.[8] Each year, FEMA initiates studies of flood hazards in communities across the country, but limit the number of communities they can review due to funding constraints. Once a map revision for a community is initiated, FEMA uses data from various sources, such as river flow, storm tides, hydraulic analyses and rainfall and topographic surveys to create updated flood maps. A map update is a lengthy process, and from start to finish can take up to 18 months to complete; it is common for an update to take much longer than this. The flood map update process is covered in detail in a later section.

2.2 The Flood Zones

On a flood insurance rate map, there are three primary flood risk zones: A, V, and X. Zones A and V comprise the 100-year floodplain (the probability of a major flooding event is one percent or greater in any given year), and are designated as Special Flood Hazard Areas (SFHA). There are several different subcategories of Zone A, such as AE and AH. These correspond to differences in potential depths of floodwater. Zone V corresponds to areas

[7] Visit www.fema.gov/flood-insurance-reform-law for more detailed information about the reforms.

[8] Many communities in Florida have outdated flood maps; for example, St. Petersburg's were last updated in 2003 and Miami-Dade's were last updated in 2009.

subject to hazardous coastal flooding conditions, such as storm surge from tropical storm systems. Zone X represents the 500-year floodplain (the probability of a major flooding event is 0.2 percent per year) and areas of minimal flood risk; a house located in Zone X is not considered to be in a flood zone.[9] If someone purchases a home that is located in a SFHA (Zones A or V) and the mortgage is obtained from a federally regulated lending institution, then the borrower is required by law to purchase flood insurance throughout the life of the loan. Flood insurance is not required if the purchased home is located in Zone X or if the home is owned outright.[10] Figure 1 illustrates the flood map changes around Ted Hendricks Stadium in Milander Park, Hialeah. The blue shaded areas represent locations that were mapped into a flood zone, while the red shaded area represents locations that were mapped out a flood zone. In the Appendix, Figure 5 illustrates flood zone changes for the entire county.

Preliminary flood zones for the next update were published February 25, 2021; however, these are subject to change and do not impact the current flood zones. On the old flood zone map, the floodplain in Miami-Dade is approximately 49.93% of total land area; this decreases slightly to 49.01% of total land area after the 2009 map update. Approximately 1.8% of the total land area is added to the floodplain, while approximately 3.18% of total land area is removed from the floodplain.

2.3 The Flood Map Update Process

This study will use FEMA's mandate to review and update flood maps as a quasi-natural experiment to analyze how housing prices respond to updated information about flood risk. Figure 2 details the entirety of the update process.

A map update should ideally take no more than 25 months to complete; however, due to delays, updates can take as long as 3 - 5 years (or more) to complete.

[9]See FEMA's Appendix-D Glossary for more detailed information about the different flood zones www.fema.gov/media-library-data/20130726-1535-20490-7429/appxd.pdf

[10]This podcast from FEMA covers the mandatory purchasing requirement in greater depth: www.fema.gov/media-library/assets/audio/166198

Once a map revision for a community is initiated, FEMA employs regional contractors to collect the necessary data to create the updated flood hazard maps. Typically, this takes two years. This is followed by one year of quality review, where all the information is gathered into a formal Flood Insurance Study and a preliminary flood map is released. FEMA contacts local officials and hosts public meetings to explain the documents to the community. Shortly after this, a 90-day appeal period begins. During this period, if a community finds any scientific or technical concerns, they may hire consultants to provide their own studies to support their appeal. After FEMA resolves any and all valid scientific and technical concerns, they finalize and issue a Letter of Final Determination which sets the effective date for the new flood map.

3 Data

To further examine the relationship between flood risk and housing prices in a coastal county, I incorporate three primary datasets into my study: (i) property tax data files from the Florida Department of Revenue, (ii) newly digitized FIRMs, and (iii) Decennial Census data from 1990, 2000, and 2010. I obtained Miami-Dade county's final tax rolls from the FDOR for 1995 - 2020. The 1995 tax rolls contain all transactions dating back to at least 1990, which is the year I select for the beginning of the study. The tax rolls contain a parcel identification number and detailed information about each parcel, including size of the home and lot, age of the house, and year and month of sale. The sample was reduced to only include residential arms-length transactions of single family homes, resulting in 1,098,190 transactions between 1990 - 2020. Limiting the sample to only arms-length transactions ensures only independent transactions are observed, and not a sale between family members, which could include artificially low sales prices. Every sale price is indexed to the fourth quarter of 2012 for the Miami-Dade Metropolitan Statistical Area. Next, each transaction in the sample is geocoded using the historical and current flood maps for Miami-Dade county. Then each parcel is matched to the 1990, 2000, and 2010 GIS shapefiles of the Decennial Census. These shapefiles contain a plethora of information from each Decennial Census, including block group and Census tract identification numbers, and detailed demographic data at the block group level. Thus, I am able to match each transaction to its respective block group and census tract at time of sale, allowing me to control for possible unobserved differences in neighborhood characteristics. Next, I dropped all observations that were not successfully geocoded, reducing the sample by 73,099 observations.[11] To insure only valid arms-length transactions are included, all transactions with an indexed price below $5,000 are dropped from the sample, reducing the sample to 669,017 observations. Lastly, I drop all parcels that only have one transaction during the time period, resulting in 606,424 transactions from 164,727 parcels. Summary statistics are presented in Table 1.

Overall, approximately 51% of all transactions occur in a flood zone. This is substantially larger than the 4% figure in Shr & Zipp (2019); the authors note this 4% figure is common in the flood risk literature.[12] The large floodplain in Miami-Dade is beneficial to the study; however, it also implies caution must be used when extrapolating my estimates to other settings. On average, the sale price is higher for homes that were ever in a flood zone compared to homes that were never in a flood zone. This is not surprising given the beach amenities in Miami-Dade. I observe 15,928 transactions where the home was mapped into the floodplain, and 26,759 transactions where the home was mapped out of the floodplain. Lastly, the median distance of a home to the closest old flood zone boundary is approximately 456m, which illustrates the highly localized nature of the flood zones.

[11] The primary reason these homes were not successfully geocoded is because they are missing the property's zip code.

[12] In Hennighausen & Suter (2020), they note that about 3% of all buildings are located inside the floodplain in Boulder County, CO.

4 Theoretical Framework and Empirical Strategy

For decades, the value consumers place on local environmental amenities and disamenities has been an area of extensive research. Pioneered by Rosen (1974), the standard workhorse model in this literature is the hendonic property model, which is used to estimate marginal implicit prices of different housing characteristics. The hendonic model's versatility is one of its strengths and it is used frequently in many applications related to environmental economics, with more recent studies examining how various environmental amenities, including wind turbines (Dröes & Koster (2016)), traffic congestion (Tang (2021)), and lead paint (Billings & Schnepel (2017)) affect housing value.

The naive approach of estimating the flood risk discount is to include a dummy variable equal to one if the parcel is located in the 100-year floodplain at the time of sale. However, this identification strategy may lead to biased estimate results due to the possible confounding effects of flood risk. The dummy variable is taking the average effect of location in a floodplain, and when flood zone status is identified by a temporal change in flood zone status, this specification treats the effect of getting mapped into and out of the floodplain as equal weighted. In their study, Shr and Zipp (2019) provide evidence of the presence of two-way differential effects of flood zone re-mapping, which also demonstrates the shortcomings of the naive approach. This suggests that in order to obtain precise estimates of the true effect of the disamentity of location in a flood zone, the mapped-in and mapped-out approach must be used.

4.1 Identification

The primary identifying assumption is that absent flood zone status, homes on either side of the flood zone boundary have similar characteristics and thus have similar housing value. Figure 1 illustrates the highly localized nature of the flood zone boundaries. It is reasonable to assume that following the 2009 map update, any change in a home's flood zone status is as good as random. A concern for identification is that the new flood zone boundaries may not be completely exogenous. It is easy to imagine a homeowner (or a group of homeowners) petitioning FEMA during the map update process to have their property exempt from the new flood zone. However, for reasons discussed in Kousky and Wilson (2019), this is highly unlikely. To appeal your flood zone status, a homeowner must first hire their own scientific consultants who must provide evidence to FEMA showing why a revision to the new flood map is necessary. FEMA reviews the appeal and issues a decision.[13] Given that the appeal process is lengthy and quite expensive, it is doubtful that it will bias the estimates. Additional information about the appeals process from FEMA's website details the reasons why an appeal can be submitted. Due to scale limitations, newly drawn flood maps may inadvertently include areas of natural high ground in a flood zone. Therefore, a homeowner can appeal their flood zone status based off of the base flood elevation of the home. Parcel level fixed effects control for the terrain of the property and the base flood elevation of the home.

Another concern is flood zone remapping could be influencing homeowners' decision to sell their home. In Figure 3, I plot the annual count of homes sold in Miami-Dade County by flood zone status.

From the figure, it is clear that there are more homes sold outside of a flood zone compared to homes located inside the 100-year floodplain. However, there is no discernible difference in homes sold by flood zone status after the 2009 flood map update. Homes sold in a flood zone follow a similar pattern to homes sould outside of a flood zone, suggesting the flood zone remapping is not influencing homeowners' decision to sell their home.

When estimating a hedonic model, one of the primary concerns is omitted variable bias. There may be some feature (such as slope of the terrain) that is not directly observed in the dataset, yet could potentially impact the estimates. Most studies in the flood risk literature use some type of spatial fixed effects model including a spatial weights matrix.

