The Effects of Flood Insurance on Housing Markets

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Abstract

In this article, we analyze the role of flood insurance on the housing markets of coastal areas. To do so, we assembled a parcel-level dataset of the universe of residential sales for two coastal urban areas in the United States—Miami-Dade County (2008–15) and Virginia Beach (2000–16)—matched with their Federal Emergency Management Agency (FEMA) flood maps, which characterize the flood-risk level for each property. First, we compare trends in housing values and sales activity among properties on the floodplain, as defined by the National Flood Insurance Program (NFIP), relative to properties located elsewhere within the same area. Despite the heightened flood risk in the past two decades, we do not find evidence of divergent trends. Second, we analyze the effects of the recent reforms to the NFIP. In 2012 and 2014, Congress passed legislation announcing important increases in insurance premiums and flood map updates. We find robust evidence of large price reductions for properties that were drawn into the flood zone of the new FEMA flood maps. We estimate that, as a result of the mandatory insurance requirement in the flood zone, NFIP insurance costs for such properties in Virginia Beach will increase by an average of about $3,500 per year and lead to a reduction in housing values of about $64,000.

Introduction

Rising sea levels have increased the risk of coastal flooding over the past few decades, becoming the most economically damaging effect of climate change for many coastal locations (Buchanan, Oppenheimer, and Kopp, 2017). The increasing flood risk has been shown to arise from increased likelihood of tidal flooding in low-lying areas (Cooper et al., 2013; Sweet and Park, 2014; Sweet et al., 2014), increased frequency and severity of coastal flooding (Vitousek et al., 2017), and intensification of extreme flooding events (Hunter, 2010; Park et al., 2011; Tebaldi, Strauss, and Zervas, 2012).

At the same time, the population in shoreline areas in the United States has substantially increased (Hauer, Evans, and Mishra, 2016). One factor that may have contributed to this trend is the availability of subsidized flood insurance through the National Flood Insurance Program (NFIP; Conte and Kelly, 2017). The program, managed by the Federal Emergency Management Agency (FEMA), was created through the 1968 National Flood Insurance Act and has since risen to more than 5 million policyholders in 2016. Over the past two decades, NFIP has become burdened with enormous amounts of debt following hurricanes Katrina (2005) and Sandy (2012), which prompted a profound reform in 2012 and 2014, respectively. A major goal of the reform was to increase insurance rates to reflect the increase in flood risk between now and the inception of the program. As a result, flood insurance premiums increased substantially for many floodplain properties.[1]

The main goal of this article is to examine whether flood insurance affects the housing markets of coastal areas. NFIP is the key program at the disposal of the U.S. Government to try to influence individuals' housing location decisions in areas close to bodies of water. In the context of rising sea levels, assessing whether the key elements of NFIP—that is, the new flood maps and the resulting changed schedule of insurance premiums—are effective in shaping location decisions is important.

To carry out the analysis, we assembled a parcel-level dataset including the universe of residential sales for two coastal urban areas in the United States—Miami-Dade County (2008–15) and Virginia Beach (2000–16)—matched with their FEMA flood maps, which characterize the flood-risk level for each property.[2] Parts of these areas are prone to flooding events, and flood insurance is a first-order policy issue in both.

The first question we ask is whether there has been any divergence in trends regarding housing values and sales activity among properties under high risk of flooding, as defined by NFIP, relative to properties located elsewhere within the same area. Evidence of divergence in trends would suggest that housing markets have already been incorporating the increases in coastal flooding risk. We find that these variables behaved very similarly in the floodplain of these coastal areas, relative to the rest of the respective areas, and mostly traced the economic cycle. The lack of evidence of a generalized

[1] Flood insurance premiums vary as a function of flood risk and elevation. To understand the consequences of flood insurance reform on housing values in a simple manner, it is helpful to consider an example based on Kousky (2017). Based on the 2012 reform, the new flood insurance rate corresponding to a single-family home within the 100-year floodplain and 4 feet below the base flood elevation increases from $2,644 to $10,263. Given that the prereform rates did not vary by elevation, however, some properties sitting above the base flood elevation may experience a decrease in premiums. Properties outside the 100-year floodplain pay much lower rates. As a result, the median premium across all single-family policies is $512.

[2] Lacking a national sales registry, obtaining data from local sources and homogenizing individual sales data is a time-consuming endeavor.

differential trajectory for housing values on the floodplain of the coastal areas we analyze may be explained by the role of flood insurance. After all, we would not expect an increase in flood risk to have a large impact on housing values in a setting where properties are fully insured and insurance premiums remain constant over time.

Second, we focus on the recent reforms to NFIP in order to identify the effects of flood insurance on the housing market. In 2012 and 2014, Congress passed legislation to consider the updated (higher) estimated flood risk and ensure the financial viability of the flood insurance program. We focus on two important features of the reform: the increase in flood insurance premiums scheduled to take place from July 2012 onward and the release of updated flood maps, which impose changes to a set of properties that are now subject to mandatory flood insurance requirements. We hypothesize that the increases in premiums mandated by the reforms should have negatively affected the values of properties located in the floodplain, many of which are subject to mandatory flood insurance requirements. Specifically, we ask whether the increase in premiums affecting properties sold after July 2012 affected sales prices. We conduct a difference-in-difference analysis on the change in sales prices around the date of the reform. Our estimates do not reveal a differential effect from the enactment of the Biggert-Waters Act on previously established floodplain properties for the areas of Virginia Beach and Miami-Dade. In addition, we study the changes in the values of properties whose idiosyncratic flood risk has been updated in the new flood map. In the case of Virginia Beach, where updated maps came into effect in 2015, we find clear evidence of a large reduction in sales prices (of 25–28 log points) for properties that were drawn into the new flood maps. Hence, this finding is evidence that flood risk revisions affect housing values within 2 to 3 years, primarily through the effect on insurance premiums. As grandfathering of premium subsidies is phased out, these effects are likely to become more salient.

The rest of this article is organized as follows. The next section presents a brief review of the related literature. The following section provides background information on the history of flood insurance and recent policy changes. Then, we describe the main data sources and the merging process, followed by a section with descriptive statistics on the main variables. Next, we study overall trends of housing prices in flood risk areas relative to the overall area. The next two sections present the main results, followed by our conclusion. Some details of the legislation are relegated to an appendix.

Literature

A large literature estimates the price discount on sales of houses within the 100-year floodplain (Atreya, Ferreira, and Kriesel, 2013; Bin, Kruse, and Landry, 2008; Bin and Landry, 2013; Harrison, Bin, and Polasky, 2004; Smersh and Schwartz, 2001). Most studies use highly localized data and find evidence of a discount, but the magnitude ranges widely (from about 4 percent to 12 percent). In recent studies, Zhang (2016) and Zhang and Leonard (2018) estimated spatial quantile regression models using data for the Fargo-Moorhead metropolitan statistical area. They found evidence of a 3- to 6-percent floodplain penalty, larger among lower-priced homes. The authors argued that this heterogeneous effect may reflect the existence of upper bounds on coverage limits. These studies also show that the penalty rose sharply following a large flooding event in 2009 but fell back to its normal value 2 years later. Compared with these studies, our dataset is much larger, and we focus on the role of flood insurance rather than the evolution of housing markets in the aftermath of large storms or flooding episodes.

Several recent papers also study flood risk and its implications. Gallagher (2014) studied how economic agents update flood risk beliefs after floods occur, as measured by insurance take-up rates. Using a national dataset with information on all flood insurance policies and whether a community is hit by a flood, he found strong evidence of an immediate increase in the fraction of homeowners covered by flood insurance in the affected communities, although the effect vanishes after a few years. Conte and Kelly (2017) documented that the distribution of aggregate hurricane damage in the United States is fat-tailed. They argued that this may be because the distribution of coastal property is also fat-tailed; that is, storms tend to intersect geographic areas with little or no property but also intersect areas with large amounts of property more often than expected, given a normal distribution. The authors then went on to present a model of homeowner behavior for buying insurance, which includes a disaster relief agency that reimburses a fraction of household losses, and showed that moral hazard[3] leads to an increase in the number of households living on the coast and in the size (value) of these properties, resulting in more damage during catastrophic storms.

Our analysis is particularly related to four recent studies. Bakkensen and Barrage (2017) estimated that coastal housing prices exceed fundamentals[4] by about 10 percent. Their analysis suggests that residents of flood-prone areas may have below-average fear of flooding, which might explain the sluggishness in the response of home prices in flood-prone areas to new information of increased flood risk.

Our use of changes to the flood maps as a source of identification is reminiscent of Votsis and Perrels (2016). These authors studied the effects of flood risk on housing values in Finland, exploiting the introduction of flood maps following the European Union Water Directive. These flood risk maps were made publicly available in 2006–07 for several flood-prone areas in Finland. The authors employed a difference-in-difference approach to capture the price differential of flood risk disclosure. They defined the treatment group as those dwellings located in the flood-prone area and the control group as nearby dwellings outside the flood-prone area. They found a significant price drop after the flood risk maps were released, with values ranging from 6 percent to 30 percent.

