The impact of 2019 changes to Texas' flood disclosure requirements on house prices

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February 2024

Abstract

This paper examines the impact of a 2019 change to Texas's real estate disclosure law that introduced requirements to disclose when a property is in a moderate risk flood zone and increased the prominence of all flood-related disclosures. Using the universe of single-family arm's-length sales transactions in Texas from 2017 to 2022, we find that prices in 500-year flood zones fell 4.2 percent compared to properties outside of flood zones. Price declines following the policy are broadly observed for alternative specifications of flood risk. However, the starkest effects are observed 20 months after the policy went into effect. Properties in 100-year flood zones that always had to disclose flood zone status saw no significant price changes in the months following the policy change, but subsample analysis of Harvey-impacted zip codes suggests heterogeneous effects based on previous insurance coverage and claim status, highlighting the interaction of multiple disclosure types. Additional research on flood risk disclosure mandates and salience are suggested.

Disclaimers and Acknowledgments
We thank Jaclene Begley, Becka Brolinson, Justin Contat, Caroline Hopkins, and seminar participants at AREUEA/ASSA and APPAM conferences for their feedback on earlier versions of this paper.
The views expressed are those of the authors and not those of Fannie Mae nor the Federal Housing Finance Agency.
This publication is based upon work conducted under the U.S. Department of Homeland Security Cooperative Research and Development Agreement No. 21-TCD-003.
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1. Introduction

To what extent do house prices reflect the risk of future damages from natural hazards? A history of property damage and the risk of future damages from natural hazards may both impact housing market outcomes. Direct impacts of a hazard, such as flooding, on a property's value results from actual physical damages, which may not be resolved prior to a sale or be evident to a buyer. These effects will depend on the extent of physical damage and the degree of insurance. In addition, a property's inherent risk from natural hazards may also impact outcomes by capitalizing future expected damages, or the cost of insuring them, into prices.

For flood risk, the literature suggests a high degree of variability of prior capitalization. One meta-study found the impact on property values of a property being located in a 100-year floodplain ranging from a 75.5 percent discount to a 61.0 percent premium (Beltran, Maddison and Elliot 2018). Flood insurance is required for federally-backed mortgages in FEMA's Special Flood Hazard Areas (SFHAs), which typically coincide with 100-year flood zones. In many studies, flood risk capitalization occurs primarily in areas where flood insurance is required. This may reflect the fact that flood risk is more salient for homes that are required to obtain flood insurance and can only be capitalized if buyers are aware of past damages and able to measure expected future damages. Further, the monthly payment burden associated with the insurance premium may in itself have an impact on the price of homes with mandated flood insurance. While some properties may have obvious signs of damages, for example distressed sales following a disaster, or a minimum level of risk may be common knowledge, for example through property insurance requirements, many buyers are likely to be unaware of historical damages or inherent risk.

Mandatory disclosure policies are one mechanism for alleviating this information asymmetry. By requiring sellers to reveal a history of damages, buyers are better able to both assess past damages and the likelihood of future damages. If prior to disclosure buyers were systematically over- or under-estimating hazard risks, changes to disclosure requirements should result in corrections to price. This research examines one such change that the state of Texas implemented in 2019: prior to September 1st of that year only properties in 100-year floodplains or with a prior history of flooding had to disclose that risk. From September 1st onwards, disclosure also applied to properties in 500-year flood zones and floodways, for example from levees.

To assess the impact of this change, we use data from Fannie Mae's collateral risk management system, Collateral Underwriter (CU), and combine a hedonic model of sales price with a difference-in-differences (DiD) framework and event studies to assess how transaction prices changed after the policy across different impacted geographies. We consider impacts on properties in 500-year flood zones compared to properties in 100-year flood zones and those with negligible flood risk. In addition, we combine transaction data with information on whether properties in Hurricane Harvey-impacted zip codes had a National Flood Insurance Program (NFIP) flood insurance policy in effect at the time of the storm or a policy claim associated with this event. We also consider impacts on the time that a property spends on the market and how patterns in FEMA National Flood Insurance Program policies changed following the policy.

While average prices increased in general over the post-policy period, we find statistically significant and negative relative price effects for properties that face greater flood risk across most of these comparisons. For properties in 500-year flood zones, a group particularly impacted by the disclosure change, prices were 4.3 percent lower relative to properties with negligible flood risk, after controlling for property characteristics and the timing of flooding events. This is unlikely to be simply an effect of physical damage from flooding, since properties in 100-year flood zones that face greater risk of damage but already had mandatory disclosure saw no significant impact on prices statewide. Subsample analysis on transactions that have been matched with National Flood Insurance Program policy and claim data from Hurricane Harvey suggest that the increased salience of flood risk on the updated disclosure may have differential impacts on properties in 100-year zones by whether they have a history of damages, with properties with no identified claim from Harvey seeing prices increase after the policy change.

While negative effects are observed broadly after the policy across different specifications and approaches for classifying impacted properties, event studies suggest caution interpreting the result as a pure policy effect. The starkest negative effects are observed 20 months after policy implementation, suggesting either that there was a significant delay in how the disclosure mandate impacted market behavior or, more likely, there were other factors that impacted properties with higher flood risk during this same period. In addition, subsample analysis that allows cleaner comparisons, based on a history of insurance coverage and flooding, suggest that the specific elements of disclosure all combine to influence outcomes. This paper discusses possible explanations for this delay, including other possible sources of flood information, the Covid-19 pandemic, and the potential role of the disclosure policy. We suggest future research to address these issues. In addition, we provide an initial analysis of how the patterns of flood insurance prevalence across flood zones was impacted by the disclosure change, finding that policies were 29 percent more likely to be for a property in a 500-year zone after the policy change.

Sizing the role that natural hazard risk plays in the housing market is of particular interest as the market adapts to climate change. The extent of historical flood risk capitalization is an important measure for assessing how much historical uninsured flood risk the market is bearing, as well as for estimating how changing levels of flood risk may impact values in the future. If policies such as mandatory disclosure improve market pricing of hazard risk, support for disclosure can be an important tool in preparing for climate change. This is particularly the case if a changing climate results in systematic mismeasurement of risk that could be improved by more up-to-date information on risk status. This includes the direct effect of changing patterns in hazard exposure or intensity resulting in underinsurance or weakening relationships between past and future risk. For example, if buyers are aware that flooding has increased in an area, but that insurance is not required, a lemons market may develop for properties with undisclosed and unrepaired damages. This is especially the case if damages are small or easy to conceal.

The remainder of the paper proceeds as follows: section 2 reviews the literature and provides background on the policy change; section 3 describes the data and methodology; section 4 discusses the results; and section 5 concludes.

2. Background

2.1 Literature review

The literature addresses two primary issues. One body of work considers the extent to which damages and risk associated with flooding or other natural hazards are capitalized into home prices and impact loan performance. Much of this literature can be divided further into those that address the immediate impacts of flooding or other damages on sales activity and price levels and those that look at how prices differ across variation in measured hazard risk. Another body of work is focused on how disclosure or risk mapping impacts market outcomes. Most literature on the direct effects of flooding on property values rely on hedonic modeling combined with geospatial data on flood areas. Studies on loan performance consider flood event impacts on delinquency, prepayment, forbearance, or loan modifications.