[13]If FEMA's decision is appealed again, then a Scientific Resolution Panel is formed by the National Institute of Building Sciences. They independently review the case and issue a decision.

To overcome any potential omitted variable bias, I employ a parcel fixed effects model; this results in a repeat sales sample only when parcel-level fixed effects are included. To illustrate how the model with parcel-level fixed effects improve precision of the estimates, I include specifications of the model with fixed effects at two additional levels: Census tracts and Census block groups.

4.2 Primary Specification

A key contribution from Zhr and Zipp (2019) is that they are able to identify the asymmetric nature of the relationship between being mapped in and mapped out of a flood zone; they found that homes incur a steep price discount when they are mapped into a flood zone while there is no impact on price when a home is mapped out of a flood zone. This study further examines this relationship and the mechanisms behind it. Using a larger dataset, I am able to investigate whether or not there is a stigma effect for properties that are mapped out of flood zone, as well as how the flood risk discount evolves over time following a flood map update. I am also able to examine how proximity to the old flood zone boundary impacts the flood risk discount. Investigating how proximity impacts the flood risk premium will help provide additional support for the presence of a strong saliency effect.

To estimate the impact of being mapped into or out of a flood zone, I estimate the following hedonic property model using two different levels of fixed effects:

$$\begin{aligned} lnSP_{itb} = \beta_0 + \beta_1 mapped\ in_{it} + \beta_2 mapped\ out_{it} \\ + \beta_3 always\ mapped_{it} + \beta_4 X + \tau_t + \delta_b + \varepsilon_{it} \end{aligned} \quad (1)$$

Where *ln SP* is the natural log of the indexed sales price of home i sold in year t and in Census block group b . The coefficients of interest are β_1 and β_2, where $\beta_1 map\ in$ is a dummy variable equal to one if house i is mapped into a 100-year flood zone and $\beta_2 map\ out$ is a dummy variable equal to one if house i is mapped out of a 100-year flood zone. $\beta_3 always\ mapped$ is a dummy variable equal to one if the parcel is always located in a flood zone during the study. Thus, the omitted category is homes that are never mapped into a flood zone during the study. $\beta_4 X$ is a vector containing descriptive housing characteristics, including age, lot size, quarter of sale, and total size of the living area. τ_t represents year of sale fixed effects. δ_b represents neighborhood fixed effects; the first specification includes Census tract fixed effects, and the second specification includes Census block group fixed effects. Standard errors are clustered at one level higher than the fixed effects in the model, which helps address issues of spatial autocorrelation and dependence (for example, if I include block group fixed effects, the standard errors are clustered at the Census tract level.)

The primary estimating equation with parcel-level fixed effects is:

$$lnSP_{it} = \beta_0 + \beta_1 mapped\ in_{it} + \beta_2 mapped\ out_{it} + \beta_3 X + \tau_t + \nu_i + \varepsilon_{it} \quad (2)$$

where the Census tract/block group fixed effects δ_b are now replaced by ν_i, the parcel fixed effects. In a hedonic property model with parcel fixed effects, the implicit prices are identified through temporal variations of the variable. Thus, the implicit price of flood risk is identified when there are temporal variations in a home's flood zone status, which the flood map update provides. Including parcel level fixed effects controls for any time-invariant characteristics of the property as well as the neighborhood. Parcel fixed effects are a better method of controlling for any possible omitted variables compared to higher level fixed effects, such as block group or Census tract level fixed effects.

Miami-Dade's current flood map became effective September 11, 2009. However, it is important to consider the flood map update process; it is standard for preliminary maps to be issued at least one year prior to their effective date and it is unlikely for any of the proposed boundaries to change significantly before the final version is published. I define the treatment period beginning in September 2008, as this corresponds to the timing that the first drafts are made publicly available. I examine the sensitivity of the estimates when the finalized, 2009 map is published as well. Now, $map\ in_{it} = 1$ if the transaction occurred after September

2008 and the home is located in a flood zone after previously being outside of the 100-year floodplain before the update, and $map\ in_{it} = 0$ otherwise. Similarly, $map\ out_{it} = 1$ if the transaction occurred after September 2008 and the home is no longer located in a flood zone after previously being inside the 100-year floodplain before the update, and $map\ out_{it} = 0$ otherwise. It is important to account for this differentiated effect of flood risk; without distinguishing it, I would not be able to accurately estimate the effect of changes in flood risk on housing value.

4.2.1 Primary Specification with Distance Cutoffs

In this section, I examine how sensitive the primary results are to restricting the sample to only include homes sold within a certain distance to their old flood zone boundary. Specifically, I estimate equation (2) after restricting the sample to only include parcels within the following distances to the old flood zone boundary: 50m, 100m, 150m, 200m, 300m, 500m, 750m, 1000m. With the highly localized nature of the flood zone boundaries in mind, these distance cutoffs will help further understand the effect distance has on the flood risk discount.

4.3 Proximity to Old Flood Zone Boundary

After estimating the average treatment effect of being mapped into and out of a flood zone, I investigate the impact distance to the old flood zone boundary has on housing value, the first study to incorporate this. I estimate the following:

$$\begin{aligned} lnSP_{it} = \theta_0 + & \sum_{\tau=0}^{T} \beta_\tau map\ in_{i\tau} * Distance_{i\tau} \\ & + \sum_{\tau=0}^{T} \phi_\tau map\ out_{i\tau} * Distance_{i\tau} + \gamma X + \tau_t + \nu_i + \varepsilon_{it} \end{aligned} \tag{3}$$

The coefficients of interest are β_τ and ϕ_τ; they estimate the effect *distance* to the old flood zone boundary has on sales price[14]. They are constructed by first creating a series of dummy variables equal to one if the house is within a certain distance [the distance bins range from 50 meters - 7,000 meters] from the old flood zone boundary. Then, these dummy variables are interacted with the dummy variables for being mapped into and out of a flood zone. This specification will help assist in determining how intensity of the flood map update varies with distance to the old flood boundary.

4.4 Time Since the Flood Map Update

Furthermore, I test to see how the flood risk discount evolves over time using a modified event-study framework with the following equation:

$$lnSP_{it} = \theta_0 + \sum_{\tau=-T}^{T+2} \beta_\tau map\ in_{i\tau} + \sum_{\tau=-T}^{T+2} \phi_\tau map\ out_{i\tau} + \gamma X + \tau_t + \nu_i + \varepsilon_{it} \quad (4)$$

In this specification, additional time is added in the post-map change period; this is because it is expected for there to be longer lasting effects on housing value after the flood maps update. The coefficients of interest are β_τ and ϕ_τ; they estimate the effect of getting mapped into or out of a flood zone τ-years before$(-\tau)$ or after$(+\tau)$ a flood map update. Therefore, $\tau = 0$ when the updated flood map becomes effective.

4.5 Heterogeneous Effects

I use the following specification to see if the flood risk premium varies by neighborhood composition:

$$\begin{aligned} lnSP_{it} =& \beta_0 + \beta_1 map\ in_{it} + \beta_2 Pct\ Minority * map\ in_{it} + \beta_3 map\ out_{it} \\ &+ \beta_4 Pct\ Minority * map\ out_{it} + \beta_5 Pct\ Minority + \beta_6 X + \tau_t + \delta_i + \varepsilon_{it} \end{aligned} \quad (5)$$

Using 1990 Census data, the average minority share of a block group is 62.5 percent.

[14] see the Appendix for a detailed description of how the distance bins were constructed

Lastly, I examine how the flood risk premium varies by neighborhood income levels:

$$\begin{aligned} lnSP_{it} =& \beta_0 + \beta_1 map\ in_{it} + \beta_2 Pct\ Poverty * map\ in_{it} + \beta_3 map\ out_{it} \\ &+ \beta_4 Pct\ Poverty * map\ out_{it} + \beta_5 Pct\ Poverty + \beta_6 X + \tau_t + \delta_i + \varepsilon_{it} \end{aligned} \quad (6)$$

Using 1990 Census data, the average share of a block group at or below the poverty line is 12.72 percent.

4.6 The Insurance Effect and the Saliency Effect

The first study to examine flood zone re-mapping found the map updating process had asymmetrical effects on sales prices, and the flood risk premium associated with getting mapped into a flood zone was roughly equivalent to the net present value of all future flood insurance premiums. This suggests that, at least in Centre County, the negative effect is entirely being driven by the mandatory purchasing requirement; this is supported by the fact that the authors did not find an impact on sales price for homes that were mapped out of the 100-year floodplain.

I propose a new framework where the sales price discount for the (dis)amenity of location in a flood zone is greater than the NPV of all future flood insurance premiums. In this new setting, the flood risk premium can now be separated into two components: the "insurance effect" (the NPV of all future flood insurance premiums) and the "saliency effect" (the share of the flood risk effect not explained by the insurance effect); the relationship is illustrated by equation (1).

$$Total\ Flood\ Risk\ Discount = Insurance\ Effect + Saliency\ Effect \quad (7)$$

Now, the saliency effect reflects the capitalization of the change in flood risk from the flood map update into sales price. This framework implies that in Centre County, the saliency effect is nonexistent. It is beneficial to examine how the flood risk discount evolves across space and time; this will assist in understanding more about the saliency effect. To do so, I incorporate two additional modifications to the analysis: distance to the old flood zone boundary and how much time has elapsed since the flood map update.

5 Results

I use three different fixed effects levels: Census tract, Census block group, and parcel level to estimate three different models, each using only one level of fixed effects. In the first two baseline models using Census tract and block group fixed effects, the sample is a repeat cross-sectional sample. In the model with parcel fixed effects, the sample is a repeat sales sample; this is my preferred specification.