Recent work on the relationship between flood risk and housing values has been concentrated on the aftermath of Hurricane Sandy in New York in 2012. Ortega and Taşpınar (2018) argued that the hurricane triggered an increase in the perceived risk of living in the flood zone, persistently lowering housing values. Relatedly, Gibson, Mullins, and Hill (2019) studied the response of New York's housing prices to what they considered three flood risk signals:

[3] Moral hazard is defined as the behavior of increasing exposure to risk while insured, especially when the increased risk is taken because someone other than the policy holder bears the cost of those risks.
[4] Here, "fundamentals" is understood as the basic quantitative and qualitative information that contributes to the financial valuation of a house—for example, number of rooms, year built, neighborhood location, and so on.

(1) the Biggert-Waters Flood Insurance Reform Act; (2) Hurricane Sandy; and (3) revised FEMA flood maps. This study shares with ours the goal of estimating the effects of the Biggert-Waters Act on the housing market. Their analysis solely concerns New York City, however.[5]

Flood Insurance

Background: A Brief History of Flood Insurance

Congress created the National Flood Insurance Program (NFIP) in 1968, which is administered by Federal Emergency Management Agency (FEMA), with the goal of providing affordable flood insurance to homeowners. An integral part of the program is the Flood Insurance Rate Map (FIRM), which establishes risk zones. These zones determine flood risk for each property, building code requirements, and flood insurance requirements. Importantly, properties on the high-risk zone, also known as the 100-year floodplain, are required by law to purchase flood insurance if they have federally backed mortgages (or if they have received FEMA assistance in the past).

Largely because of Hurricane Katrina, NFIP accumulated a large amount of debt—more than $25 billion. To make the program financially stable, Congress passed the Biggert-Waters Flood Insurance Reform Act in 2012, which planned to eliminate subsidies to flood insurance rates and phase out several exemptions. However, as a result of vigorous public opposition in affected areas, Congress passed the 2014 Homeowner Flood Insurance Affordability Act. This act repealed some mandates of the 2012 act and slowed down some rate increases (as of April 1, 2015).[6]

Premium Increases

The 2012 Biggert-Waters Act stated that policies for properties purchased or newly insured after July 2012 would have to pay full-risk rates. The act also mandated annual premium increases of 25 percent until rates reflect full risk for structures with severe repeated flood losses as well as for nonprimary residences and businesses (GAO, 2013). The 2014 act slowed down the premium increases to 18 percent per year but did not repeal them.

New Flood Zone Maps

In addition to the aforementioned changes in flood insurance rates, revised FEMA flood maps were commissioned by the 2012 act. The release of these maps differs across areas of the United States. For instance, the new flood zone map for Virginia Beach went into effect on January 2015, whereas the flood map for Miami-Dade has not yet been revised.[7]

Flood maps are created by FEMA in partnership with states and local communities. Hydrologic and hydraulic studies determine ground elevations, as well as the depth of floodwaters, the amount of water that will be carried during flood events, the width of floodplains, and obstruction of water flows. If FEMA determines that a flood map is required, it consults with state and local officials and

[5] A previous version of our article (Indaco, Ortega, and Taşpınar, 2018) included analysis of the effects of NFIP reform on New York City's housing market. We concluded that the close temporal overlap between Hurricane Sandy and the Biggert-Waters Act made it impossible to discern the effects of the two events. As a result, the current version of the article focuses solely on Virginia Beach and Miami-Dade, which were affected by the flood insurance reform but not by Hurricane Sandy. We were not aware of the study by Gibson, Mullins, and Hill (2019) at the time of conducting our analysis, and it seems that the authors of that study were not aware of our article either. Both studies seem to have been carried out simultaneously.
[6] The appendix contains further details.
[7] A new flood map for New York City was released in early 2013 but has not become effective as of early 2019. Thus, political and affordability concerns can affect the timing of the adoption of revised flood maps.

issues a preliminary map. Local authorities can propose amendments or appeals that are considered before issuing the definitive map and making it publicly available.

The Homeowner Flood Insurance Affordability Act of 2014 directs FEMA to notify members of Congress when constituents in their district are affected by a flood mapping update. Typically, members of Congress then disseminate the news to the homeowners in their districts. In addition, in many states, sellers are required to disclose flood risk to potential buyers.

Data

Our dataset merges two different types of data. The first type of data is the universe of sales in the areas of Virginia Beach and Miami-Dade. These datasets have a similar structure for the two areas, but the coverage in terms of years and the actual property characteristics varies somewhat. The second type of data that we use are the FIRMs produced by FEMA for each of these two areas. These data contain shape files that allow us to overlay the tax parcel from the sales dataset onto the map of the flood risk zones.

The resulting dataset contains all sales that took place for these two areas, along with the flood risk class for each of the properties involved.

Housing Sales Data

We obtained the sales data for Virginia Beach from the Virginia Beach Real Estate Assessor's Office. The dataset contains the sales price and date for the last three transactions for every property in Virginia Beach. Approximately 160,000 properties included in this dataset have been sold at least once. The data contain all transactions between January 2000 and September 2016. We merged the sales data with another dataset provided by the area that contains the precise FEMA code for each property both for the previous map of 2009 as well as the most recent map that came into effect in 2015. The merged dataset contains data on 72,289 properties and 120,551 transactions realized after January 2000.

Our data for Miami-Dade County is based on the Florida Department of Revenue tax data files. We obtained and merged the Sales-Data-Files (SDF), the Name-Address-Legal (NAL), and the Name-Address-Personal (NAP) files. The merged dataset contains detailed information on parcels, including land use code, sales price, sales year, sales month, and assessment value, as well as on the geographic characteristics of the parcels. Our sample corresponds to sales recorded from 2008 to 2015, with a total of 356,672 observations. The flood zone information for the parcels is based on the FEMA flood insurance risk maps (effective since 2009).

Flood Insurance Rate Maps

We obtained the shape files for the FEMA flood insurance maps for our two urban areas of interest. These maps partition the areas into three areas: the 100-year floodplain (also known as Special Flood Hazard Areas), the 500-year floodplain, and the rest of the area. Among these, the highest risk of flooding pertains to the 100-year floodplain.[8] In the past few years, FEMA has produced revised flood maps. The release of the revised maps has been staggered, and for some areas, the new maps

[8] The flood maps include a finer partition of the set of properties, which can then be aggregated. As reported by FEMA (https://www.fema.gov/flood-zones), the 100-year floodplain is the union of the following categories: A, AO, AH, A1-A30, AE, A99, AR, AR/AE, AR/AO, AR/A1–A30, AR/A, V, VE, and V1–V30. The 500-year floodplain (not including the 100-year floodplain) is the union of category B properties and the X-shaded category. Finally, the minimal flood risk zone is the rest of the area, defined as the union of category C properties and the X-unshaded category.

are still under construction. As of early 2019, there exist revised maps for Virginia Beach but not for Miami-Dade. We provide more details on these maps in a later section.

Descriptive Statistics

In order to get rid of entries affected by typos in the sales price, and to eliminate sales of tiny parcels or other transactions that do not refer to proper housing units, we restrict to sales with sales prices above $10,000 and trim observations at the 99th percentile of the sales price. Exhibit 1 provides information on the distribution of sales by housing type in each of our two areas. Our dataset for Virginia Beach (the data cover the 2000–16 period) contains 120,542 sales, of which 3.9 percent correspond to properties located on the floodplain. We see a higher share of single-family and two-family homes on the floodplain (80 percent) than in the rest of the area (74 percent). The data for Miami-Dade cover the 2008–15 period and contain 220,303 sales. In Miami-Dade, the floodplain accounts for a much larger share of sales (51 percent) than for Virginia Beach, and the share of sales corresponding to single-family and two-family homes is similar on the floodplain (67 percent) and in the rest of the area (68 percent).

Exhibit 1

Frequency of Sales by Type of Property (Land Use)

	freq All	freq FP	freq **Outside FP**	rel. freq. All	rel. freq. FP	rel. freq. **Outside FP**
Virginia Beach 2000–2016						
Single-Family to Two-Family	89,275	3,713	85,562	0.74	0.80	0.74
Multifamily (More Than 2)	173	12	161	<0.01	<0.01	<0.01
Other	31,094	917	30,177	0.26	0.20	0.26
Total	120,542	4,642	115,900	1.00	1.00	1.00
Miami-Dade 2008–2015						
Single-Family to Two-Family	149,118	63,120	86,101	0.68	0.67	0.68
Multifamily (More Than 2)	14,172	6,063	8,126	0.06	0.06	0.06
Other	57,013	25,507	31,593	0.26	0.27	0.25
Total	220,303	94,690	125,820	1.00	1.00	1.00

FP = floodplain.
Notes: Floodplains are defined based on the FEMA flood insurance rate maps. The Virginia Beach and Miami-Dade flood maps are the 2009 versions.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office and the Florida Department of Revenue

We now turn to the timing of sales, which is summarized in exhibit 2. This exhibit only reports sales pertaining to single-family homes in order to focus on a more homogeneous subsample that can be better compared within and across areas. The first three columns refer to Virginia Beach. On average, 199 single-family homes on the floodplain sold, constituting 4 percent of the areawide sales, a rate that has fluctuated very little during the 2000–16 period. The last three columns of the exhibit refer to Miami-Dade. On average, 7,890 single-family homes located on the floodplain sold annually, amounting to 42 percent of areawide sales.[9] In sum, those data suggest that sales activity on the floodplain has kept the same pace as in the rest of the respective areas during our period of analysis.