Several studies have relied on variation in the geographic impact from major storms or other major flooding events on either prices or loan performance. Vigdor (2008), Ortega & Taspinar (2018), and Kousky, Palim, & Pan (2020) look at the effects of Hurricanes Katrina, Sandy, and Harvey, respectively. The first two assess price effects from the storms, with somewhat conflicting results. Since Hurricane Katrina resulted in a 50 percent decline in the number of housing units in New Orleans from 2000 to 2006, reduced supply exceeded reduced demand and prices actually rose (Vigdor 2008). For Hurricane Sandy, damaged properties experienced an immediate and severe price decline, but ultimately converged towards non-damaged prices as restoration proceeded (Ortega and Taspinar 2018). Overall, average prices in flood zones declined 8 percent following the storm, even if not damaged directly. The authors interpret this result as an update to expectations of future flood risk.

Kousky et al. (2020) match data on loan performance to data on post-disaster home inspection and flood zone designations for insurance purposes. They find that damaged properties are more likely to become delinquent. They find that insurance mediates these effects, with prepayment rising in areas with flood insurance requirements and modifications more likely in areas experiencing damage without any insurance requirements.

Other papers have considered local flooding events, finding broadly consistent results. Fang, Li & Yavas (2021), Atreya, Ferreira, & Kriesel (2013), Livy (2022), and Bin & Landry (2013) all find price declines in the immediate impact of a flood event, even when the event is non-destructive, but with discounts vanishing over time as damaged properties are restored and shifts to supply and demand normalize. Other work has instead focused more on intrinsic risk, for example due to sea-level rise or using flood plain designations. These results can vary substantially, with significant interactions between geospatial amenities and risk. Bernstein, Gustafson, & Lewis (2019), find a price penalty for homes exposed to sea-level rise risk, with the penalty increasing in the degree of risk. Atreya & Czkowski (2019), on the other hand, find that in a single coastal county of Texas, properties with the highest flood risk actually have a price premium. Several studies have considered how this effect is mediated by belief in climate change or awareness of the risk (Baldauf, Garlappi and Yannelis 2020, Gibson, Mullins and Hill 2019, Keys and Mulder 2022).

Some authors have looked explicitly at disclosure requirements. Pope (2008) combines a hedonic model with a spatial fixed-effects strategy to assess the impacts of a new flood disclosure

requirement in North Carolina. They find a 4 percent decline in prices as a result of the policy in FEMA flood zones AE, corresponding with a 100-year flood risk, compared to similar properties in 500-year flood zones that had no disclosure requirements. Votsis and Perrels (2016) looked at the introduction of 100-year flood risk maps in Finland and find a short-term negative shock to prices, which they attribute to spatial re-sorting in response to newly discovered flood risk. Similarly, Hsieh (2021) looked at the introduction of flood risk maps to Taiwan and found significant and negative price effects in local high-risk markets, but not in aggregate. This work extends these by focusing on a group more traditionally used as a comparison group in these studies (properties in 500-year flood zones), helping to identify the extent of unpriced flood risk in the Texas residential real estate market.

2.2 Policy change

In 2019, Texas enacted Senate Bill 339, which added and modified a number of flood-specific disclosure requirements to the Texas property code's existing disclosure rules.[1] Disclosures must be presented by a seller (or seller's agent) to the buyer prior to a buyer putting down an offer for purchase. Figure A1 in the appendix provides copies of the disclosure text relevant to flooding in effect prior to and from September 2019. Prior to September 2019, the disclosure included questions about whether the seller was aware at the time of sale of previous flooding or water penetration, as well as whether the property was located in a 100-year floodplain or currently had flood insurance in a list of questions that also included disclosures not related to flooding. If the seller answered yes to any of these questions, they were asked to provide additional details and documentation.

The updated disclosure included a more detailed set of questions relating to a property's history of flooding, most notably whether the property is wholly or partly located in a 500-year floodplain, floodway, flood pool, or reservoir. In addition, all flood-related questions were moved to a separate section and questions about previous flooding were expanded to include whether water penetration was due to water released from a reservoir or a natural flood event. It also required additional and more detailed disclosure about any past claims or disaster assistance, which would previously have been limited to voluntary disclosures when providing additional details on past flooding or insurance coverage. The disclosure sheet provides detailed definitions of relevant terms and asks for additional explanation if the answer is 'yes' to any of the required flood history questions.

As a result, a variety of different types of properties were impacted by the disclosure. Both before and after the policy change, properties in 100-year flood zones, properties with flood insurance, or properties with any known previous flooding or water penetration were required to disclose and provide additional details. From September 2019 on, all properties in 500-year flood zones were also required to disclose. In addition, sellers of properties with flood insurance or a history of flooding were explicitly asked about claims or other disaster assistance. Previously, a seller would have had to disclose having insurance or a past flooding event, but would disclose these additional

[1] The Senate bill is found here: https://capitol.texas.gov/BillLookup/History.aspx?LegSess=86R&Bill=SB339. The current property code is here: https://statutes.capitol.texas.gov/Docs/PR/htm/PR.5.htm#5.008. The general disclosure rules were put in place in 1994, and subsequently amended in 2005, 2007, 2008, 2009, 2010, 2011, 2013, 2016, 2017, and 2019.

details only voluntarily and as a separate exhibit.[2] After September 2019, these additional details were required. Finally, all flood-related questions were moved to a separate section and made more prominent, generally increasing salience of these risks in the disclosure process for all impacted properties.

3. Data and Methodology

3.1 Data

The main analysis of this research uses a dataset of approximately 2.2 million arms-length home sale transactions in the state of Texas with flood zone status identified at time of transaction, covering a period from January 2017 to December 2022. This period was selected as it comes at the tail end of a series of major flooding events, avoiding too much contamination of direct flooding effects while leaving enough of a pre-policy change period for comparison. In addition, a small number of transactions were excluded when there was no data available flood zone status at the time of the transaction.[3]

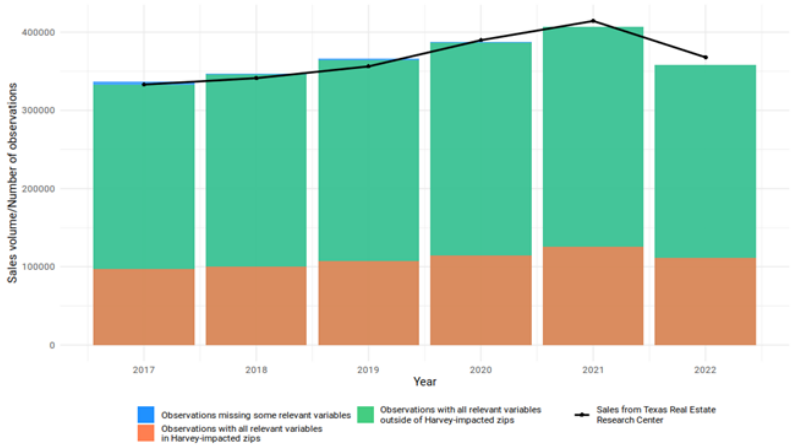


Figure 1 Total dataset sales for full and Harvey subsample vs. Texas Real Estate Research Center report

Transactions came from the CU's comparable transactions property database. CU is Fannie Mae's collateral risk management system. When properties are being sold, CU is used to assess appraisals and collateral risk. The comparable transactions dataset includes characteristics of all previous subject properties, supplemented by processed third-party transaction data for use in the sales model and is meant to cover the universe of home sales transactions. As can be seen Figure 1, the set of comparable transactions (sum of blue, orange, and green shaded bars in Figure 1) closely

[2] Since filing a claim or receiving assistance are generally seen as a positive for properties with a flood history as they indicate repair/rebuilding, resulting in a smaller discount or even a premium, it is likely that these would have been disclosed even before the September 2019 change for any property that reported past flooding. However, we do not have access to disclosure records and cannot say the extent that these were voluntarily disclosed prior to September 2019.