5.1 Primary Specification Results

In this section I turn to my primary specification, which estimates the effect of getting mapped into and out of flood zone after the 2009 flood map update. The results from estimating Equation 1 with three different levels of fixed effects are displayed in Table 2.

The first column displays results from the regression model using fixed effects at the Census tract level. The coefficients of interest are the *mapped in* and *mapped out* variables. The point estimates indicate when a home is mapped into a flood zone, its selling price decreases by approximately 9.8 percent. The effect is also negative, but the magnitude is smaller when a home is mapped out of a flood zone; its selling price decreases by approximately 4.8 percent. Both of these estimates are significantly higher than the point estimates obtained from the naive specification, and gives credence to the current framework[15]. In the middle column, I implement block group fixed effects and the resulting point estimates for the coefficients of interest are similar to the estimates obtained from the first model. The standard errors are slightly smaller with the block group fixed effects in model 2, suggesting

[15] The regression results using the naive specification are in Appendix A.

the finer level fixed effects help improve precision of the estimates.

In column three, I include parcel-level fixed effects in the estimation, which results in a repeat-sales sample. Now, the results indicate that a home incurs a flood risk penalty of 14.7 percent after being mapped into a flood zone, while a home that is mapped out of the flood zone still experiences a risk premium of 5.8 percent. The coefficient estimate for *mapped out* is similar to the first and second models, while the coefficient estimate for *mapped in* is significantly larger in magnitude. The standard errors for both coefficients are smaller and more precise than the previous two models, indicating that of the models used, the parcel-level fixed effects model performs best at controlling for unobservable and time invariant characteristics.

These results are the first evidence against the hypothesis of asymmetric outcomes after a flood map update; homes that are mapped out of and mapped into flood zones both experience statistically significant declines in sales price. This is also the first paper to identify a flood risk premium that is larger than the net present value of all future flood insurance payments. Shr and Zipp (2019) do not find any significant effect on sales price for homes that are mapped out of the floodplain, while the dollar equivalent of the flood risk discount for homes mapped into the floodplain is almost the same as the average flood insurance payment in perpetuity ($19,981 compared to $20,000). The point estimate from model 3 indicates that a home mapped into a flood zone experiences an average decrease in sales price of $45,779. The average annual flood insurance premium in Miami-Dade County is approximately $1,000, and the net present value of this premium in perpetuity (assuming a 5% discount rate) is $20,000. This suggests the saliency of flood risk is also negatively affecting sales price after a flood map update. The estimates from model 3 imply that approximately 44 percent of the total flood risk discount can be attributed to the insurance effect, while 56 percent of the overall effect can be attributed to the saliency effect. This is the first paper to identify such an effect after a change in flood zone status.

Homes that were mapped out of a flood zone are no longer required to purchase flood insurance. Thus, when considering these results in the context of equation (5), the insurance effect is now zero since the insurance mandate has been removed, and any price discount can be attributed to the saliency effect.

5.1.1 Primary Specification with Distance Cutoffs

Given the extremely localized nature of the flood zone boundaries, I re-estimate equation (2) using restricted samples based on the parcel's distance to the old flood zone boundary; the results are displayed in Table 3.

These results help illuminate the importance of a parcel's proximity to the old flood zone boundary. When the sample only includes transactions of homes within 50 meters of the old boundary, the coefficient estimate for *mapped in* is not statistically different than zero. However, there is a small, negative effect for homes that were mapped out of the floodplain (although this is only statistically significant at the 10 percent level). As the distance cutoff expands and the sample size increases, the flood risk discount for *mapped in* and *mapped out* increases in magnitude.

5.2 Proximity to Old Flood Zone Boundary

The results from the previous section suggest homes that were added to and removed from the floodplain experienced negative effects following their change in flood zone status, indicating the presence of a strong saliency effect. The large sample size allows me to examine how the intensity of the flood risk discount varies with distance to the old boundary, which will assist in understanding more about the saliency effect. The coefficient estimates from estimating equation (3) with parcel level fixed effects are plotted in frames (a) and (b) of Figure 4. The omitted category is the last distance bin, which ranges from 2km to 7.5km.

For homes that were mapped into a flood zone, distance to the old flood zone boundary has a significantly negative effect on sales price, excluding homes that were within 50 meters of the old boundary. However, homes within 50m - 500m of the old boundary experienced a flood risk discount of approximately 10 percent. There is a steep increase in the flood risk discount for homes within 500m - 2,000m of the old boundary; the coefficient estimates double from 10 percent in the 100m-500m range to 20 - 25 percent in the 750m-2,000m range.

These results suggest distance to the old flood zone boundary impacts the saliency of flood risk; as distance to the old boundary increased, the flood risk discount increased as well. It is likely that homeowners that were closer in proximity to the old flood zone boundary were more aware of the underlying flood risk than homeowners further away from the boundary. In the context of equation (5), these results suggest for homes mapped into a flood zone, the saliency effect increases with distance to the old flood zone.

In the bottom frame of figure (4), I plot the coefficient estimates for homes that were mapped out of the 100-year floodplain. While these results are less clear, homes within 100m - 1,500m of the old flood zone experienced a statistically significant decline in sales price, even though there were removed from the 100-year floodplain. As a reminder, homes that are mapped out of a flood zone are no longer required to purchase flood insurance. Thus, any flood risk premium is entirely attributable to the saliency effect.

This is the first study to identify an effect from proximity to old flood zone boundaries on housing value after a flood map update. The results in figure (4) provide additional insight into how the saliency of flood risk evolves across space, which depends whether the parcel was mapped into or out of the floodplain. For homes that were mapped into the floodplain, the saliency effect increased as distance to the old flood zone boundary increased. This relationship is less clear for homes that were mapped out the floodplain; however, it provides additional evidence that these homes continue to incur a flood risk discount after being removed from a flood zone.

5.3 Flood Risk Discount Over Time

Next, I examine how the flood risk discount evolves over time, which will help provide more understanding of the saliency effect. To do so, I estimate equation (4), which employs a modified event study framework and plot the coefficients from the regression results in Figure 5. Panel (a) plots the point estimates of the effect of being mapped into a flood zone on housing value over time, and Panel (b) plots the point estimates for homes that were mapped out of flood zone (the red line is the point estimate from the baseline specification (ever mapped in a flood zone, -.016). For homes mapped into a flood zone, the effects are negative, statistically significant, and persist at least seven years after the flood map update. The magnitude of the flood risk discount fluctuates between -10% and -20%, reaching a maximum discount of -22% five years after the update. Once again, the results for homes mapped out of a flood zone are less clear. Homes mapped out of the floodplain are expected to have a negative impact on housing value before the map change. After the map change, the point estimates oscillate between positive and negative. The long-lasting effect of the flood risk discount for homes mapped into a floodplain is an interesting result in the broader context of the flood risk literature. Typically, the saliency of flood risk increases after a natural disaster occurs (Gallagher (2014), Bin & Landry (2013)), followed by a reversion to some pre-disaster mean. This is not the case in the context of the current study; it is clear from Panel (a) in Figure 5 that the large negative price discount persists for many years after the new flood map was issued (providing an information update about flood risk in the area).

5.4 Heterogeneous Effects

Next, I investigate how the flood risk discount varies by neighborhood composition by estimating equation (5). Similar to the primary specification, I estimate three different models, each employing three different levels of fixed effects (Census tract, block group, and parcel-level); the results are displayed in Table 4. The coefficient estimates from the preferred model, column three, indicate the negative side effects of flood zone remapping are occurring mostly in minority neighborhoods. If homes located in a neighborhood with the sample average minority share (of 62.5 percent) were mapped into a flood zone, they experienced an average flood risk discount of 10.8 percent. Conversely, homes in similar neighborhoods that were mapped out of a flood zone experienced an average flood risk discount of 5.9 percent.

I also examine how the flood risk discount varies by neighborhood income levels; the output from estimating equation (6) is displayed in Table 5. The results indicate the flood risk discount is strongest in neighborhoods with low income levels.

6 Robustness Checks

First, I investigate if outliers in the homes' sale prices are influencing the primary results. To account for any potential outliers, I apply a 90 percent Winsorization rate to the dataset by indexed sales price. After dropping all transactions below $5,000, I identify the sales price of the top and bottom 5th percentile of the dataset. Then, the sales price of the extreme values in the top and bottom 5 percent of the sample are all transformed to their respective threshold prices ($833,069 and $55,135 respectively). The sales price for every home in the top five percent of the sample is now $833,069, and the sales price for every home in the bottom five percent is now $55,135. I replicate Table 2 using the Winsorized data.

The results from the repeat-sales specification in column 3 are smaller in magnitude compared to the full sample; however, the are both statistically significant and negative. The figures replicating the proximity and time subsections are in Appendix section D. As an additional robustness check, I omit all transactions in the top and bottom 5 percentiles and estimate the primary specification; the results are similar to the Winsorized data, and are presented in Appendix E.

This is the first paper to identify a relationship between a parcel's distance to their old flood zone boundary. I estimate equation (2) using the Winsorized sample and the results are presented in Appendix D; the magnitudes are smaller but the coefficients follow the same pattern, a decrease at 100 meters and 1000 meters. The results for distance are also robust to changing the distance cutoffs, these results are presented in Appendix F.