[9] The frequency of sales for 2015 in Miami-Dade County in our dataset is roughly one-half the size of the number of sales in 2014. That is because the data are missing the sales corresponding to the last two quarters of 2015. Note, however, that the share of sales corresponding to floodplain properties is 43 percent, in line with the share for the previous years.

Exhibit 2

Frequency of Sales by Year: Single-Family Homes Only

Year	VB FP	VB Outside FP	VB FP Share (%)	MD FP	MD Outside FP	MD FP Share (%)
2000	173	4,831	0.03			
2001	213	6,210	0.03			
2002	205	6,376	0.03			
2003	201	5,754	0.03			
2004	299	7,219	0.04			
2005	256	6,304	0.04			
2006	175	5,108	0.03			
2007	204	4,888	0.04			
2008	140	3,821	0.04	4,406	6,182	0.42
2009	174	4,132	0.04	5,917	8,330	0.42
2010	162	4,145	0.04	8,491	11,786	0.42
2011	188	4,059	0.04	7,544	10,333	0.42
2012	209	4,287	0.05	8,980	12,090	0.43
2013	218	4,716	0.04	11,000	14,792	0.43
2014	186	4,478	0.04	10,958	14,552	0.43
2015	224	4,843	0.04	5,824	8,036	0.42
2016	161	3,592	0.04			
Avg.	199	4,986	0.04	7,890	10,763	0.42

FP = floodplain. MD = Miami-Dade. VB = Virginia Beach
Notes: Floodplains are defined based on the FEMA flood insurance rate maps. The Virginia Beach and Miami-Dade flood maps are the 2009 versions. Sales in 2016 for Virginia Beach do not include the data for the last quarter of that year. Likewise, sales for Miami-Dade in 2015 do not include data for the last quarter of that year.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office and the Florida Department of Revenue

Let us now turn to the evolution of median sales prices. Exhibit 3 reports median sales prices for single-family homes. The average sales price for a single-family home in Virginia Beach is substantially higher on the floodplain than elsewhere in the area ($296,000 versus $229,000) by about 29 percent. Column 3 shows that this ratio has also fluctuated substantially between 2000 and 2016 but without a clear trend. The last three columns in the exhibit report the data for Miami-Dade County. In this case, median sales prices are very similar inside and outside the floodplain ($186,000 versus $182,000). The floodplain differential has remained constant at around 3 percent in the 2008–15 period. In sum, we do not observe a reduction in the floodplain price differential associated with houses located on the floodplain taking place from 2013 onward.

Trends in Floodplain Premiums

Housing values in an area's floodplain may be higher or lower than in the rest of the area. On one hand, proximity to the coast has an amenity value; on the other, it exposes those properties to risk of flooding. Regardless of whether the floodplain price differential is positive or negative, the increased

Exhibit 3

Median Sales Price by Year: Single-Family Homes Only

Year	VB FP	VB Outside FP	VB FP/Outside (%)	MD FP	MD Outside FP	MD FP/Outside (%)
2000	172,500	138,000	1.25			
2001	148,000	145,000	1.02			
2002	202,140	159,900	1.26			
2003	225,000	175,500	1.28			
2004	309,900	210,000	1.48			
2005	381,750	265,000	1.44			
2006	399,000	284,900	1.40			
2007	355,950	285,000	1.25			
2008	300,000	267,885	1.12	256,500	255,000	1.01
2009	257,000	250,000	1.03	165,000	165,000	1.00
2010	299,375	250,000	1.20	141,100	140,000	1.01
2011	290,041	240,000	1.21	149,250	145,200	1.03
2012	310,000	245,000	1.27	160,000	154,000	1.04
2013	295,000	245,000	1.20	185,000	180,000	1.03
2014	377,000	247,638	1.52	203,905	199,000	1.02
2015	341,000	250,000	1.36	224,250	220,000	1.02
2016	307,500	259,000	1.19			
Avg.	296,346	229,347	1.29	185,626	182,275	1.02

FP = floodplain. MD = Miami-Dade. VB = Virginia Beach.
Notes: Floodplains are defined based on the FEMA flood insurance rate maps. The Virginia Beach and Miami-Dade flood maps are the 2009 versions. Sales in 2016 for Virginia Beach do not include the data for the last quarter of that year. Likewise, sales for Miami-Dade in 2015 do not include data for the last quarter of that year.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office and the Florida Department of Revenue

flood risk associated with rising sea levels might have reduced the floodplain price premium if it had been incorporated into the beliefs of market agents. One needs to keep in mind, however, that flood insurance may dampen these effects. If insurance premiums remain unchanged, floodplain housing prices may not respond to increased flooding risk. Therefore, whether the rise in risk of flooding has already affected housing markets is an empirical question.

Specifically, this section compares the trends in sales prices and sales activity for properties located on the floodplain of each of the two areas relative to properties located elsewhere within the same area. Importantly, in doing so, we will also account for individual-property or neighborhood-level heterogeneity.

Sales Activity

We begin by analyzing sales activity. One option would be to compare annual counts of sales in the floodplain to sales in the rest of the area. The same goal can be attained, however, while accounting for property-level heterogeneity. Specifically, we build a balanced property-level panel where each property i is observed in each year.[10] Our data contain the universe of property sales in each of the areas. Hence, we can define an indicator $Sold_{it}$ for whether property i that takes a value of 1 in years when that property was sold and zero otherwise. Then we estimate a linear probability model:

$$Sold_{it} = \alpha_i + \lambda_t + \beta_t FP_i + \varepsilon_{it}, \tag{1}$$

where we are including property fixed-effects (α_i), capturing all time-invariant characteristics of the property, in addition to year fixed-effects (λ_t) that capture the evolution over time of the sales probability outside the floodplain. Time-varying β_t captures the differential in the sales probability associated with being located in the 100-year floodplain (FP).[11] The probability that a property is sold in a given year can be interpreted as a measure of selling activity based on the share of the stock of housing that is sold in any given year.

Exhibit 4a

Virginia Beach, Sales Probability: Areawide

Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office

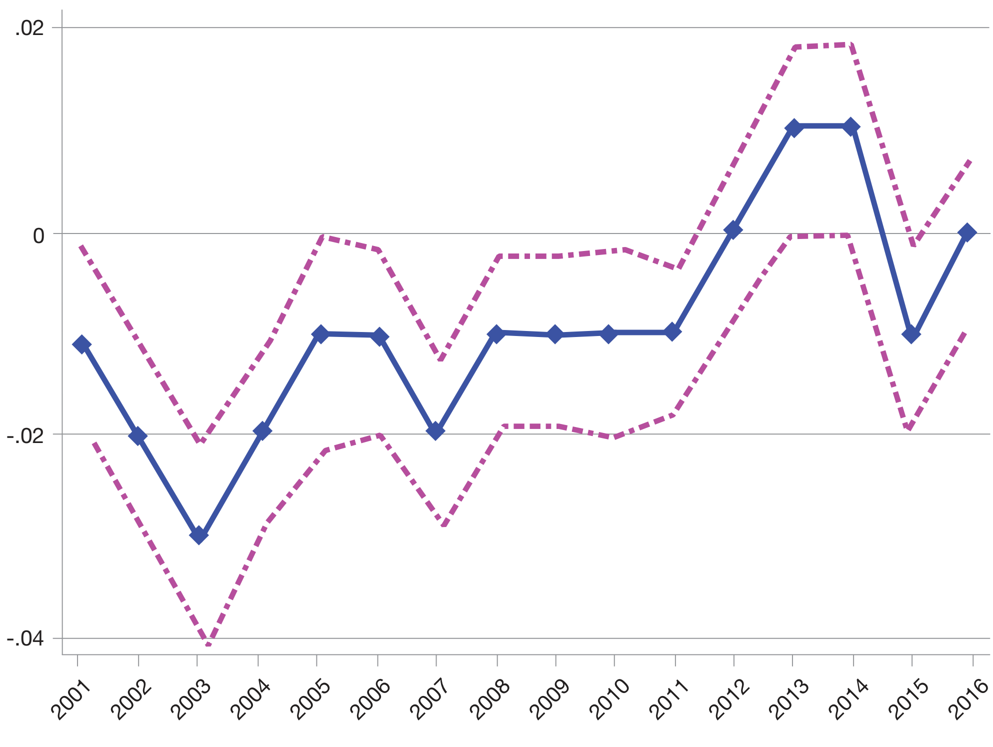
[10] For each of the two areas, we obtained a complete roster of all residential properties, identified by their tax identifier. We build a balanced panel at the annual level for all these properties. Because we know all sales over our sample period, we can then create a zero-one sales indicator for each property in each year.

[11] In practice, $\beta_t FP_i$ is shorthand notation for the sum over all periods of interactions between the floodplain indicator, FP_i, and the corresponding year dummy, D_t.