[3] We use both the 2017 and 2022 National Flood Hazard Layers to identify flood zone in effect at the time of the transaction. For 6,095 transactions we only observe flood zone designations after the transaction date. This may occur because the map was changed before the effective date of our 2017 layer or because the map changed more than once in between 2017 and 2022.

matches external benchmarks of total sales volume (black line in Figure 1), based on total sales reported in the Texas Housing Activity Report from the Texas Real Estate Research Center.[4]

In addition to data on the flood zone classification, a limited sample of properties located in Harvey-impacted zip codes have data on flood insurance status at the time of the 2017 storm and whether any claims were filed related to that storm. There are 658,701 transactions from 2017 to 2022 in Harvey-impacted zip codes.[5] Of these, 107,293 are identified as having a policy in effect as of August 2017, 19,778 of which filed claims associated with Harvey.

To identify the flood zone classification at the time of the transaction, properties with loans acquired by Fannie Mae were matched with data on FEMA flood maps. For some properties, multiple classifications were available, either reflecting different flood map dates or a parcel that covered more than one zone. For properties with more than one type of flood zone, we selected the most severe (e.g. a property located partially in a 100-year and a 500-year zone would be coded as 100-year) because disclosure is required even if a property is only partially located in a zone. When multiple map dates were available, we selected the map in effect at the time of the sale, when available. If a flood zone classification was available only from a map in effect after the transaction, the observation was dropped. FEMA's decision to update a map prioritizes areas most in need of revision when initiating map updates or is based on a request from local communities to consider changing flood hazards. As a result, using updated maps is likely to bias estimates in unpredictable ways that are relevant for pricing risk.

Given the nature of the 2019 policy change, the ideal treatment group would be properties in 500-year flood zones without flood insurance and with no known history of flood damage or water penetration. This is because these properties would not have had any mandatory disclosure prior to September 2019 but would be required to disclose after the change. While we are able to identify flood zone status for 99.7 percent of our sample, we only observe information about insurance coverage or past claims for a limited sample and for one event (Hurricane Harvey). However, since the disclosure change also made flood disclosure more prominent and more detailed, the change is relevant for properties that have experienced flood damage, even if they are not in a 100-year or 500-year zone.

As such, we begin by looking at the effects on properties in 500-year zones compared to properties outside of flood zones and in 100-year zones across all of Texas. This allows us to compare the effect of the policy on properties classified in a 500-year flood zone (now required to disclose that information) to properties with negligible risk (unlikely to have ever had to disclose) and properties in 100-year zones (always required to disclose). Since only those with previous flood damage or insurance would have had to disclose prior to September 2019 but all were required to do so as a result of the law change, properties in 500-year flood zones provide the cleanest identification of treated group in our data. However, since properties with a history of flooding always had to disclose regardless of flood zone and since the 2019 change also included a potential shock to saliency by moving the flood questions to a separate section, we cannot fully identify never-treated

[4] https://www.recenter.tamu.edu/data/housing-activity/#!/activity/State/Texas

[5] Per Kousky et al. (2020), the Harvey-impacted zip codes are defined as those more than 20 valid registrations for FEMA's IHP, following Hurricane Harvey. In total 422 zip codes are included in this impacted set.

and always-treated by zone alone. For a subsample of loans in Harvey-impacted zips, however, we have limited information about NFIP policy and claim status as of August 2017. Using this subsample we look closer at differences in pricing dynamics based on properties with 2017 NFIP policies or claims compared to properties outside of flood zones who did not have insurance or a claim in 2017.

Table 1 contains summary statistics for the full 2017 – 2021 sample and by flood zone. Summary statistics for the Harvey-impacted sample with NFIP policy and claim data are available in Table A1 in the appendix. The set of property characteristics shown here are also used as controls in the hedonic regressions. On average, properties sold for $346,172 ($280,000 at the median) and took 51 days to sell (17 at the median). The vast majority of properties were located in metropolitan areas, although those with then highest flood risk were more likely to be in micropolitan or small town areas. Properties in 500-year zones, the zone most affected by the policy change, are conversely more likely to be metropolitan. About a fifth of all transactions were for new properties, which would have no prior damages or insurance policy to be disclosed, although properties in 100-year flood zones were slightly less likely to be new (13.0 percent compared to 20.7 percent in negligible risk areas and 21.3 percent in 500-year zones).

Properties in 100-year flood zones were also significantly more likely to be given a 'Beneficial' location rating (11.3 percent of 100-year properties, compared to 1.8 percent for properties outside of flood zones). This is expected, given that properties in flood zones are more likely to have unique location attributes such as coastline or nearby rivers. In addition, properties in 500-year zones are more likely to be of the highest quality materials and construction methods. These emphasize the need to accurately account for known property attributes when studying the effect of flood risk, or flood disclosures, on transaction prices as these properties in flood zones can be markedly different.

Properties in Harvey-impacted zip codes look broadly similar (available in the appendix), although unsurprisingly they are more likely to include properties in flood zones (especially for those with a 2017 policy). In addition, properties with policies and 2017 claims were significantly more likely to be rural (5.2 percent compared to 0.7 percent overall) and to need significant repairs (2.6 percent compared to 0.6 percent overall). Roughly 3 percent of the Harvey-impacted sample is matched to a 2017 NFIP claim, just under half of which are identified as located outside of a 100-year zone, giving some sense of the magnitude of potential already-treated properties in the full sample.

Table 1 Summary statistics – Flood zones identified at time of transaction. Standard deviations for means shown in parentheses.

	Total	Negligible	500yr/levee	100yr
Transactions	2,193,661	1,976,436	132,562	84,663
Sale price (Average)	$346,172 (207.25)	$345,393 (214.27)	$347,537 (971.70)	$362,212 (1,224.15)
Sale price (Median)	$280,000	$280,000	$275,000	$275,000
Days on market (Average)	51 (0.07)	50 (0.07)	56 (0.24)	71 (0.37)
Days on market (Median)	24	23	28	37
Age (Average)	24 (0.02)	23 (0.02)	23 (0.06)	31 (0.09)
Age (Median)	17	16	17	30
Total bedrooms	3 (0.001)	3 (0.001)	3 (0.002)	3 (0.003)
Total bathrooms	2 (0.001)	2 (0.001)	2 (0.002)	2 (0.003)
Gross living area	2212 (0.63)	2214 (0.66)	2311 (2.81)	2020 (3.34)
Flood declaration w/in 6 months of transaction	44.8% (0.000)	44.9% (0.000)	44.4% (0.001)	43.8% (0.002)
Flood zone				
Negligible	90.1% (0.0002)			
500-year/levee	6.0% (0.0002)			
100-year	3.9% (0.0001)			
Area type				
Metropolitan	91.8% (0.0002)	92.3% (0.0002)	94.3% (0.0007)	77.1% (0.0016)
Micropolitan	5.4% (0.0002)	5.0% (0.0002)	3.9% (0.0006)	16.6% (0.0014)
Small town	2.0% (0.0001)	2.0% (0.0001)	1.6% (0.0004)	3.4% (0.0008)
Rural	0.8% (0.0001)	0.7% (0.0001)	0.3% (0.0001)	2.9% (0.0004)
Condition				
New property	20.5% (0.0003)	20.7% (0.0003)	21.3% (0.0012)	13.0% (0.0013)
No major repairs needed	79.0% (0.0003)	78.8% (0.0003)	78.1% (0.0012)	85.9% (0.0013)
Significant repairs needed/damaged	0.5% (0.0001)	0.5% (0.0001)	0.6% (0.0002)	1.1% (0.0004)
Quality				
Highest quality	47.5% (0.004)	46.9% (0.0004)	55.3% (0.0015)	49.5% (0.0020)
Meets or exceeds code	51.7% (0.0004)	52.3% (0.0004)	44.0% (0.0014)	49.5% (0.0020)
Minimum code, inexpensive materials	0.7% (0.0001)	0.7% (0.0001)	0.6% (0.0002)	1.0% (0.0004)