7 Discussion and Conclusions

This paper investigates how consumers in a coastal county respond to an update in stated flood risk by estimating the affect a change in flood zone status has on housing value. I find evidence of a steep price discount for homes mapped into a flood zone after the 2009 flood map update in Miami-Dade County; this effect is long-lasting as well, enduring for at least seven years after the map update. When analyzing the effect of being mapped out of flood zone, the results are less clear. Furthermore, how this effect evolves over time is complicated as well; in some years, the effect is positive, while in other years, the effect is negative. On average, there is still a negative, statistically significant effect; however, it is smaller in magnitude compared to the coefficient estimate for being mapped into a flood zone.

Proximity is important as well; homes that were mapped into a floodplain, but within 50 meters of the old flood zone boundary did not experience an significant effect on price. However, the flood risk discount increased as the distance to the old flood zone boundary increased. Homes sold between 50 - 600 meters of the old flood zone boundary experienced a 10 percent decline in value after getting mapped into a flood zone; this effect nearly doubles for homes sold between 500 - 2,000 meters from the old flood zone boundary. The price discount is most prominent for houses sold in neighborhoods with high minority population and neighborhoods with low income.

As we continue to learn how to prepare for the aftermath of climate change, this paper provides an interesting case study of the ramifications of a flood map update on housing value in a coastal county. It is widely agreed that the climate is changing, but the how and why are less clear, which creates a lot of uncertainty about how consumers will respond to climate change. Along New Zealand's Kapiti Coast, the government published coastal erosion projections that indicated at least 1,000 homes would be directly impacted by coastal erosion. A recent study found that this policy had no significant impact on coastal housing value Filippova et al. (2020).

One thing is certain, and that is the frequency of extreme weather events, such as floods and hurricanes, is increasing. Recently, Germany experienced a series of devastating floods, leaving over 130 citizens dead. According to the Wall Street Journal, German politicians who surveyed the damage all agreed, "the record rainfalls and ensuing disaster were the product of climate change."[16] It is imperative that local governments are prepared to face all of the challenges caused by climate change, such as the increase in flood risk.

Since flood risk continues to evolve over time, flood maps must be as up-to-date as possible. Once these new flood maps are issued, this paper demonstrates that there will be severe financial consequences for homes that are impacted by the map change. As more homes are brought into the 100-year floodplain (which is likely to be the case for coastal communities due to SLR), the value of the property inventory for the area will decrease. As the value of the property inventory decreases, so will the local tax inventory, affecting local government budgets. Analyzing how FEMA flood map updates impact housing outcomes is a growing section of the literature, and there are many interesting future avenues of research; Miami-Dade County published new preliminary flood maps in February of 2021, it would be interesting to see if housing prices have already started reacting to the information shock. Also, researching the effect of flood map changes in a different part of Florida would be beneficial to see if the results are unique to Miami-Dade's location. Perhaps a larger sample size would allow for further investigation into a possible "stigma effect" for houses that are mapped out of a flood zone[17]. There are publicly available SLR projection maps for Florida, these could be used to see if the future risk of SLR is capitalized prices in the Florida housing market.

[16] $https : //www.wsj.com/articles/flooding - in - germany - demonstrates - need - to - prepare - for - climate - change - scientists - say - 11626886600?reflink = desktopwebshare_permalink$

[17] Taylor et al. (2016) find no evidence of any stigma effect after contaminated sites are remediated in Minneapolis-St.Paul

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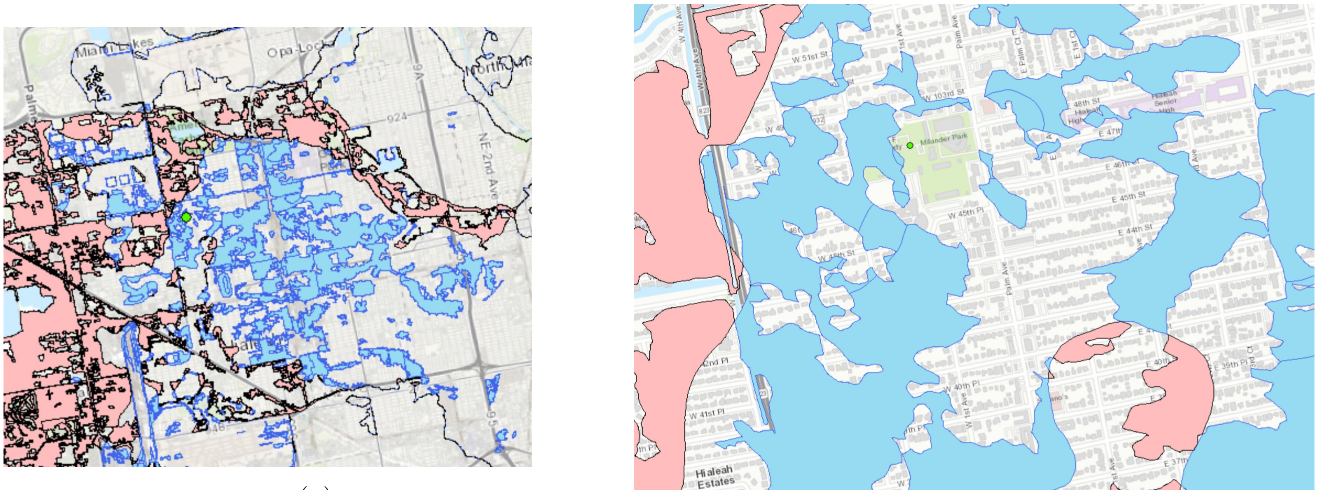


(a)

(b)

Figure 1: Changes in Miami-Dade's flood zones surrounding Ted Hendricks Stadium in Milander Park, Hialeah