We begin with the results for Virginia Beach, shown in exhibit 4a and exhibit 4b. The former figure shows an areawide large and monotonic drop in sales between 2004 and 2008, which then plateaus between 2009 and 2011. Since 2011, sales have been slowly increasing but are still far below the 2004 level. Given that data for 2016 are only through September, the probability of sales for the year is somewhat inferior to that of previous years. This evolution clearly reflects the economic cycle—see also column 1 in exhibit 5. Turning now to the floodplain sales differential depicted in exhibit 4b, we observe an initial drop of the floodplain penalty in 2001 of 1 percentage point, relative to the reference year of 2000, that remains below the reference year until 2012. The floodplain differential eventually oscillates around its year-2000 value between 2012 and 2016.

Exhibit 4b

Virginia Beach, Sales Probability: Floodplain Differential



Notes: Point estimates from the event study at annual frequency on the sample of single-family homes. We are plotting the coefficients of the year dummies (top) and interactions with 100-year floodplain, or FP100 (bottom). Regressions include property fixed-effects, and standard errors are clustered at the block level, which allows for arbitrary correlations across parcels in the same block and over time.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office

Exhibit 5

Estimation Floodplain Differential

Dep. Var.	Virginia Beach 1 Sold	Virginia Beach 2 lnp	Miami-Dade 3 Sold	Miami-Dade 4 lnp
FP x D2001	-0.01	-0.50***		
	[0.008]	[0.101]		
FP x D2002	-0.02	-0.29***		
	[0.009]	[0.081]		
FP x D2003	-0.03***	-0.23**		
	[0.009]	[0.090]		
FP x D2004	-0.02***	-0.04		
	[0.007]	[0.069]		
FP x D2005	-0.01	-0.01		
	[0.009]	[0.061]		
FP x D2006	-0.01	-0.03		
	[0.008]	[0.057]		
FP x D2007	-0.02***	-0.04		
	[0.007]	[0.061]		
FP x D2008	-0.01	0.03		
	[0.007]	[0.061]		
FP x D2009	-0.01	0.00	-0.000	0.052*
	[0.007]	[0.061]	[0.004]	[0.027]
FP x D2010	-0.01	-0.04	-0.000	0.004
	[0.008]	[0.060]	[0.003]	[0.023]
FP x D2011	-0.01	-0.02	0.002	0.020
	[0.006]	[0.069]	[0.004]	[0.024]
FP x D2012	0.00	-0.02	0.005	0.025
	[0.006]	[0.074]	[0.005]	[0.024]
FP x D2013	0.01	-0.08	0.004	0.013
	[0.008]	[0.071]	[0.003]	[0.023]
FP x D2014	0.01	-0.10	0.008**	0.010
	[0.008]	[0.082]	[0.004]	[0.023]
FP x D2015	-0.01	-0.01	0.001	0.025
	[0.008]	[0.077]	[0.003]	[0.025]
FP x D2016	-0.00	0.00		
	[0.007]	[0.053]		
Observations	1,063,928	89,275	815,104	131,230
Number of blocks	54,268	54,268	101,888	101,915
Fixed-effects	parcel	parcel	parcel	parcel
Clustering s.e.	block	block	block	block

Dep. Var. = dependent variable. FP = floodplain. lnp = log of sales price. s.e. = standard errors.
****p < 0.01, **p < 0.05, *p < 0.1*
Notes: All models include property fixed-effects. Sample contains sales of single-family homes only. The sales probability models are estimated on a balanced panel, where each parcel appears in every year. The sample periods are 2000–16 for Virginia Beach and 2008–15 for Miami-Dade County. The coefficients referring to the first year in each area's sample are dropped to avoid perfect collinearity. Standard errors clustered at the block level, which allows for arbitrary correlations across parcels in the same block and over time.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office and the Florida Department of Revenue

The graphs for Miami-Dade County also confirm this pattern. Sales activity clearly traces the economic cycle (exhibit 6a), and sales probabilities for floodplain properties appear to increase slightly during our sample period before going back to their initial value in the reference year 2008 (exhibit 6b).[12]

Exhibit 6a

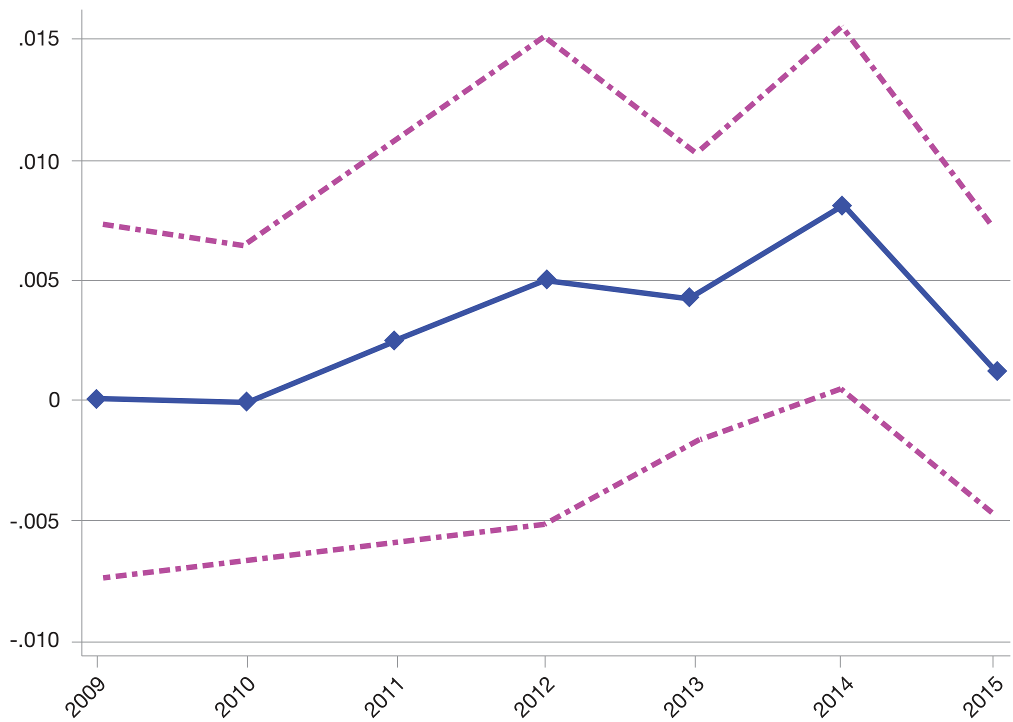
Miami-Dade, Sales Probability: Areawide

Note: Exhibit plots the point estimates along with the corresponding 95-percent confidence interval.
Source: Authors' calculations, using data from the Florida Department of Revenue

[12] The estimates are collected in column 6 of exhibit 5. Note also the sharp drop in exhibit 6a corresponding to 2015. This reflects the fact that our data for 2015 are missing the sales for the last two quarters. However, this seems to affect similarly properties on and off the floodplain. Thus, it probably does not bias the estimated floodplain differentials plotted in exhibit 6b.

Exhibit 6b

Miami-Dade, Sales Probability: Floodplain Differential



Notes: Point estimates from the event study at annual frequency on the sample of single-family homes. We are plotting the coefficients of the year dummies (top) and interactions with 100-year floodplain, or FP100 (bottom). Regressions include property fixed-effects, and standard errors are clustered at the block level, which allows for arbitrary correlations across parcels in the same block and over time.
Source: Authors' calculations, using data from the Florida Department of Revenue

In conclusion, our analysis shows that sales in each area have been largely driven by the housing cycle, and we do not find systematic evidence of a differential evolution of sales activity in the floodplain of the areas we have analyzed.

Sales Prices

Next, we turn to the analysis of sales prices. Let p_{it} denote the sales price of property $\boldsymbol{i}$ in year $\boldsymbol{t}$. We assume the log of the sales price is given by

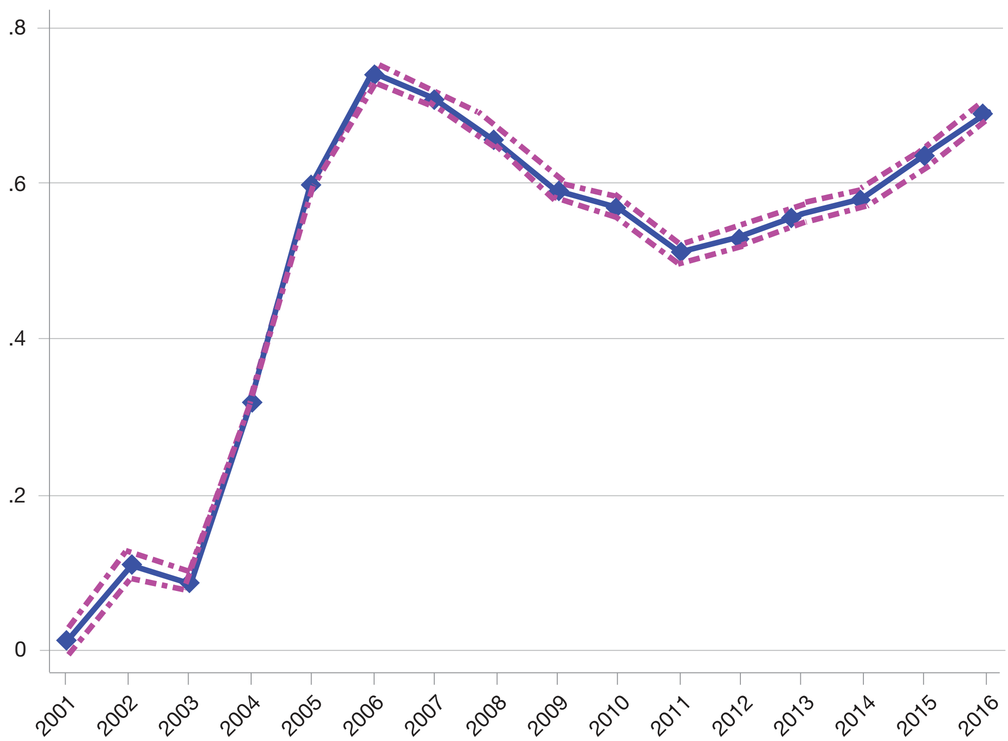
$$\ln p_{it} = \alpha_i + \lambda_t + \beta_t FP_i + \varepsilon_{it}, \tag{2}$$

where FP_i is an indicator for being located on the 100-year floodplain (as defined at the beginning of the sample period). The point estimates for year dummies $\{\lambda_t\}$ trace out the average housing prices (for single-family homes) in the area, while $\{\beta_t\}$ captures the floodplain price differential. Clearly, because of the property fixed-effects, properties that are sold only once do not contribute to the identification of the coefficients. In effect, our sample consists of properties that were sold repeatedly during our sample period.[13]