Lowest quality	0.00% (0.0000)	0.00% (0.0000)	0.00% (0.0000)	0.00% (0.0000)
Location				
Adverse	0.9% (0.0001)	0.9% (0.0001)	1.0% (0.0003)	1.4% (0.0005)
Neutral	96.7% (0.0001)	97.3% (0.0001)	94.9% (0.0006)	87.2% (0.0012)
Beneficial	2.3% (0.0001)	1.8% (0.0001)	4.1% (0.0006)	11.3% (0.0012)

In addition to data on housing market transactions, we carry out analysis of the disclosure law changes' impact on flood insurance uptake for properties in 500-year flood zones. We make use of the Federal Emergency Management Agency's public dataset of National Flood Insurance Program (NFIP) policies.[6] The publicly available data is derived from the NFIP's reporting platform and represents more than 50,000,000 overall policy transactions, 8,757,680 of which are for residential properties in Texas. Limiting analysis to single family non-condo residences with the relevant variables for our analysis, 3,450,227 policies were in effect at some time between January 2017 and December 2021. While public NFIP data does not allow identification of specific properties, it does include information about the FEMA flood zone classification for each policy's property, as well as information on the effective date, termination date, Census tract, and some policy details (e.g. cost, rate method, premium, and coverage).

Table 2 Summary statistics – Public NFIP policies for single family homes from 2017 – 2021. Standard deviations for means shown in parentheses.

	Total	Negligible	500yr	100yr
Policies	3,450,227	2,597,986	108,700	743,541
Policy cost (Average)	$689 (0.37)	$523 (0.13)	$552 (0.96)	$1291 (1.46)
Policy cost (Median)	$516	$482	$482	$849
Flood zone				
Negligible	75.3% (0.0002)			
500-year	3.2% (0.0009)			
100-year	21.6% (0.0002)			
Census tract variables (Averages)				
Share 500-year zone	10.2% (0.0001)	9.2% (0.0001)	40.6% (0.0011)	9.2% (0.0002)
Share 100-year zone	10.6% (0.0001)	5.1% (0.0001)	13.2% (0.0007)	29.5% (0.0004)
Housing units	2457	2634	1788	1935

[6] FEMA's public NFIP policy data can be found here: https://www.fema.gov/openfema-data-page/fima-nfip-redacted-policies-v1. All analysis in this paper was carried out using the public dataset available for download on January 23rd, 2023.

	(0.81)	(1.00)	(2.54)	(1.06)
Transactions previous six months	15 (0.02)	15 (0.02)	9 (0.05)	15 (0.04)

While the public data includes information that can be used to explore the potential impact of the policy change on insurance behavior, we are not able to link the public NFIP data with our property transaction data and therefore cannot look at insurance decisions after purchases or taking into account other housing characteristics.[7] However, we can use tract-level housing unit counts from the Census and the flood zone classifications in the public NFIP data to estimate overall insurance uptake at the Census tract level across flood zones over time. In addition, using data from First Street Foundation we are able to estimate the Census tract-level share of properties in 500-year, 100-year, and negligible risk flood zones and a measure of tract-level average flooding risk. We have data on the flood zone and a flood risk score for 9,503,587 properties.

3.2 Methodology

The goal of mandatory disclosure is to provide buyers with information on potential risk from flooding. If consumers capitalize flood risk into prices, then this increase in awareness of risk should be reflected in price changes after the introduction of the policy. The 2019 policy change went into effect at the same time for all of Texas, but only some properties were actually affected by the new disclosure requirements. In particular, the disclosure requirements changed for properties located wholly or partially in a 500-year flood zone and increased the prominence of flood-related questions in general.

Our main research design uses an event study framework to gauge pricing and time on market dynamics after the policy was implemented based on the flood zone of the property at the time of the transaction. In addition, for a subsample of transactions in Harvey-impacted zip codes, we leverage limited data about policy and claim status associated with Harvey to create a cleaner control group and disentangle between the effect of additional zone disclosure requirements and general salience effects. To begin with, however, we look at simple pre/post DiD estimates to compare prices and time on market after the policy went into effect based on several alternative potential treatment statuses. Namely, we consider pairwise comparisons by (1) flood zone at time of transaction and (2) 2017 insurance policy/claim status for properties in Harvey-impacted zips.

An important empirical issue in assessing the extent of flood risk capitalization is that a property's geospatial location will drive both flood risk and the amenity value of the property. In particular, areas prone to flooding are often located on coasts or near major rivers, housing markets that may have fundamentally different dynamics than elsewhere. As a result, simply comparing results across flood zones may omit important variables on the property's characteristics. To help address this issue, we ran all DiD and event study regressions within a hedonic that controlled for a variety of key attributes presented in Table 1, including the USDA Rural-Urban Commuting Area code

[7] There are several other challenges with using the public NFIP data. The dataset is large and there is limited capacity to perform self-validation that all policies are unique, since identifying information has been removed. Since policies typically have one-year terms, when a policy is continued from one year to another it may appear that there are two policies in the same month. We follow FEMA procedure for determining how many policies are in effect for a given month. In addition, FEMA regularly updates, adds, and modifies data in the OpenFEMA portal. As a result, some analysis may change with future releases of the public NFIP data.

and appraisal records on the condition of the property and the quality of its location. MSA and year fixed effects are included for all DiD regressions and MSA and month-year fixed effects are included for event studies.

The key outcomes *Y* we measure are the log of sales price and weeks on market.[8] For each outcome variable and treatment groupings, we assess DiD coefficients from a modified hedonic regression given by:

$$Y_i = \alpha_1 Post_i + \gamma Treatment_i + \theta Post_i * Treatment_i + \beta X_i + \mu + \delta + \epsilon_i,$$

Where *Post* is an indicator variable equal to 1 if the sale date is after August 31st, 2019; *Treatment* is an indicator variable for (1) properties in a 500-year or 100-year flood zone compared to either properties in areas with negligible flood risk, 100-year flood zones, or the two combined; or (2) the insurance policy and claim status of properties in Harvey-impacted zips compared to properties in Harvey-impacted zips with no NFIP policy at the time of the disaster; *X* is a vector of property characteristics (including whether a property is in a county with a FEMA declared flooding disaster in the 6 months prior to the transaction), presented in Table 1; and μ and δ are MSA- and year fixed effects. The main coefficient of interest is θ, which gives either the percent change in sale price or absolute change in weeks on market for the treatment group, depending on the specification.

A key assumption for differences-in-differences is parallel trends across treatment groups in the pre-policy period. In all areas raw sale prices (i.e., without accounting for property characteristics) were either flat or slowly growing prior to September 2019, but grew sharply from then on. In addition, this increase was notably steeper for properties in 100-year flood zones. We ran traditional unconditional pre-trend tests and conditional pre-trend tests, finding some small but statistically significant differences in pre-trends for our main treatment category (500-year zones). In both cases, the pre-trend suggests that the treated groups had slightly flatter growth prior to the change.