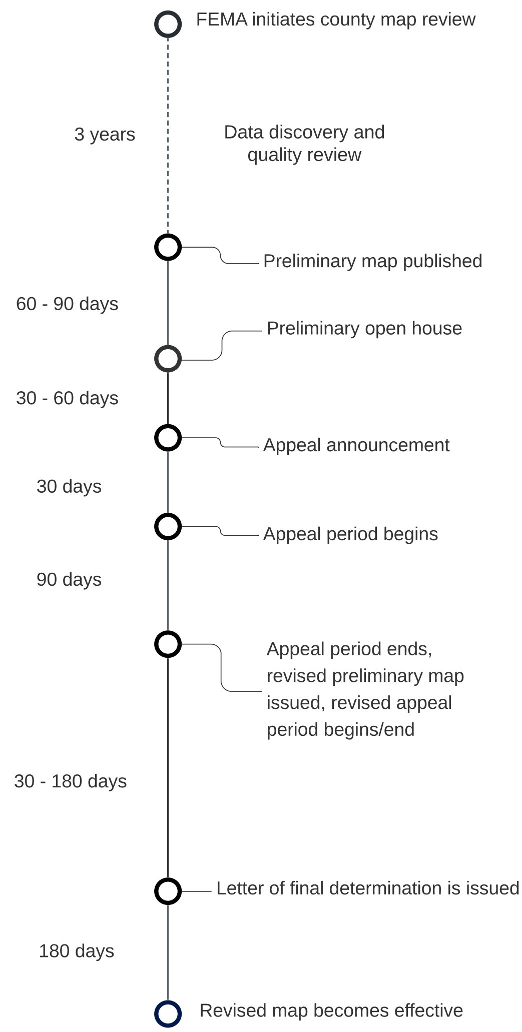


Figure 2: Standard Flood Insurance Rate Map Adoption Process

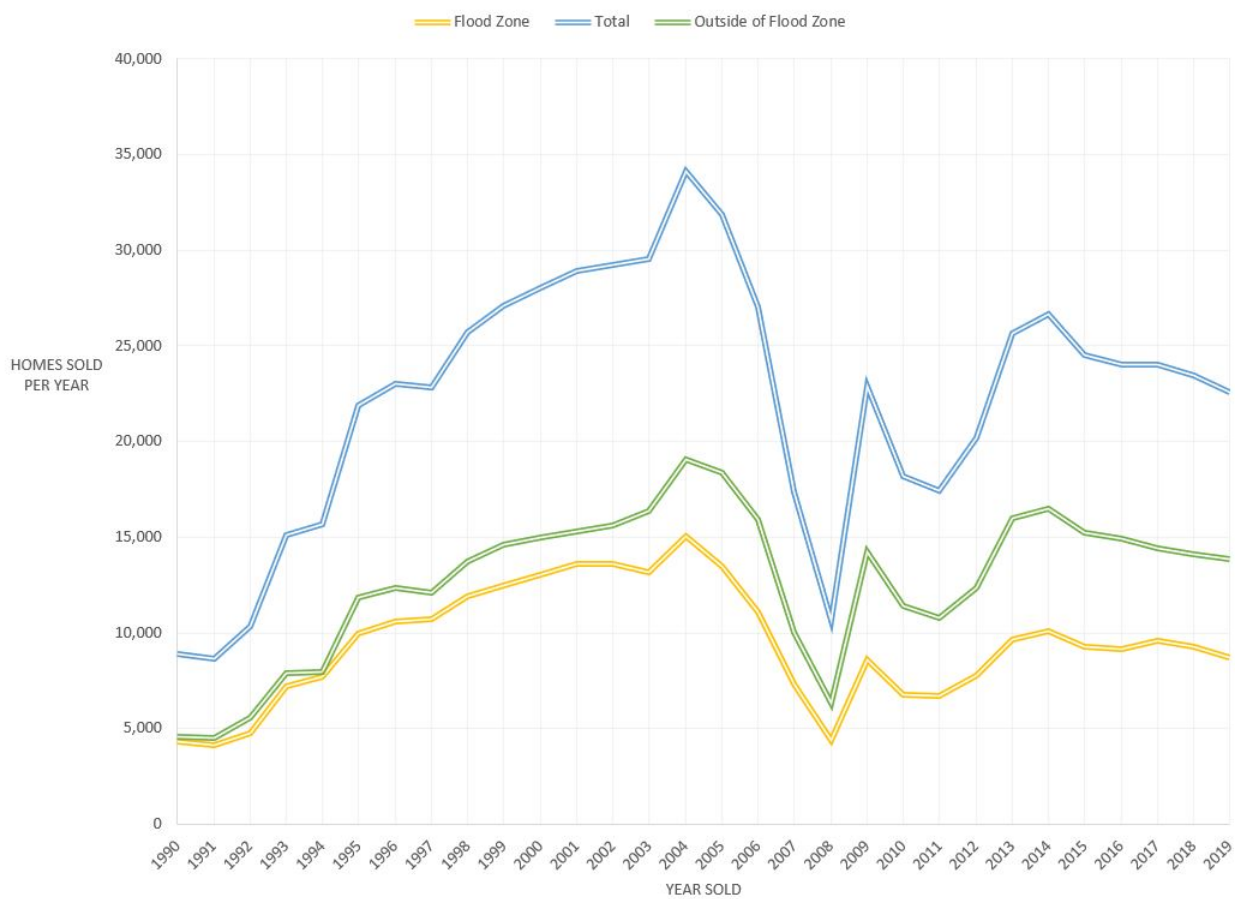
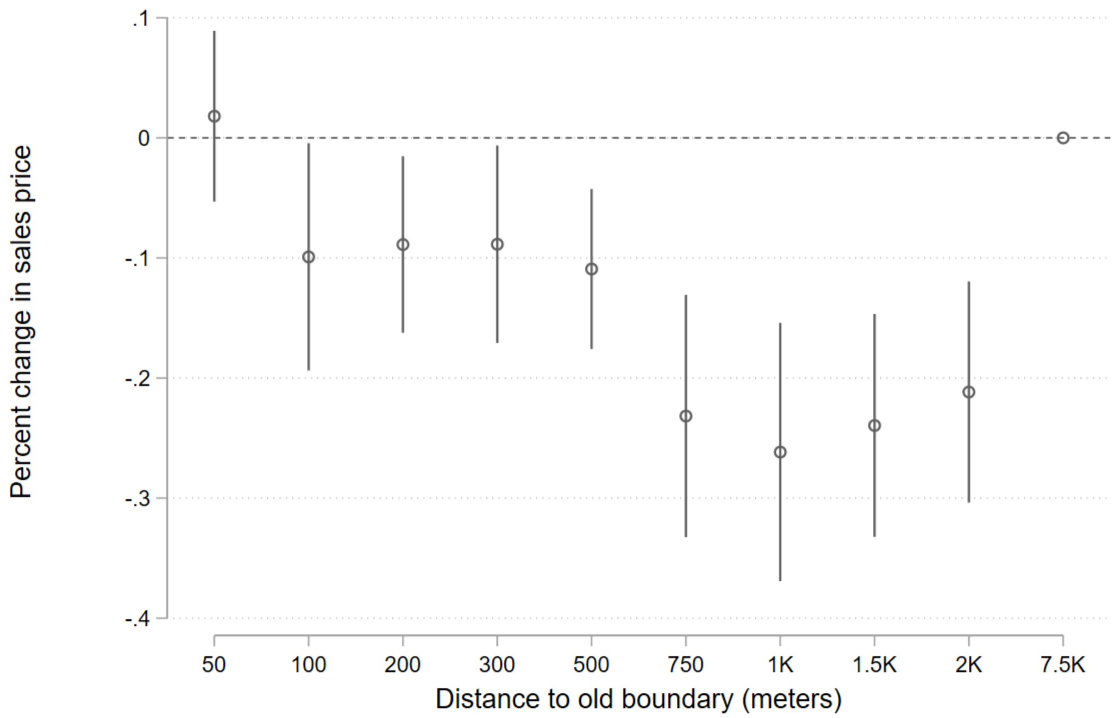
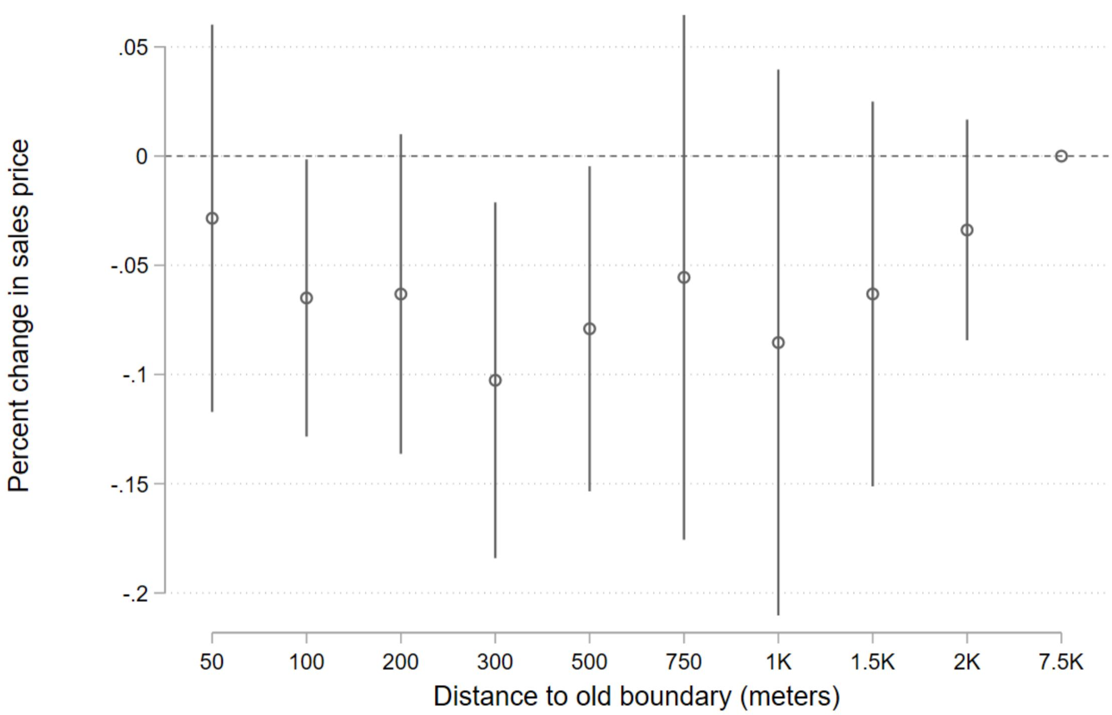