We report the time-varying coefficients graphically, beginning with the results for Virginia Beach. As shown in exhibit 7a, the housing cycle was also clearly noticeable in this area, with prices peaking in 2006, falling until 2011, and recovering since then. More relevant for our purposes, exhibit 7b suggests that the floodplain price differential remained stable around the 2000 level between 2004 and 2012, when the Biggert-Waters Act was implemented. The detailed estimates for $\{\hat{\beta}_t\}$ can be found in column 2 in exhibit 5. Exhibit 8a illustrates the results for Miami-Dade. As seen in the figure, sales prices outside the floodplain remained depressed between 2009 and 2011 and then increased rapidly from 2012 onward. But, once again, we see no evidence of a differential trend in sales prices on the floodplain relative to that of the rest of the area in exhibit 8b. The estimates for $\{\hat{\beta}_t\}$ for Miami-Dade can be found in column 4 in exhibit 5.

Exhibit 7a

Virginia Beach, Sales Price: Areawide

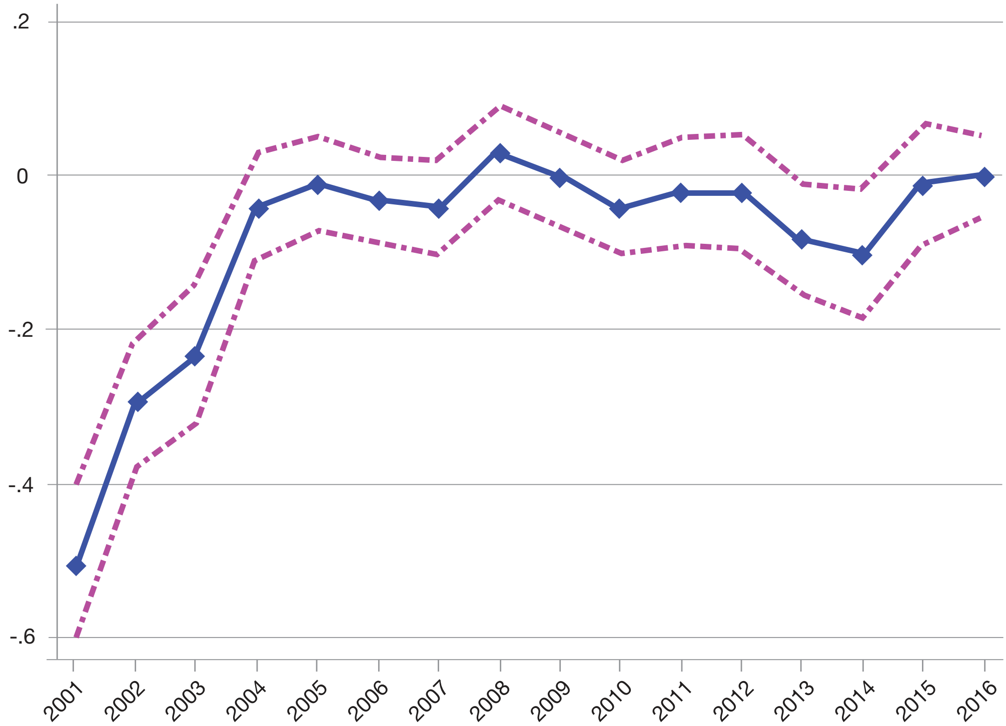


Note: Exhibit plots the point estimates along with the corresponding 95-percent confidence interval.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office

[13] The point estimates are very similar if we use area-block fixed-effects in place of property fixed-effects. The reason is that houses in the same neighborhood (defined as an area or census block) tend to share many characteristics, such as construction year and size, because they were developed around the same time.

Exhibit 7b

Virginia Beach, Sales Price: Floodplain Differential



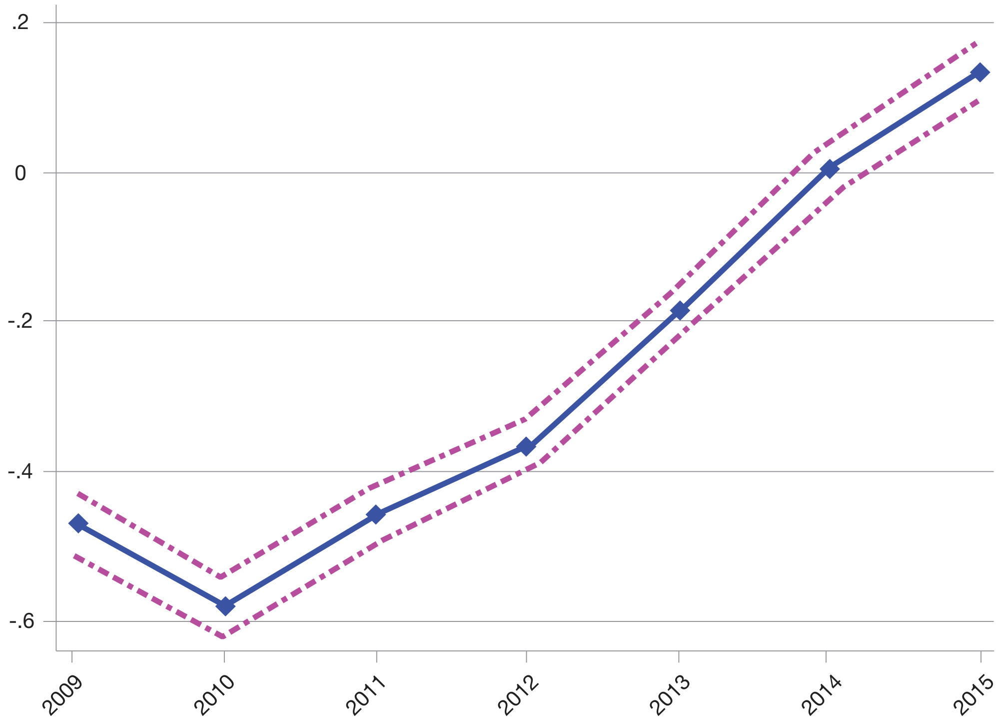
Notes: Point estimates from the event study at annual frequency on the sample of single-family homes. We are plotting the coefficients of the year dummies (top) and interactions with 100-year floodplain, or FP100 (bottom). Regressions include property fixed-effects, and standard errors are clustered at the block level, which allows for arbitrary correlations across parcels in the same block and over time.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office

Summing up, our analysis in this section suggests that sales activity and housing prices have been strongly influenced by the economic cycle. This has been true both for properties located on the floodplain as elsewhere in the area. But, in general, we find very little evidence of differential trends for the floodplain areas. Our interpretation of this finding, particularly for the years prior to the 2012–14 flood insurance reform, is that flood insurance has cushioned the impact of increased flooding risk on housing values. The reason is that premiums remained subsidized and largely unchanged during that period, despite the increased evidence of higher risk.[14] The trends analysis in this section can also be used to assess the assumption that causal interpretation of difference-in-difference estimates requires the identifying assumption of a lack of differential pretreatment trends for flood zone properties. Given that sales activities and sales prices evolved in a very similar fashion in and outside the flood zones in these areas, we understand that a causal interpretation of the estimates for Virginia Beach and Miami-Dade County is justified.

[14] This interpretation is consistent with the findings in Bosker et al. (2018). Using detailed data for the Netherlands, where flood insurance is unavailable, these authors estimate a 1-percent price penalty for residential properties located in the flood zone. The availability of flood insurance in the United States may have been enough to shrink the flood zone price penalty down to almost zero.