[8] Since price and time on market are determined simultaneously and we do not assess interdependent movements of the two, we do not include either in the regression of the other as is common in the literature (Sirmans, Macpherson and Zietz 2005).

Figure 2 Sale price before and after policy by flood zone

In addition to this result, there are other challenges to interpreting the DiD estimates as causal. The two most obvious are that treatment is not perfectly identified by either measure and because there may be omitted variables correlated with both flood zone status and property amenities. In the former case, the issue arises from the fact that in addition to requiring disclosure for properties in 500-year FEMA zones, the 2019 disclosure form change modified the form to make flood-related disclosures more prominent. Since the disclosure form also includes information about a history of flooding or current insurance status, two disclosure that may be more relevant for potential buyers, and since we do not observe either, we cannot safely say that all properties outside of flood zones are 'never treated' or all properties in 500-year zones are 'newly treated.' As such, we cannot fully separate the effect of increased salience of flood risk from the effect of zone disclosure. We rely on a limited window of information about policy and claim status for properties in Harvey-impacted zips to address this issue. For the latter issue of omitted variable bias, controlling for some property and location characteristics helps alleviate potential bias on coefficients from the 100-year flood zones and in pre-trends tests, but lack of information about more flood-relevant amenities like water views or distance to coast poses a challenge we cannot currently surmount. However, subsample analysis on the Harvey-impacted zips allows us to abstract away from the 100-year effect by comparing properties in either flood zone to the most likely never-treated group (properties outside of flood zones with no 2017 policy or claim history).

Complications identified in recent literature around staggered treatments, two-way fixed effects, and heterogeneous treatment effects are not applicable here, since there is a single policy change and we do not rely on two-way fixed effects to estimate treatment effects (de Chaisemartin and D'Haultfœuille 2023, de Chaisemartin and D'Haultfœuille 2020, Sun and Abraham 2021). However, the implication of these and other recent developments in the literature is that testing for

pre-trends and dealing with implicit weights in a DiD model requires strong assumptions that real-world data frequently fail to achieve. In addition to the issues discussed above, heterogeneity in treatment effects and potential general equilibrium effects and violations of the stable unit treatment value assumption pose empirical challenges that cannot be fully overcome without additional data on historical flooding or insurance status at time of transaction. Salience and relevance of flood risk for a buyer varies over the search process, but the disclosure can occur quite late in the process of finalizing a sale. As a result, the effect of the policy is likely to be delayed and diffuse. While transactions in 500-year flood zones closing in September 2019 needed to disclose that risk, the search process for many of those transactions took place in a market that had not yet been impacted by the increased disclosure requirements. Sellers may react to knowing they will have to disclose flood risk by changing pricing or moving disclosure up front. These dynamics will likely develop as the market has more exposure to the policy, especially if real estate agents observe the impact of disclosure around closing and adjust sales strategies on future properties with flood risk in response.

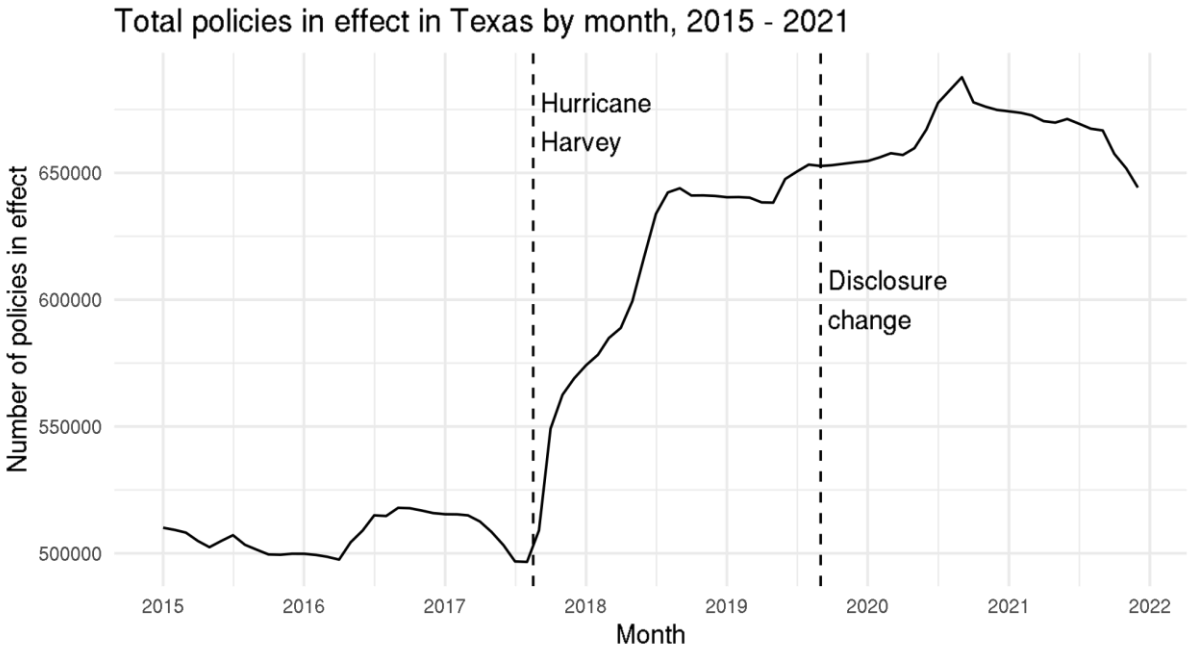
While our exploratory DiD analysis requires us to abstract away from simultaneity in our regressions, the lead-lag relationship between transaction volumes, market tightness, and price also support an event-study design to better understand how changes in our two main outcomes move over time (Carrillo, de Wit and Larson 2015, Keys and Mulder 2022). To better understand these dynamics, we also looked at the main treatment effects in the months before and after the policies:

$$Y_i = \theta\, Treatment_i * Months_i + \beta X_i + \mu + \delta + \epsilon_i,$$