Figure 3: Homes sold in Miami-Dade County

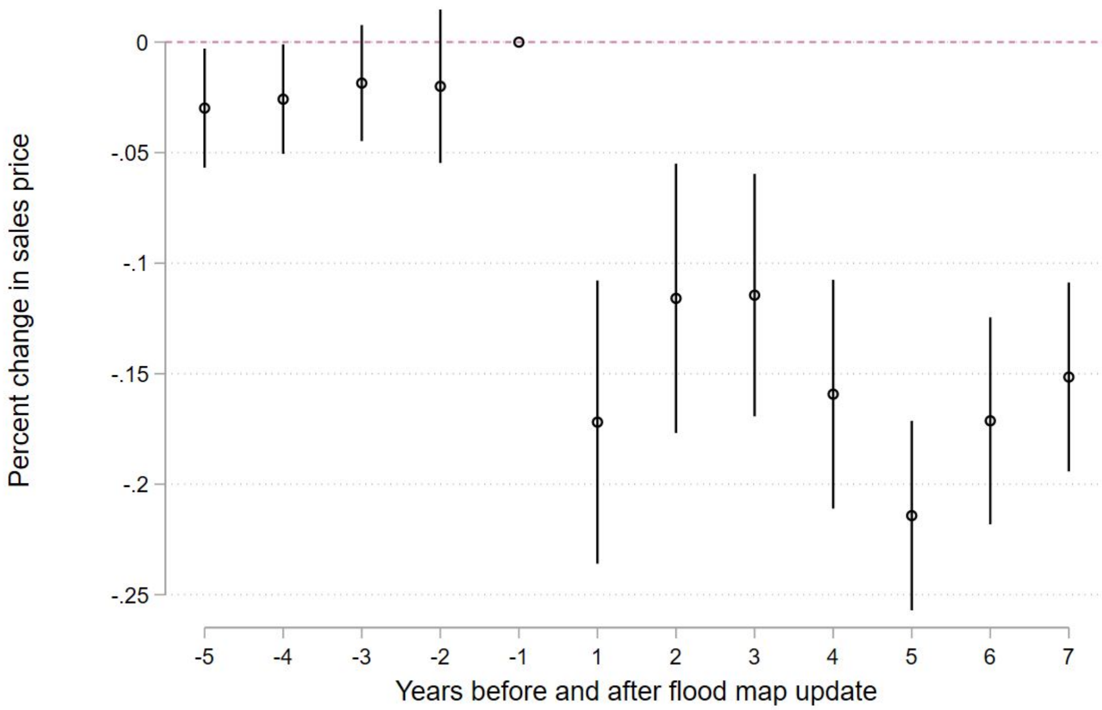


(a) Estimates for *mapped in*

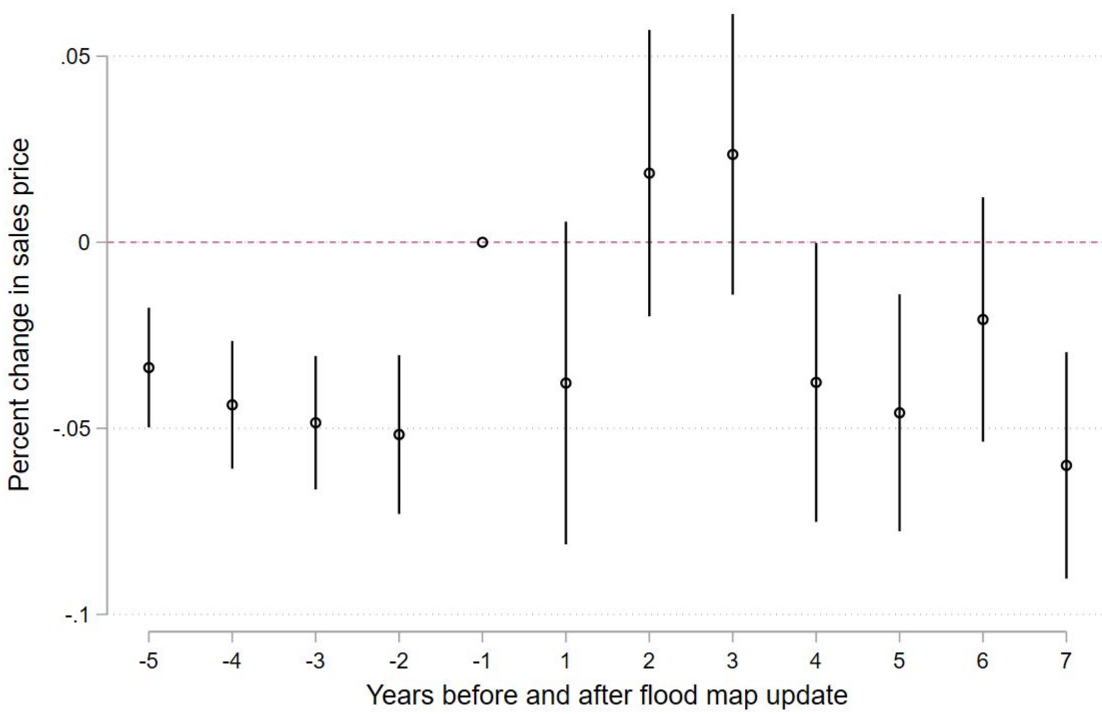


(b) Estimates for *mapped out*

Figure 4: Coefficient estimates from equation (3)



(a) Estimates for *mapped in*



(b) Estimates for *mapped out*

Figure 5: Coefficient estimates from equation (4)

Table 1: Summary Statistics

Panel A: All parcels: 607,092 transactions			
Variable	Mean	Median	Std. dev.
Indexed sale price	$310,791	$ 204,059	$589,201
Living Space (square feet)	1958.6	1711	1023.2
Age	35	35	45
Distance to old flood zone boundary	770.8m	455.8m	839.1m
Panel B: Parcels ever in a Flood Zone: 310,725 transactions			
Variable	Mean	Median	Std. dev.
Indexed sale price	$353,638	$ 217,578	$731,586
Living Space (square feet)	2089.7	1834.0	1088.1
Age	30	27	41
Distance to old flood zone boundary	873.9m	423.3m	1014.6m
Panel C: Parcels never in a Flood Zone: 296,367 transactions			
Variable	Mean	Median	Std. dev.
Indexed sale price	$265,868	$ 183,996	$382,158
Living Space (square feet)	1821.3	1597.0	930.9
Age	41	43	50
Distance to old flood zone boundary	662.7m	488.1m	583.2m

[1] 188,026 transactions occur when the property is always mapped in a flood zone.

Table 2: Primary Specification

Model			
	1	2	3
Variable	lnSP	lnSP	lnSP
Mapped in	-0.0984***	-0.1018***	-0.1473***
	(.0179)	(.0146)	(.0091)
Mapped out	-0.0483***	-0.0354***	-0.0583***
	(.0181)	(.0148)	(.0062)
Always mapped	0.0150*	0.0184	
	(.0091)	(.0129)	
Living area	0.0004***	0.0004***	0.0003***
	(.00002)	(9.77e^{-6})	(8.91e^{-6})
Living area^2	-1.40e^{-8}***	-1.33e^{-8}***	-9.87e^{-9}***
	(1.26e^{-9})	(9.27e^{-10})	(6.56e^{-10})
Age	-0.0005***	-0.0005***	-0.0006***
	(.00007)	(.00007)	(.00009)
Year and quarter dummies	Yes	Yes	Yes
Adj. R-squared	0.7239	0.7292	0.8230
Observations	605,963	605,963	606,424
Groups	257	669	164,727
Fixed effects	tract	block groups	parcel
Clustered errors	Yes	Yes	Yes

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels.

Table 3: Results using Distance Cutoffs

Outcome variable: ln sales price					
Model	1	2	3	4	5
Distance cut-off	full sample	$\leq 50m$	$\leq 100m$	$\leq 150m$	$\leq 200m$
Mapped in	-0.1473***	0.0095	-0.0471**	-0.0572***	-0.0721***
	(.0091)	(.0258)	(.0221)	(.0195)	(.0172)
Mapped out	-0.0583***	-0.0386*	-0.0558***	-0.0606***	-0.0661***
	(.0062)	(.0218)	(.0166)	(.0137)	(.0122)
Adj.R^2	0.8230	0.8232	0.8175	0.8165	0.8236
Observations	606,424	44,566	96,526	139,895	179,728
Groups	164,727	12,233	32,671	47,178	60,423
Fixed effects	parcel	parcel	parcel	parcel	parcel
Sample	repeat sales	repeat sales	repeat sales	repeat sales	repeat sales

Outcome variable: ln sales price				
Model	6	7	8	9
Distance cutoff	$\leq 300m$	$\leq 500m$	$\leq 750m$	$\leq 1000m$
Mapped in	-0.0855***	-0.0955***	-0.1236***	-0.1357***
	(.0139)	(.0121)	(.0115)	(.0110)
Mapped out	-0.0835***	-0.0871***	-0.0865***	-0.0862***
	(.0105)	(.0090)	(.0083)	(.0078)
Adj.R^2	0.8360	0.8413	0.8412	0.8388
Observations	227,310	320,708	396,926	444,910
Groups	61,873	87,054	107,627	120,591
Fixed effects	parcel	parcel	parcel	parcel
Sample	repeat sales	repeat sales	repeat sales	repeat sales

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels. [2] errors are clustered at the parcel level.

Table 4: Flood Risk Discount by Neighborhood Minority Population Levels

Model			
	1	2	3
Variable	lnSP	lnSP	lnSP
Mapped in	0.0705*	0.0821**	0.0861***
	(.0406)	(.0401)	(.0248)
Mapped out	0.0313	0.0208	0.0725***
	(.0451)	(.0471)	(.0165)
Percent minority	-0.0051***	-0.0050***	
	(.00084)	(.0014)	
Percent minority x	-0.0024**	-0.0025***	-0.0031***
mapped in	(.00049)	(.00048)	(.00033)
Percent minority x	-0.0012*	-0.0011	-0.0021***
mapped out	(.0006)	(.0007)	(.0002)
Year and quarter			
dummies	Yes	Yes	Yes
Adj. R-squared	0.7271	0.7321	0.8232
Observations	605,963	605,963	606,424
Groups	257	669	164,727
Fixed effects	tract	block groups	parcel
Clustered errors	Yes	Yes	Yes

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels.

Table 5: Flood Risk Discount by Neighborhood Income Levels

Model			
	1	2	3
Variable	lnSP	lnSP	lnSP
Mapped in	-0.06684***	-0.0620***	-0.0394***
	(.0217)	(.0203)	(.0125)
Mapped out	0.01370	0.0273	0.0359***
	(.0199)	(.0176)	(.0101)
Percent poverty	-0.0055***	-0.0094***	
	(.00083)	(.0014)	
Percent poverty x	-0.0024***	-0.0029***	-0.0067***
mapped in	(.00067)	(.00087)	(.00067)
Percent poverty x	-0.0061***	-0.0068***	-0.0089***
mapped out	(.0011)	(.0012)	(.00084)
Year and quarter			
dummies	Yes	Yes	Yes
Adj. R-squared	0.7260	0.7318	0.8234
Observations	605,963	605,963	606,424
Groups	257	669	164,727
Fixed effects	tract	block groups	parcel
Clustered errors	Yes	Yes	Yes

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels.