Exhibit 8a

Miami-Dade, Sales Price: Areawide



Note: Exhibit plots the point estimates, along with the corresponding 95-percent confidence interval.
Source: Authors' calculations, using data from the Florida Department of Revenue

Flood Insurance Reform: Premium Increases

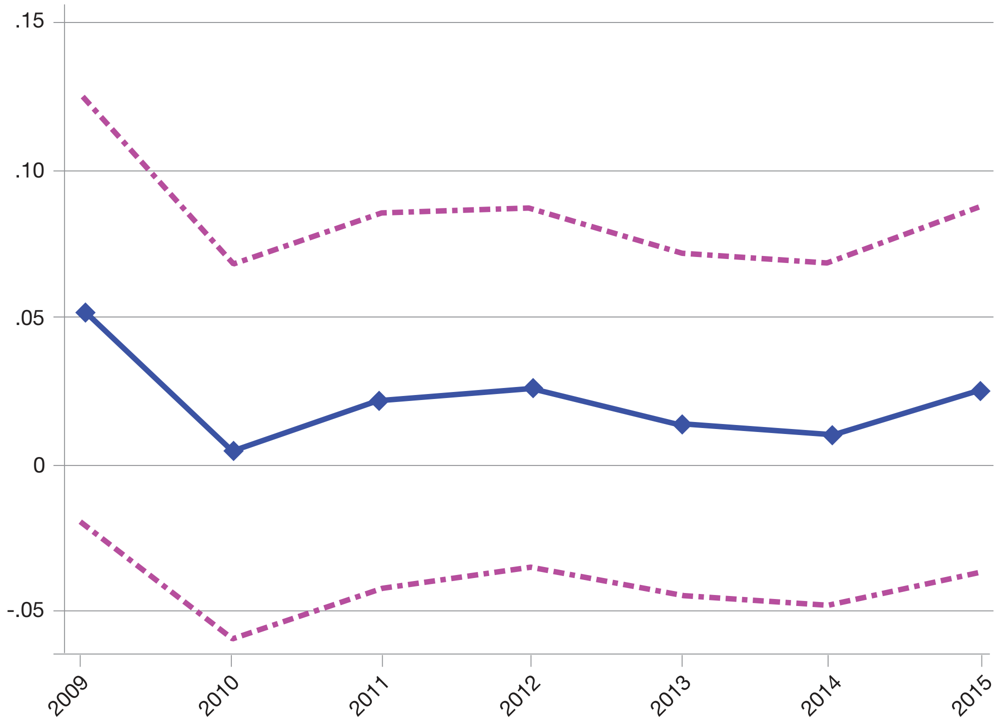
Difference-in-Difference Estimation

As argued earlier, the 2012 flood reform ushered in increases in flood insurance premiums that may have affected some sales that took place after July 2012. The 2014 act attenuated these increases (to 18 percent per year) but did not eliminate them. As a result, it is natural to consider a difference-in-difference estimator around that date, comparing properties in the floodplain to properties located elsewhere in the area. In order to more cleanly identify the effects of the policy change, we follow Hallstrom and Smith (2005) (who were interested in the effects of flood risk) and focus our analysis on the repeat sales subsample that brackets July 2012.[15] We hypothesize that the price increases between two such sales for properties on the floodplain will be smaller than the price increase experienced by properties located elsewhere in the area. It is helpful to think of our treatment group as containing houses located on the floodplain that were sold before and after

[15] For houses that were sold more than once after July 2012, we keep only the first sale and drop the later ones. This corresponds to 241 sales for Virginia Beach and 6,178 for Miami-Dade.

Exhibit 8b

Miami-Dade, Sales Price: Floodplain Differential



Notes: Point estimates from the event study at annual frequency on the sample of single-family homes. We are plotting the coefficients of the year dummies (top) and interactions with 100-year floodplain, or FP100 (bottom). Regressions include property fixed-effects, and standard errors are clustered at the block level, which allows for arbitrary correlations across parcels in the same block and over time. Exhibit plots the point estimates, along with the corresponding 95-percent confidence interval.
Source: Authors' calculations, using data from the Florida Department of Revenue

July 2012. The control group includes repeat sales that happened before July 2012 and repeat sales that may straddle across 2012 but refer to properties located outside the floodplain.[16]

More specifically, we define a new indicator, $PostBW_t$ (for Biggert-Waters Act), for sales that took place after July 2012, and FP_i denotes the floodplain dummy as before. We then pose that the log of the sales price for property i in year t is given by

$$\ln p_{it} = \alpha_i + \lambda_t + \beta_t PostBW_t \times FP_i + \varepsilon_{it}, \tag{3}$$

where coefficient β identifies the effects of the 2012 Biggert-Waters Act (effective from July 2012) on houses in the floodplain. We expect this coefficient to be negative because of the increase in flood insurance for houses located on the floodplain and estimate the model separately for each of our two coastal areas.

[16] We can experiment with different variations of the control group, for example, restricting only to repeat sales that bracket July 2012. In that case, the control group is only made up of the repeat sales outside the floodplain.

As before, we restrict to the sample of single-family homes. The data for Virginia Beach contain 89,275 sales for single-family units between January 2000 and September 2016. Roughly 31 percent of those correspond to properties that have been sold only once in this period and are thus dropped. In our sample period, roughly 40 percent of properties were sold exactly twice, and roughly 29 percent were sold at least three times.[17] For Miami-Dade, our data contain 131,099 sales for single-family homes from 2008 to 2015. Approximately 76 percent of the sales refer to properties that were sold only once in this period. Among properties sold more than once, about 20 percent of the sales correspond to properties that were sold twice, and about 2.7 percent were sold three times.[18]

Let us now turn to our estimation results. The key coefficient is the one associated with the interaction between the post-reform and the floodplain indicators, denoted by β. This coefficient is identified by the change in price for houses that were sold both before and after the reform and are located on the floodplain, the net of the price changes between other pairs of sales. Exhibit 9 collects the estimates. We begin with the results for Virginia Beach. In column 1, the point estimate of the coefficient of interest is positive but not statistically different from zero. In the case of Miami-Dade (column 2), it is negative, but, again, we are unable to reject the zero-null hypothesis. Taken together, these estimates suggest that the premium changes associated with the 2012 act have not had, for the time being, any effect on sales prices for properties located on the floodplain on account of the data for the two areas in our sample.

Exhibit 9

Difference-in-Difference Estimator for the Log Sales Price Around July 2012, Repeat Sales Only

Dep. Var. lnp	Virginia Beach 1	Miami-Dade 2
FP x PostBWA	0.04	-0.008***
	[0.023]	[0.020]
Observations	61,281	49,290
R-Squared	0.329	0.222
Number of Parcels	26,428	23,808
Year-Month Dummies	yes	yes
Sample	2000–16m9	2008–15

BWA = Biggert-Waters Act. FP = floodplain. Dep. Var. lnp = Dependent variable is log of sales price.
****p < 0.01, **p < 0.05, *p < 0.1*
Notes: All models include property fixed-effects. PostBWA is an indicator taking a value of one for sales that took place after July 2012. Standard errors clustered at the block level, which allows for arbitrary correlations across parcels in the same block and over time.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office and the Florida Department of Revenue

[17] Recall that the data provided to us by the Virginia Beach Government Real Estate Assessor's Office include only the last three sales for each household.
[18] The remaining 3 percent are units sold four to six times.

Flood Insurance: New Flood Maps

The 2012 Biggert-Waters Act called for updating the flood maps across the country. This is a staggered process. Whereas new maps for Virginia Beach were completed and put in effect in 2015, the revision of the flood map for Miami-Dade is still under construction, with an unknown release date.

Interesting for our purposes, the new flood maps typically change the risk classification for some properties. For instance, when the floodplain is expanded, some units that were located outside the floodplain under the old map now find themselves located inside the new floodplain because of the increased risk of flooding. This has potentially large consequences in terms of flood insurance. First, these properties are now subject to the mandatory flood insurance requirements. In addition, the premiums these properties face are typically substantially higher, in line with the new risk classification. It is important to keep in mind that the 2012 and 2014 reforms allow for "grandfathering." Namely, properties that were already insured can keep their old (lower) premiums. When the property is sold (or the insurance policy lapses), however, the applicable premiums will be those that correspond to the new risk classification.

It is also worth noting that property reclassifications may not always purely reflect an increase in flood risk. Pralle (2019) analyzed the politics behind flood map revisions and documented several instances where FEMA's revisions were likely influenced by local political concerns, rather than being solely driven by objective risk assessments. Nonetheless, a change in a property's risk classification that draws that property in or out of a flood zone will typically have an impact on the flood insurance premium paid by the owner, which should be expected to capitalize in the market value of the property.

Our goal in this section is to exploit the variation in the risk category of the properties that were reclassified in the new flood maps. We hypothesize that the prices of the houses subject to risk reclassification may have been affected by the release of relevant information.

FEMA Flood Maps

FEMA flood maps for Virginia Beach were revised in both 2009 and 2015.[19] The 2015 map happens to contain fewer buildings in the flood zone than its predecessor.[20] Exhibit 10 summarizes the changes in risk classification. In terms of sales, our data contain 520 cases of properties that were not part of the 100-year floodplain under the 2009 map but have been included in the newly defined floodplain. At the same time, 683 sales correspond to properties that were previously in the floodplain but are now excluded from it. The corresponding numbers for single-family homes are 485 and 534, respectively.

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[19] The link lists the FEMA flood map revisions scheduled for 2015: https://www.servicelinknationalflood.com/Content/pdfs/2015_Revision_List.pdf.

[20] Individual properties or whole developments can request changes in risk classification to FEMA by providing their own technical assessments and by adopting protective measures.