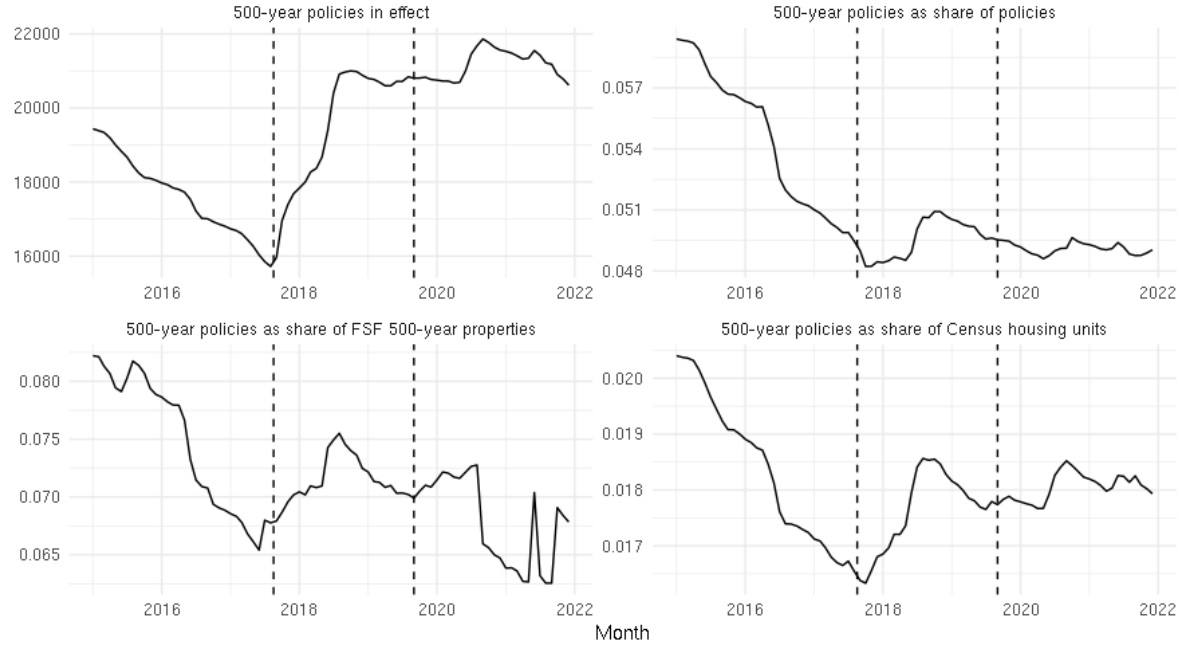
where *Months* is a vector of indicator variables for the number of months from September 2019 that the transaction took place; X and μ are the same as above; and δ are month-year fixed effects. This provides a non-parametric estimate of relative pricing dynamics across and within a variety of potential treatment statuses.

As discussed above, for our analysis of insurance uptake we are not able to match insurance data with the property transaction dataset. As a result, we cannot easily look at how insurance uptake changed on recently sold properties and taking into account full property characteristics. Most importantly, we cannot individually look at how insured properties differed from uninsured properties, since the NFIP data obviously only includes information on insured properties. However, the NFIP data does include information on the FEMA flood zone of the insured property. As such, we are able to compare how patterns of insurance take-up change before and after the policy change when properties are in 500-year flood zones as opposed to 100-year zones or areas with negligible risk.

Figure 3 NFIP policies in effect during sample period



(a) Total policies in force in the state of Texas by month, 2015 through 2021



(b) Policies in effect on properties in 500-year zones and 500-year policies as a share of total policies, of FSF 500-year properties in tract, and of Census housing units in tract

In general, we observe that the total number of NFIP policies in effect rose sharply after Hurricane Harvey, particularly for properties that are not in 100-year flood zones. In the period before Hurricane Harvey, the total number of policies for properties in 500-year flood zones was declining. After the storm, the total policies increased sharply and remained elevated. Another

burst of new policies appeared in 2020, after the disclosure law change, for both 500-year and negligible risk zones. Since properties with a negligible amount of flood risk also saw total policies in effect increase sharply after Hurricane Harvey, properties in 500-year flood zones as a share of all policies remained lower than the period before Hurricane Harvey.

Combining this with tract-level data on housing units and flood risk, the shares of properties that are in 500-year and 100-year flood zones in a Census tract and the average First Street Foundation Flood Factor score for a Census Tract, we estimate a simple model of how the probability that a policy is in a 500-year flood zone changed after the policy intervention. Since in general the probability that a policy is for a property in a 500-year zone is fairly low (on average only 3.2 percent of policies from 2015 through 2021 are for 500-year zone properties), we estimate the marginal effect of the policy using a logit model:[9]

$$\pi(500yr\ property_i = 1|Post, X) = \frac{e^{\theta Post_i + \beta X + \gamma + \epsilon_i}}{1 + e^{\theta Post_i + \beta X_t + \gamma + \epsilon_i}},$$

where *Post* is the indicator for whether a policy went into effect after September 1st 2019; X is a vector of controls including the policy cost, the shares of policies in the same Census tract that are in 500- and 100-year flood zones, the average First Street Foundation Flood Factor for the policy's tract, the Census count of households in the policy's tract, and the number of sales transactions in the tract over the previous six months; γ are month fixed effects to account for seasonality of insurance effective dates. We estimate the model on a sample of NFIP policies for single family properties with effective dates between January 2017 and December 2021.

In this estimation, we do not interpret the coefficient θ as a causal effect of the policy change on the probability of insurance take-up by buyers of properties in 500-year flood zones. We only observe properties with policies and do not observe when property owners decide to not purchase insurance. Instead, our estimate considers the probability that any given NFIP policy is for a property in a 500-year zone before and after the policy change, and this is how it should be interpreted. Beyond this, while the regression can be run on policy-level data we do not have the corresponding property attributes for those properties, including whether that property was a recent sale. Since the disclosure would only affect properties with a sales transaction after September 2019, the universe of policies is not a completely appropriate sample. Further, we define the *Post* variable for the NFIP data based on the policy effective date, which may not correspond to the sale date.[10] As a result, we expect that if the policy is partially driving the value of θ that component would likely be biased towards zero in the initial periods after the disclosure change.

[9] We re-ran the regressions using both linear probability and probit. Both confirm the direction and significance of the main coefficient. The linear probability models, however, estimate significantly smaller effects with less precision. Given the relative unlikelihood of the dependent categorical variable, we prefer the logit and probit specifications. We opt for the logit due to its interpretation as changes in log odds.

[10] The full private NFIP data could better estimate the effect of the policy change by allowing us to construct a sample of recent sales, as well as whether that property had a policy in effect before and after the sale. With only the public NFIP data, however, we cannot identify this sample. As a robustness test, however, we re-ran the analysis but delaying the post variable separately by 30, 60, and 90 days to account for the standard waiting period for NFIP applications, average closing time in Texas, and the two combined, respectively. Results were confirmed across all alternative specifications.

4. Results

When disclosure requirements changed in September 2019, there were two major changes: First, properties in 500-year flood zones as rated by FEMA had to disclosure that fact. Second, all flood-related questions were placed in a separate section and given more prominence, especially to whether a property was currently insured or had a history of flooding. We look at event studies and DiD regressions on properties in flood zones, including mostly newly treated properties in 500-year zones and always treated properties in 100-year zones who will be exposed to new attention from the updated disclosure forms.

The DiD results, presented in full in Table A2, are suggestive of differential pricing dynamics after the policy across these three types of flood map classifications. Properties in 500-year flood zones, which are the most newly treated, had prices roughly 3.8 percent (0.037 coefficient) higher than similar properties with negligible flood risk before the policy.[11] This declined substantially afterwards, with prices falling 4.2 (-0.043 coefficient) percent relative to those with negligible risk and 3.6 percent relative to those in 100-year zones. When considering the event study (Figure 4), however, the decline for properties in 500-year zones occurs with a delay, roughly 20 months after the policy. In addition, the month-by-month coefficients after the policy change are sometimes statistically different from just prior to the change (i.e. relative to the August 2019 coefficient) and sometimes not. Nevertheless, the DiD coefficients are quite robust to how much of the post-sample is included: the coefficient on 500-year flood zones relative to 100-year zones is negative and statistically significant for any post period from the first month of the policy on. Put differently, including just one month as a post-period or any range of months from the post-period, up to all 40 months, still yields a statistically significant relative drop in prices for properties in 500-year zones relative to those in 100-year zones.

[11] We ran several placebo tests on this and all DiD regressions. While a placebo for treatment generally fails to find significant result, date placebos frequently do. This fact is amply demonstrated by the event studies presented in the main text: inserting an effective policy date any time before January 2021 will capture the same price decline as our policy date captures, although the point estimate will change. This is another reason why we prefer the event studies at identifying differential price dynamics by flood risk.