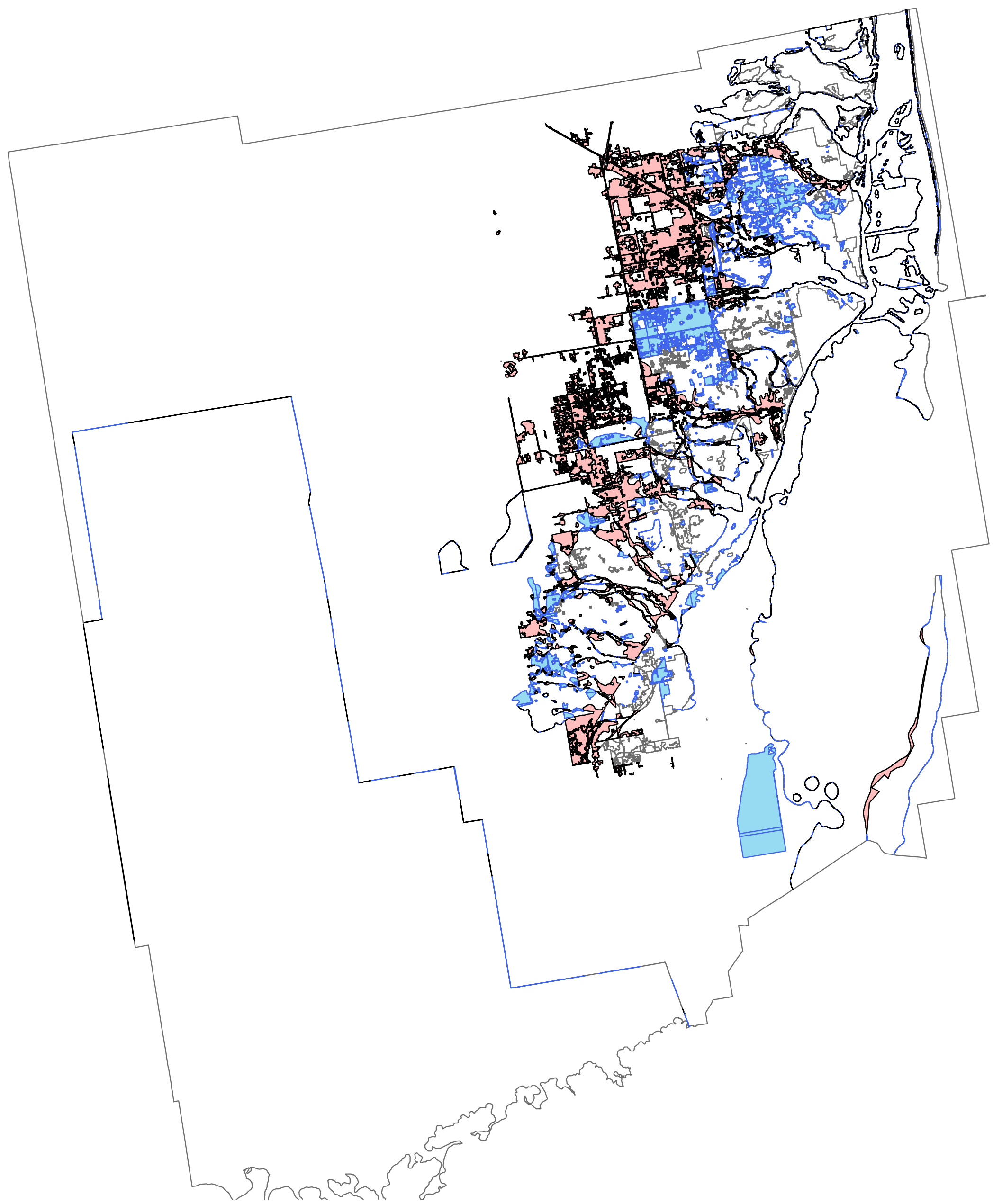
Table 6: Winsorized Data

Model			
	1	2	3
Variable	lnSP	lnSP	lnSP
Mapped in	-0.0667***	-0.0681***	-0.0973***
	(.0141)	(.0117)	(.0064)
Mapped out	-0.0375***	-0.0287**	-0.0471***
	(.0145)	(.0124)	(.0047)
Always mapped	0.0206**	0.0228*	
	(.0102)	(.0137)	
Living area	0.0004***	0.0004***	0.0002***
	(.00002)	(.00002)	(.00002)
Age	-0.0003***	-0.0003***	-0.0005***
	(.00005)	(.00005)	(.00008)
Year and quarter dummies	Yes	Yes	Yes
Adj. R-squared	0.7575	0.7632	0.8508
Observations	605,963	605,963	606,424
Groups	257	669	164,727
Fixed effects	tract	block groups	parcel
Clustered errors	Yes	Yes	Yes

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels.

A Old and New Flood Zones

The red-shaded areas illustrate the area mapped out of the SFHA following the 2009 update, while the blue-shaded areas illustrate the area mapping into the SFHA.



B The Naive Specification and Results

B.1 Naive Specification

Before estimating my primary specification, I present results using the naive approach to highlight how the estimates may be biased. The following naive hedonic model is estimated using three different levels of fixed effects: Census tract, block group, and parcel.

$$lnSP_{it} = \beta_0 + \beta_1 SFHA_{it} + \beta_2 X + \tau_t + \delta_i + \varepsilon_{it} \quad (8)$$

Where $lnSP_{it}$ is the natural log of the indexed sale price of house i in year t. In the naive method, *SFHA* is a dummy variable equal to one if a home is located in the 100-year floodplain at time of sale. The Special Flood Hazard Area (SFHA) is all areas designated by FEMA as being part of the 100-year floodplain. $\beta_3 X$ is a vector containing descriptive housing characteristics, including age, lot size, and total size of the living area. τ_t represents year of sale fixed effects. δ_i represents neighborhood fixed effects, and clustered errors are included.

B.2 Naive Specification Results

In examining the flood risk discount in Miami-Dade County, I first estimate the naive specification of flood zone risk. Results of the naive flood risk estimates are presented in Table 2, separated into three columns, one for each level of fixed effects. Results from using Census tract group fixed effects are in Column 1, and the coefficient estimate for *SFHA* is slightly positive, but not statistically different from zero. In column 2 I include Census block group fixed effects; however, the coefficient estimate for *SFHA* is once again slightly positive and not statistically different from zero. In column 3 I use parcel-level fixed effects in the model, and now the estimate for *SFHA* is -1.67 percent and statistically significant at the one percent level. This estimate is smaller than literature's average of 4.6 percent (Beltran et al.

Table 7: Naive Regression Results

Outcome variable: ln sales price			
Model	1	2	3
Variable	lnSP	lnSP	lnSP
SFHA	0.0075	0.0113	-0.0167***
	(.0083)	(.0100)	(.0049)
Living area	0.0004***	0.0004***	0.0003***
	(.00002)	$(9.76e^{-6})$	$(8.98e^{-6})$
Living area^2	-1.38e^{-8}***	-1.33e^{-8}***	-9.87e^{-9}***
	$(1.27e^{-9})$	$(9.29e^{-10})$	$(6.64e^{-10})$
Age	-0.0005***	-0.0005***	-0.0006***
	(.00007)	(.00007)	(.0001)
Year and quarter dummies	Yes	Yes	Yes
Adj. R-squared	0.7235	0.7287	0.8226
Observations	605,963	605,963	606,424
Groups	257	669	164,727
Fixed effects	tract	block groups	parcel
Clustered errors	Yes	Yes	Yes

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels.

(2018)). Within the repeat sales/parcel fixed effects framework, the variable for flood zone status is only identified when there is a temporal variation in flood zone status after the 2009 update. The results in Table 2 support the argument that there are confounding effects of flood risk and that econometric models must distinguish between the effects of mapping in and out of a flood zone. Thus, in modeling for differentiated effects of flood zone remapping, I am able to obtain more reliable estimates of the flood risk discount in Miami-Dade County.

C Distance Bin Construction

The distance bins were constructed as follows:

- (0m-50m], (50m - 100m], (100m - 200m], (200m - 300m], (300m - 500m],
- (500m - 750m], (750m - 1000m], (1000m - 1500m], (1500m - 2000m], (2000m - 7500m]

- Average distance: 770.8 meters
- 10% of sample < 67 meters
- 25% of sample < 181 meters
- 50% of sample < 455 meters
- 75% of sample < 1066 meters
- 90% of sample < 1959 meters