Exhibit 10

Transition Matrix Flood Zones: Sales Counts: Virginia Beach

Dep. Var. Inp	All Properties Counts	All Properties Shares	Single-Family Counts	Single-Family Shares
Out-Out	115,389	0.957	85,077	0.953
FP-FP	3,959	0.033	3,179	0.036
Out-FP	520	0.004	485	0.005
FP-Out	683	0.006	534	0.006
Total	**120,551**	**1.000**	**89,275**	**1.000**

Dep. Var. Inp = Dependent variable is log of sales price. FP = floodplain.
Note: A property is in the (100-year) floodplain if it has risk classification A, AE, AH, or VE in the FEMA flood map. All these categories are subject to mandatory flood insurance requirements. The specific definitions for the flood zone designations are given in the appendix. The flood maps for Virginia Beach are dated 2009 and 2015.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office

Thus, many individual homeowners received an update on their properties' idiosyncratic flood risk. Clearly, the properties that were not in the flood zone under the old map but were classified as belonging to the flood zone under the new map received the largest and most relevant amount of information. We will exploit this in the next section.

Regression Analysis

In order to analyze the effects of a change in the flood risk zone designation, we restrict to sales of properties located in the floodplain under the old map or the new one (or both). Accordingly, we build indicators for sales corresponding to properties located within the floodplain under both maps ($InIn = 1$), for sales of properties that were initially outside the floodplain but are within it under the new map ($OutIn = 1$), and for sales of properties that were initially within the floodplain but are excluded from it under the new map ($InOut = 1$). The resulting sample size (in terms of sales) is 5,162 (4,198 of which are single-family homes).

As before, we consider regression models for both sales activity and sales prices. The former analysis is based on a balanced panel, and the dependent variable is an indicator for whether a given property i was sold in year t:

$$Sold_{it} = \alpha_i + \lambda_t + \beta_{OI} Post_t \text{ x } OutIn_i + \beta_{IO} Post_t \text{ x } InOut_i + \varepsilon_{it}. \qquad (4)$$

We note that property fixed-effects and year dummies are included in the regression, and in the omitted category are properties that were located on the floodplain in both maps ($InIn = 1$). The "Post" indicator in the regression for Virginia Beach takes a value of 1 for 2015.

In terms of sales prices, we consider the following (property) fixed-effects specification:

$$\ln p_{it} = \alpha_i + \lambda_t + \beta_{OI} Post_t \times OutIn_i + \beta_{IO} Post_t \times InOut_i + \varepsilon_{it}, \qquad (5)$$

where the dependent variable is the log of the sales price of property i and quarter-year t.

Our hypothesis is that $\beta_{OI} < 0 < \beta_{IO}$, indicating that properties that are being assigned a higher flood risk and are subject to the mandatory insurance requirement should experience a drop in price, while properties whose risk is revised downward should experience a price increase. The predictions in terms of the sales probability are less clear. An increase in the risk assessment could lead to either an increase or a decrease in the probability of being sold, depending on the speed of adjustment of the property's price.

The results are collected in exhibit 11. Column 1 reports the estimates regarding the sales probability. The point estimates for both β_{OI} and β_{IO} are negative and statistically significant. That is, the sales probability for houses experiencing a change in their risk assessment (in either direction) seems to have fallen relative to houses that were in the floodplain under both the old and new maps. In terms of sales prices (columns 2 and 3), we find clear evidence of a large reduction in sales prices (of 25–28 log points) for properties that were drawn into the new flood maps, confirming our expectation. At the mean of our sample, this effect entails a $64,000 reduction in the value of a single-family home.[21]

Exhibit 11

Effects of Risk Reclassification: Virginia Beach

Dep. Var.	1 Sold	2 ln p	3 ln p
Post x Out-In	-0.01*	-0.25***	-0.28***
	[0.006]	[0.076]	[0.078]
Post x In-Out	-0.01**	-0.07***	0.01
	[0.004]	[0.085]	[0.074]
Observations	62,033	5,162	4,198
R-Squared	0.004	0.376	0.407
Number of Parcels	3,380	3,380	2,736
Building Class	All	All	Fam1

Dep. Var. = dependent variable. Fam1 = Single-family. ln p = log of sales price.
****p < 0.01, **p < 0.05, *p < 0.1*
Notes: The "Post" indicator in the regression for Virginia Beach takes a value of 1 for 2016. Property fixed-effects are included in all models. The sample only includes sales referring to properties that are located on the floodplain under the old or new flood maps (or both). The omitted category in the regression models consists of sales of properties located on the floodplain under both the old and new maps. Recall that in column 1, the dataset is a balanced panel, with zero values for property-period cells if the property was not sold. All columns include year dummies. Standard errors are clustered at the area-block level in all columns.
Source: Authors' calculations, using data from the Virginia Beach Real Estate Assessor's Office

Conclusion

The National Flood Insurance Program (NFIP) is the key program at the disposal of the U.S. government to shape the actions of individuals regarding the decision to live in flood-prone areas. In the current context of rising sea levels, it is important to assess the effectiveness of this policy tool. The mandatory insurance requirement derived from the FEMA flood maps and the corresponding premiums are the elements of NFIP that more directly affect consumers through their effect on housing values. This article analyzes the effectiveness of these two aspects of NFIP based on the recent changes to the program, using data for two important urban coastal areas: Virginia Beach and Miami-Dade County.

It is important to distinguish the effects of NFIP reforms from those of objective flood risk. At some level, the flood maps and flood insurance premiums are connected to estimates of flood risk at a high geographic granularity. Undoubtedly, however, other factors also play a role, such as the decision to update flood maps or allow grandfathering rules, or mayors' decisions to appeal a new flood map (Pralle, 2019). These factors can drive a wedge between objective flood risk and market values. From this viewpoint, the usefulness of our analysis to identify the effects of increased flood risk may be limited.

Our first finding is that property sales and sales prices have evolved similarly in the floodplains of Virginia Beach and Miami-Dade and elsewhere in these areas, largely tracing the economic cycle. In a context of increasing flood risk, we interpret this parallel evolution as driven by the availability of flood insurance at constant and subsidized rates up until 2012, which may have cushioned the impact of increased risk on housing values. First, homeowners also may not be fully aware of flood risk, homeowners less concerned about flooding risk may sort into the flood zone (Bakkensen and Barrage, 2017), and the effective difference in flood insurance costs in and out of the flood zone may have been relatively small in the prereform period.

Second, we focus on two specific features of the 2012–14 flood insurance reform to try to identify the effects of flood insurance on the housing market. First, we ask whether the scheduled increase in insurance premiums affecting properties sold after July 2012 affected sales prices. The estimates suggest that has not been the case. Because of the gradual implementation schedule of the new rates, these effects may only materialize over a longer time span. The current high degree of heterogeneity in flood insurance premiums among properties within the flood zone may also attenuate the estimates.

Third, the reform also mandated that FEMA update the flood maps of all areas, which is a staggered process. New maps were publicly released and adopted for Virginia Beach in 2015. The new maps provide an additional source of identification. Specifically, we focus on the

[21] It is also interesting to quantify the increase in flood insurance costs for properties that are drawn into the flood zone. We obtained insurance quotes from The Flood Insurance Agency for a single-family house in Virginia Beach (flood zone A, AE, or AH) with a replacement value of $250,000, content coverage of $100,000, and a $5,000 deductible. The resulting annual premium is $3,506. Using a 5-percent interest rate, the present discounted value of such a payment amounts to $70,120. This is remarkably close to the $64,000 price reduction that we estimated.

properties that have experienced an upward or downward revision in their idiosyncratic flood risk classification. We found a large and robust negative effect on the prices of properties that have suffered an upward revision in flood risk in Virginia Beach (of 25–28 log points). We estimate that, as a result of the mandatory insurance requirement in the flood zone, NFIP insurance costs for these properties will increase by an average of about $3,500 per year and lead to a reduction in housing values of about $64,000.

These findings lead us to draw the following conclusions. First, we believe that the more gradual pace of reform adopted in 2014 has delayed the effects of the more ambitious 2012 NFIP reform on the housing market. We expect flood-zone housing values to reflect the increases in flood insurance premiums over the medium term. However, our analysis has shown that the adoption of new flood maps has a large and immediate effect on the values of properties that are drawn into the new flood zone, probably due to the mandatory flood insurance requirement now affecting these properties.

All in all, our findings reveal that flood insurance reform has the potential to affect housing values and, hence, shape households' location decisions. However, the implementation of the reforms has been slowed down by political factors. At a national level, the Great Recession played an important role in the decision to adopt a more gradual increase in flood insurance premiums in 2014. Likewise, areas like New York City appealed the new flood maps made public in 2013, citing affordability concerns, delaying its implementation for several years.

Appendix

The Flood Insurance Reform Acts in Detail

The 2012 Biggert-Waters Act (BWA)

With BWA, the high-risk zones are expanded to reflect current risk levels. Regarding insurance rates, there are increases for some properties (described in the following). Although rates will not change immediately for about 70 percent of the properties (because of grandfathering rules), once those houses are sold (or experience massive flood damage), the new rates will kick in.

Specific implications:

- Policies will be written or renewed at full-risk rates for properties purchased or newly insured after July 5, 2012.

From October 1, 2013:

- Subsidized policies for (1) non-primary residences, (2) businesses, and (3) structures with severe repeated flood losses will have annual premium increases of 25 percent until rates reflect full risk.