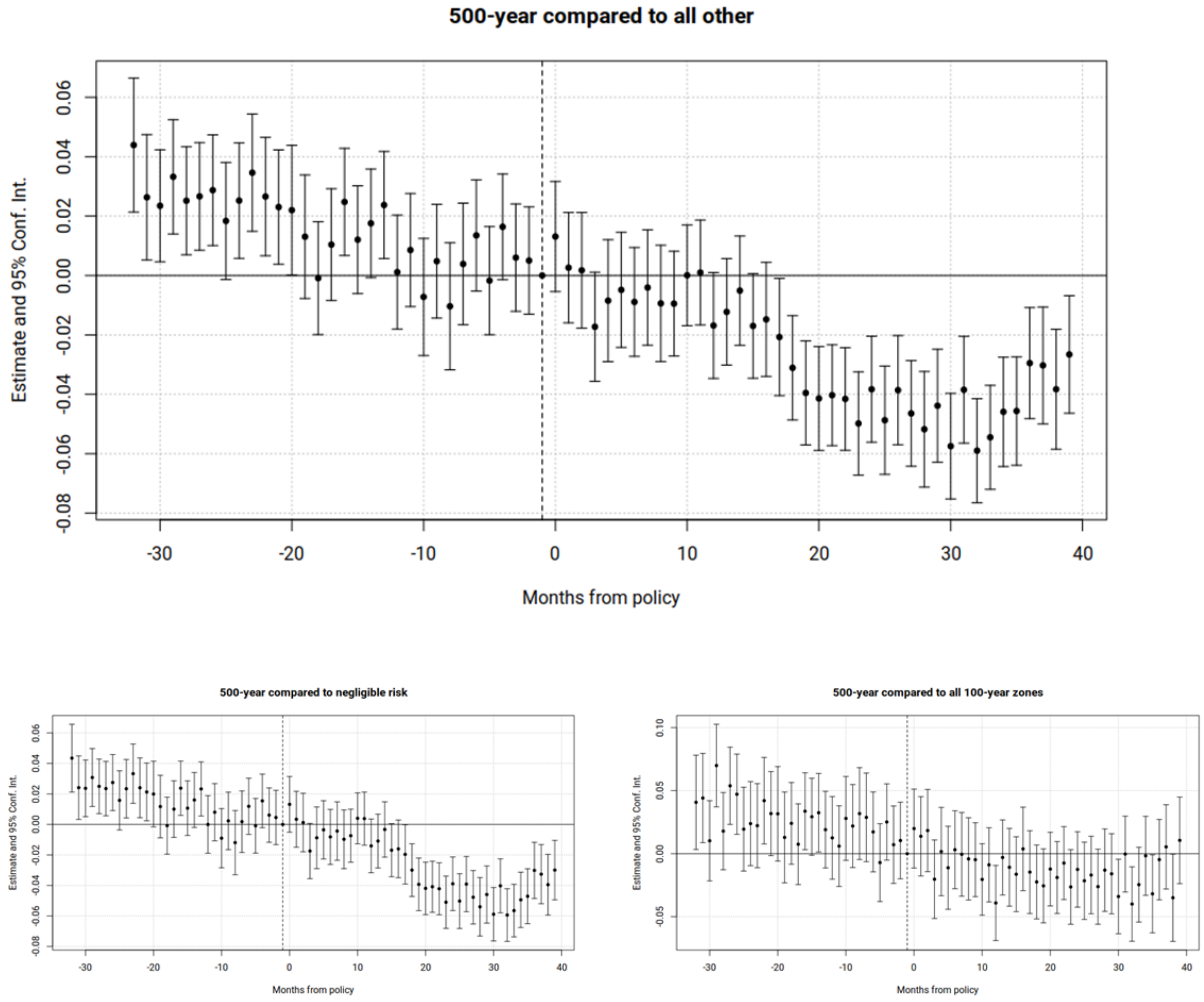


Figure 4 Event study for log (sale price) for properties in 500-year flood zones vs 100-year zones or negligible risk areas

Properties in 100-year flood zones, which are always treated in our sample, do not sell at a statistically significant different amount following the policy after controlling for property characteristics and MSA fixed effects. The DiD results comparing 100-year to all other show prices 9.1 percent (0.087 coefficient) higher in the period prior to the policy relative to those with negligible risk, but with that only changing by -0.04 percent (0.0004 coefficient) after the policy (not statistically significant at the 10 percent confidence level). As previously noted, these properties likely have unique amenities directly associated with their flood risk (e.g. a water view or access to recreation), which could explain the initial premium, while the null effect from the policy may reflect the fact that they are always treated. As the event study (Figure 5) shows, however, while there was little indication of a policy effect and that prices in fact initially increased, prices also showed a decline on a similar timeline as 500-year zones (20 months after the policy).