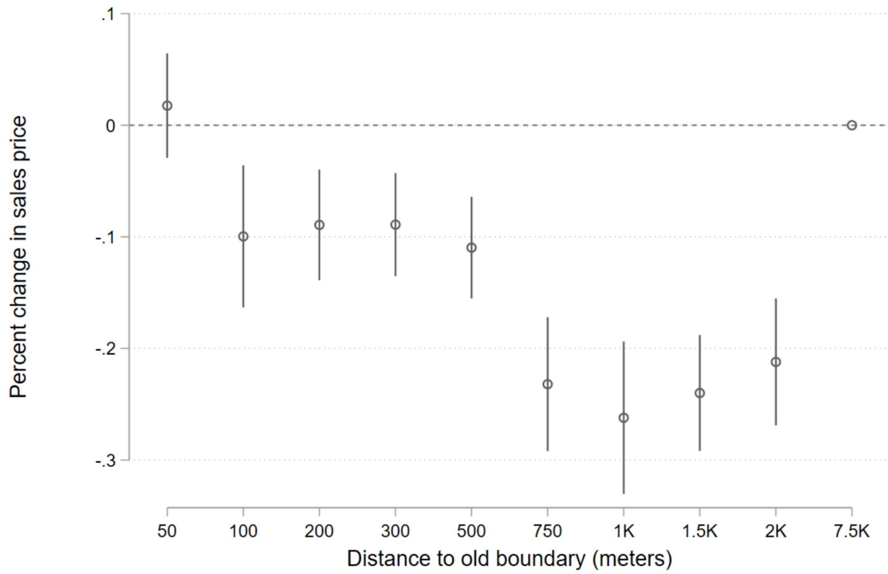
D Trimmed top and bottom 5 percent

Table 8: trimmed Data

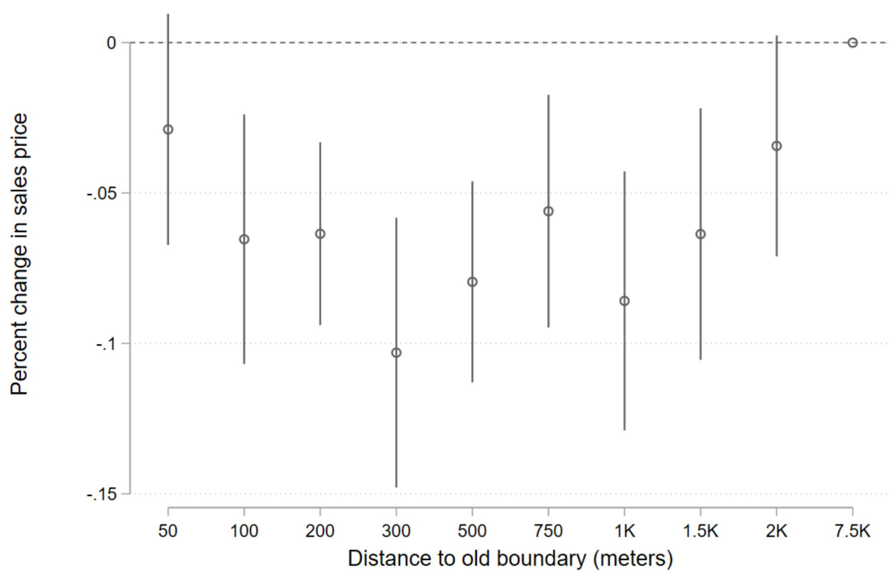
Model			
	1	2	3
Variable	lnSP	lnSP	lnSP
Mapped in	-0.0512***	-0.0515***	-0.0795***
	(.0127)	(.0109)	(.0062)
Mapped out	-0.0227*	-0.0173	-0.0344***
	(.0123)	(.0108)	(.0042)
Always mapped	0.0187*	0.0199	
	(.0093)	(.0128)	
Living area	0.0004***	0.0004***	0.0002***
	(.00003)	(.00003)	(.00001)
Age	-0.0004***	-0.0004***	-0.0006***
	(.00005)	(.00005)	(.00012)
Year and quarter dummies	Yes	Yes	Yes
Adj. R-squared	0.7415	0.7458	0.8398
Observations	545,580	545,580	545,794
Groups	256	663	157,129
Fixed effects	tract	block groups	parcel
Clustered errors	Yes	Yes	Yes

[1] ***, **, ** represent significance at the 1%, 5%, and 10% levels.

E Winsorized Proximity and Time

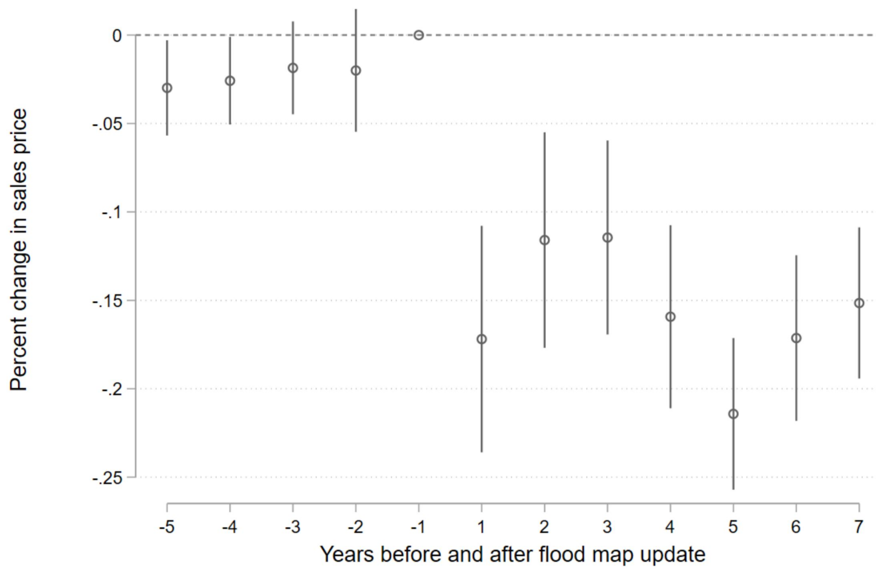


(a) Map In

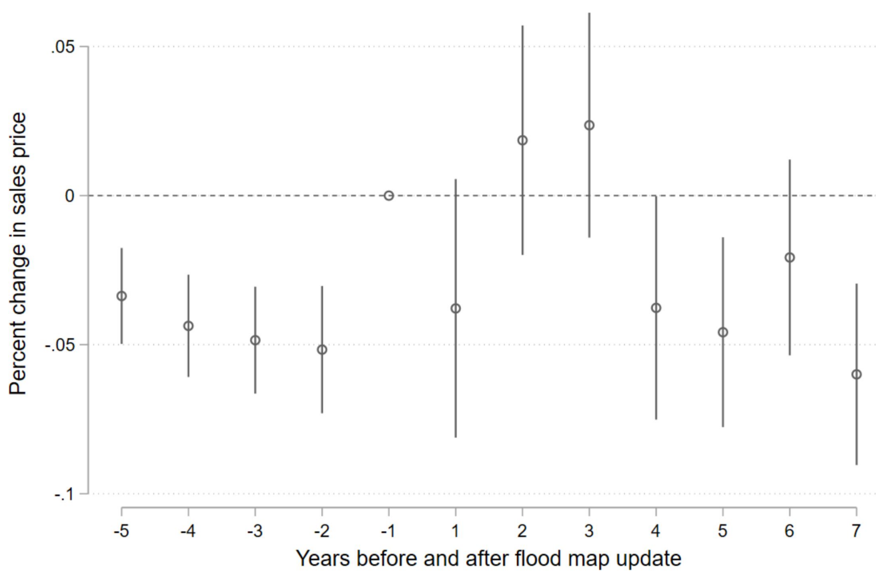


(b) Map Out

Figure 6: Proximity to Old Flood Zone Boundary using Winsorized Sample



(a) Map In

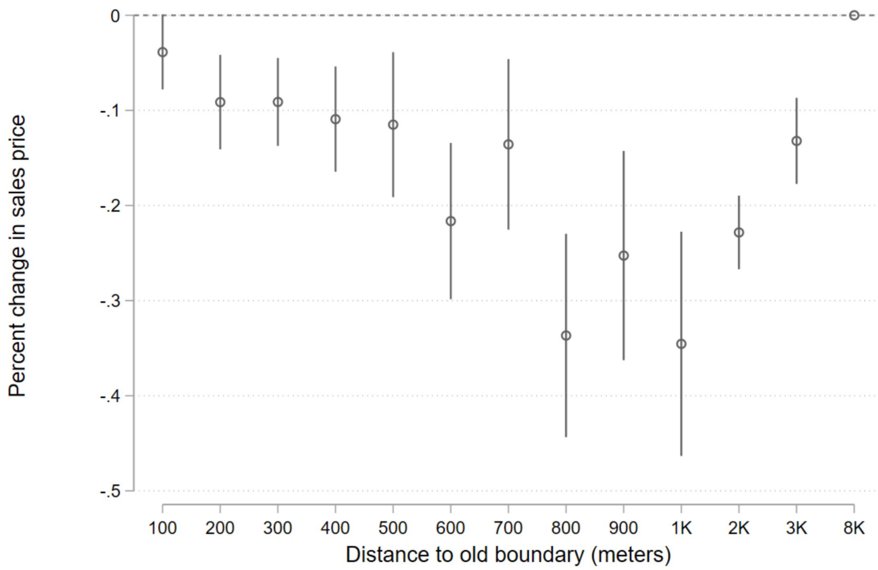


(b) Map Out

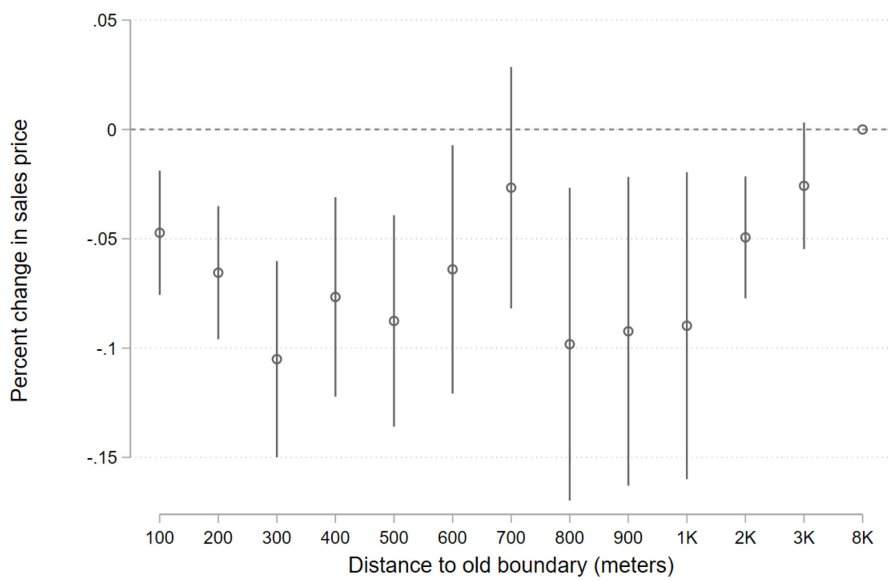
Figure 7: Flood Risk Discount over time using Winsorized Sample

F Different Distance Cutoffs

In this section, I use different cutoffs when constructing the distance bins.



(a) Map In



(b) Map Out

Figure 8: Distance to Old Flood Zone Boundary with different Cutoffs