- Primary residences in Special Flood Hazard Areas (SFHAs) can keep their subsidized rates until (1) the property is sold, (2) the policy lapses, (3) the property suffers severe flood losses (and the owner refuses an offer to mitigate), or (4) a new policy is purchased.
- Phasing out of grandfathered rates over 5 years.[22]
- Establishment of a Reserve Fund to help cover costs when claims exceed the annual premiums collected by the National Flood Insurance Program (NFIP).

The 2014 Homeowner Flood Insurance Affordability Act (HFIAA)

This act repealed some mandates of the 2012 act, slowed down some rate increases, and amended most provisions mandating that certain policies transition immediately to full-risk rates.

Specific implications from April 1, 2015:

- Limits increases for individual premiums to 18 percent per year.
- Limits increases for average rate classes to 15 percent per year.
- Increases the Reserve Fund assessments required by BWA.
- Implements annual surcharges on all new and renewed policies. This is meant to compensate for the loss in revenue from slowing down BWA rate increases. These surcharges will be collected until all subsidies are eliminated. The surcharges are flat fees applied to all policies regardless of the flood zone where the building is located. The annual surcharge for primary residences is $25, and for non-primary residences or non-residential properties, it is $250.
- Introduces cost-saving flood insurance coverage for properties newly mapped into the SFHA. They will receive PRP (Preferred Risk Policy) rates for 1 year after the maps become effective. The rates at renewal will increase no more than 18 percent per year.
- Resuscitates grandfathering. Grandfathering remains an option for policyholders when new maps show their buildings in a higher risk area (for example, zone A to zone V or increase in the Base Flood Elevation, or BFE). Available to property owners who (1) have flood insurance policies in effect when the new flood maps become effective, or (2) have built-in compliance with the Flood Insurance Rate Map (FIRM) in effect at the time of construction. These policyholders have the option of using the flood zone on a previous FIRM that was in effect when the building was originally constructed (for those built in compliance) or when coverage was first obtained (for those with continuous coverage).

[22] Prior to BWA, when revised maps showed higher risk zones, policyholders were permitted to grandfather and use the zone and elevation of an older map.

Flood Zone Designations

Zone A is the flood insurance rate zone determined by approximate methods, as no BFEs are available for these areas. Mandatory flood insurance purchase requirements apply, that is, properties with a federally backed mortgage are required to purchase flood insurance.

Zone AE is the flood insurance rate zone that corresponds with flood depths greater than 3 feet. Mandatory flood insurance purchase requirements apply.

Zone AH is the flood insurance rate zone that corresponds to areas of shallow flooding with average depths between 1 and 3 feet. Mandatory flood insurance purchase requirements apply.

Zone VE is the flood insurance rate zone that corresponds to coastal areas that have additional hazards associated with storm waves. Mandatory flood insurance requirements apply.

Zone X and Zone X-500 are flood insurance rate zones that are outside the floodplain or with average flood depths of less than 1 foot. For these properties, it is not mandatory to purchase flood insurance.

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References

Atreya, Ajita, Susana Ferreira, and Warren Kriesel. 2013. "Forgetting the Flood? An Analysis of the Flood Risk Discount over Time," *Land Economics* 89 (4): 577–596.

Bakkensen, Laura A., and Lint Barrage. 2017. Flood Risk Belief Heterogeneity and Coastal Home Price Dynamics: Going Under Water? NBER Working Paper No. 23854. Cambridge, MA: National Bureau of Economic Research.

Bin, Okmyung, Jamie Brown Kruse, and Craig Landry. 2008. "Flood Hazards, Insurance Rates, and Amenities: Evidence From the Coastal Housing Market," *Journal of Risk & Insurance* 75 (1): 63–82.

Bin, Okmyung, and Craig Landry. 2013. "Changes in Implicit Flood Risk Premiums: Empirical Evidence from the Housing Market," *Journal of Environmental Economics and Management* 65 (3): 361–376.

Bin, Okmyung, and Stephen Polasky. 2004. "Effects of Flood Hazards on Property Values: Evidence Before and After Hurricane Floyd," *Land Economics* 80 (4): 490–500.

Bosker, Maarten, Harry Garretsen, Gerard Marlet, and Clemens van Woerkens. 2018. "Nether Lands: Evidence on the Price and Perception of Rare Natural Disasters," *Journal of the European Economic Association* 17 (2): 413–453.

Buchanan, Maya K., Michael Oppenheimer, and Robert E. Kopp. 2017. "Amplification of Flood Frequencies with Local Sea Level Rise and Emerging Flood Regimes," *Environmental Research Letters* 12 (6): 064009.

Conte, Marc N., and David L. Kelly. 2017. "An Imperfect Storm: Fat-Tailed Tropical Cyclone Damages, Insurance, and Climate Policy," *Journal of Environmental Economics and Management* 92: 677–706.

Cooper, Hannah M., Charles H. Fletcher, Qi Chen, and Matthew M. Barbee. 2013. "Sea-Level Rise Vulnerability Mapping for Adaptation Decisions Using LiDAR DEMs," *Progress in Physical Geography* 37 (6): 745–766.

Gallagher, Justin. 2014. "Learning About an Infrequent Event: Evidence from Flood Insurance Take-Up in the United States," *American Economic Journal: Applied Economics* 6 (3): 206–233.

Gibson, Matthew, Jamie T. Mullins, and Alison Hill. 2019. Climate Risk and Beliefs: Evidence from New York Floodplains. Working paper 2019-02. Williamstown, MA: Williams College, Department of Economics.

Government Accountability Office (GAO). 2013. *Flood Insurance: More Information Needed on Subsidized Properties. Report to Congressional Committees* 13-607. Washington, DC: United States Government Accountability Office.

Hallstrom, Daniel G., and V. Kerry Smith. 2005. "Market Responses to Hurricanes," *Journal of Environmental Economics and Management* 50 (3): 541–561.

Harrison, David M., Greg T. Smersh, and Arthur L. Schwartz, Jr. 2001. "Environmental Determinants of Housing Prices: The Impact of Flood Zone Status," *Journal of Real Estate Research* 21 (1/2): 3–20.

Hauer, Mathew E., Jason M. Evans, and Deepak R. Mishra. 2016. "Millions Projected To Be at Risk From Sea-Level Rise in the Continental United States," *Nature Climate Change* 6: 691–695.

Hunter, John. 2010. "Estimating Sea-Level Extremes Under Conditions of Uncertain Sea-Level Rise," *Climatic Change* 99 (3): 331–350.

Indaco, Agustín, Francesc Ortega, and Süleyman Taşpınar. 2018. The Effects of Flood Insurance on Housing Markets. IZA discussion paper 11810. Bonn, Germany: Institute for the Study of Labor (IZA).

Kousky, Carolyn. 2018. "Financing Flood Losses: A Discussion of the National Flood Insurance Program," *Risk Management and Insurance Review* 21 (1): 11–32.

Ortega, Francesc, and Süleyman Taşpınar. 2018. "Rising Sea Levels and Sinking Property Values: Hurricane Sandy and New York's Housing," *Journal of Urban Economics* 106: 81–100.

Park, Joseph, Jayantha Obeysekera, Michelle Irizarry, Jenifer Barnes, Paul Trimble, and Winifred Park-Said. 2011. "Storm Surge Projections and Implications for Water Management in South Florida," *Climatic Change* 107 (1): 109–128.

Pralle, Sarah. 2019. "Drawing Lines: FEMA and the Politics of Mapping Flood Zones," *Climatic Change* 152 (2): 227–237.

Sweet, William V., and Joseph Park. 2014. "From the Extreme to the Mean: Acceleration and Tipping Points of Coastal Inundation from Sea Level Rise," *Earth's Future* 2 (12): 579–600.

Sweet, William, Joseph Park, John Marra, Chris Zervas, and Stephen Gill. 2014. *The Geography of Development: Evaluating Migration Restrictions and Coastal Flooding*. NOAA Technical Report NOS CO-OPS 073. Silver Spring, MD: National Oceanic and Atmospheric Administration.

Tebaldi, Claudia, Benjamin H. Strauss, and Chris E. Zervas. 2012. "Modelling Sea Level Rise Impacts on Storm Surges Along US Coasts," *Environmental Research Letters* 7 (1): 014032.

Vitousek, Sean, Patrick L. Barnard, Charles H. Fletcher, Neil Frazer, Li Erikson, and Curt D. Storlazzi. 2017. "Doubling of Coastal Flooding Frequency Within Decades due to Sea-Level Rise," *Scientific Reports* 7 (1): 1399.

Votsis, Athanasios, and Adriaan Perrels. 2016. "Housing Prices and the Public Disclosure of Flood Risk: A Difference-in-Differences Analysis in Finland," *Journal of Real Estate Finance and Economics* 53 (4): 450–471.

Zhang, Lei. 2016. "Flood Hazards Impact on Neighborhood House Prices: A Spatial Quantile Regression Analysis," *Regional Science and Urban Economics* 60 (Supplement C): 12–19.

Zhang, Lei, and Tammy Leonard. 2018. "Flood Hazards Impact on Neighborhood House Prices," *Journal of Real Estate Finance and Economics*: 1–19.