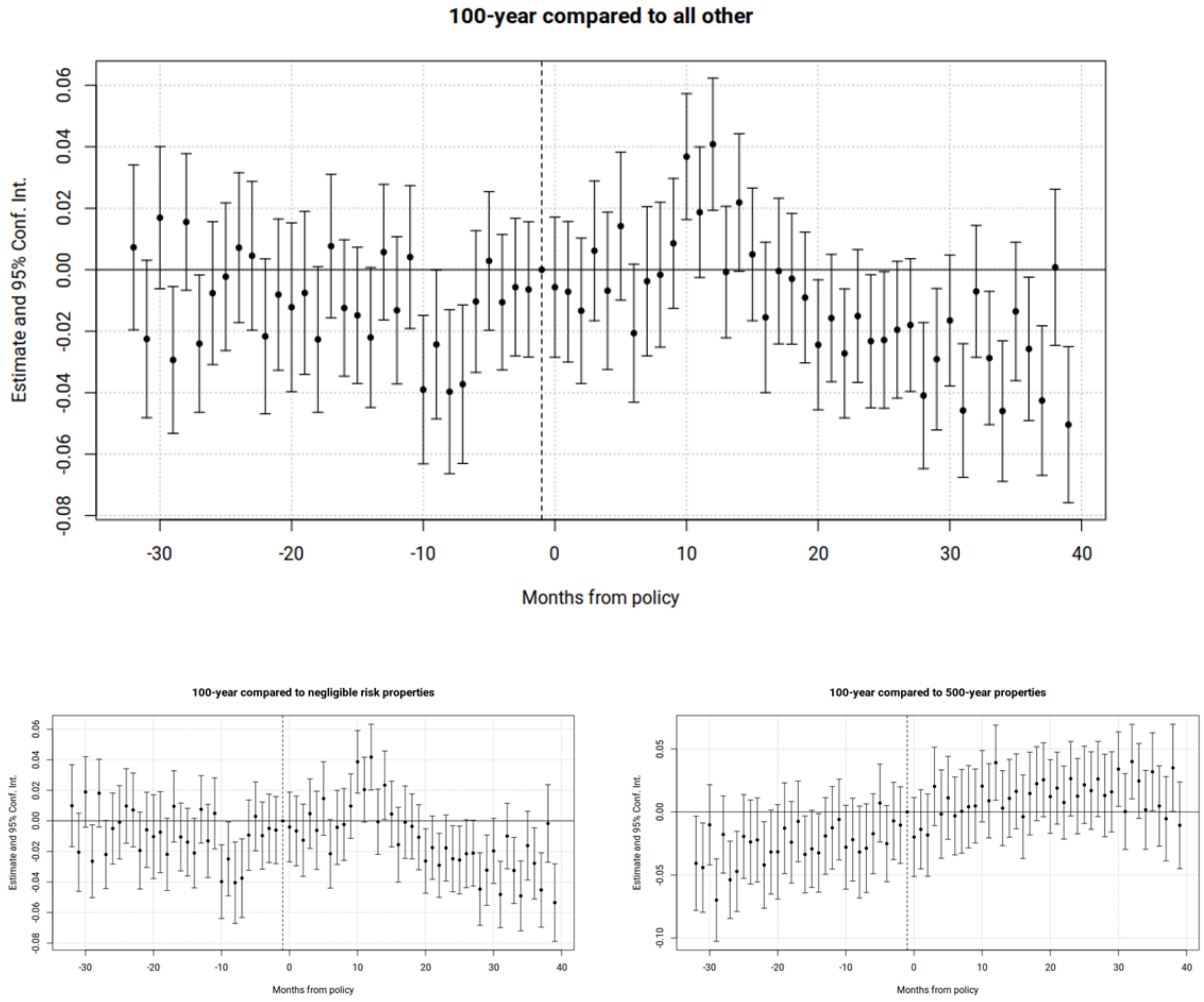


Figure 5 Event study for log (sale price) for properties in 100-year flood zones vs 500-year zones or negligible risk areas

A delay could be observed due to the fact that many transactions with sale dates immediately after the policy involve a search process completed under the previous policy.[12] It may also take time for market participants to become aware and adapt strategies to the new policy. For example, if agents observe frequent renegotiations or failures to close, they may choose to list at lower prices or disclose earlier in the search process to avoid late-stage surprises. The more immediate effect on properties in 100-year zones and relative high quality of Texas's disclosure pre-September 2019 make these explanations unlikely.

In addition to these issues, the period seven to ten months after the policy change (Spring to Summer 2020) was dominated by the COVID-19 pandemic, which had significant effects on housing markets (Duca and Murphy 2021). We assessed the potential impact of COVID-19 on these results in two ways: First, we compared our results on properties facing flood risk with price

[12] We tested whether the decline was observed with a variety of placebos, including across spatial characteristics likely to be correlated with flood risk, and selectively dropped properties associated with specific flood events to test whether a single event was driving the pattern. While the pattern can be observed across several specifications by flood risk, it does not appear to be an artifact of a correlated variable or specific event.

differences between metropolitan areas and micropolitan/small town/rural areas. This is because the COVID-19 pandemic saw significant variations in market demand across the metro-to-rural divide, and it is possible that flood risk is correlated with these. A limited set of results from these robustness checks are reported in the appendix. While we do see differences in pricing dynamics between these regions, effects are concentrated in the middle of 2020 (7 to 10 months after the policy change) rather than during that January to May 2021 period (16 to 20 months after the policy change) where we see the pronounced differences occurring in Figure 6. While there is some similar movement across these regions and flood prone areas, it is unlikely a result of correlation between flood risk and area type: while properties in metro areas are more likely to be in 500-year flood zones, their prices were higher in the 16-20 month window after September 2019. In addition to a robustness check by area type, we also consider regressions that account for Texas's stay-at-home order that was in effect April 2020.[13]

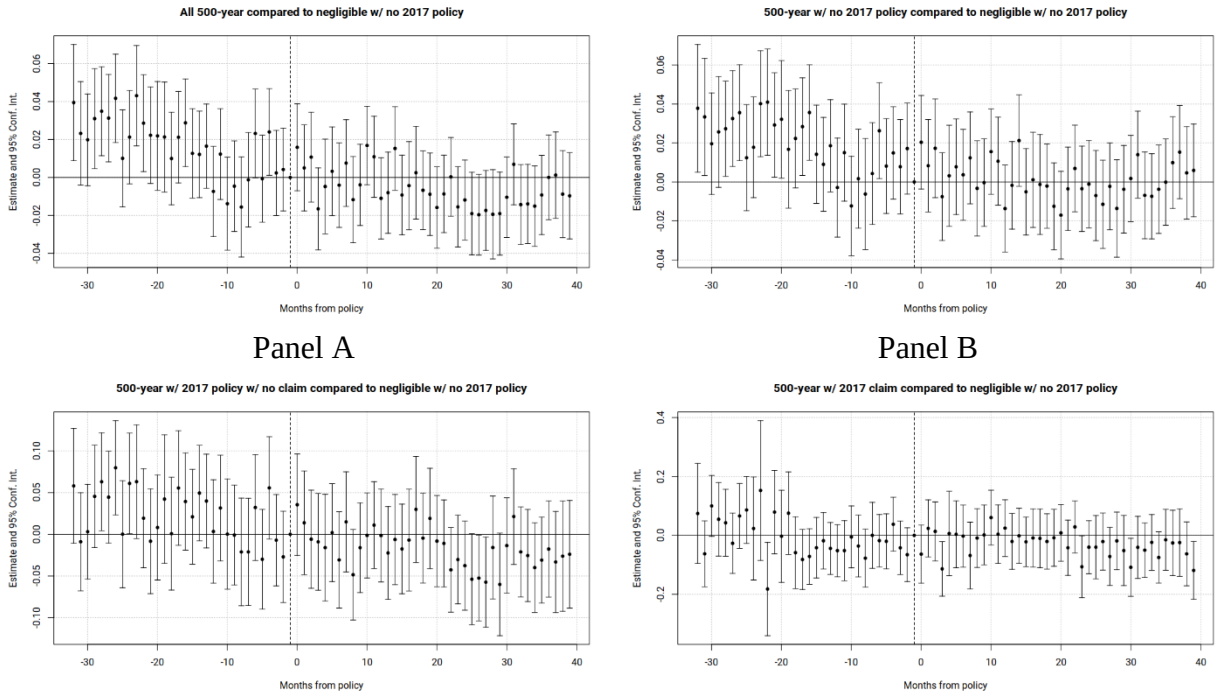
An alternative explanation could come from Redfin's national roll-out of providing data on flood risk from the First Street Foundation. Starting with a limited sample in October 2020 and then rolled out nationwide on January 3rd, 2021, Redfin showed First Street Foundation's Flood Scores and whether the property had minimal, minor, moderate, major, severe, or extreme flood risk. This followed Realtor.com's roll-out of providing both FEMA and First Street risk data on their online listings in August 2020.[14] Redfin found that users who interacted with their flood risk data were more likely to bid on properties with lower risk, with significant participation in Texas (Katz, Fairweather and Sandoval-Olascoaga 2022). This could explain why both 500-year and 100-year observe a similar pricing dynamic at that point, but different ones around the policy change.[15]

While a major component of the 2019 policy change was to require disclosure for properties in 500-year zones, it also moved flood related disclosures to their own section and provided more context. As a result, some properties in 500-year zones and outside of flood zones entirely had to disclose previously and now disclose with greater salience to the buyer. While we do not observe insurance status and flood history at time of transaction in full for any observation, for a limited subsample of our data in Harvey-impacted zip codes we have information on policies in effect as of August 2017 and any claims related to Harvey afterwards. This allows us to construct a control group of properties outside of flood zones and without a 2017 insurance policy, those most likely to have been never treated by Texas's disclosure policy.

[13] While time on market did indeed increase sharply for properties sold during and immediately after this period in line with expectations, controlling for this policy had no effect on any of the coefficients of interest. This suggests that the uptick in time on market evident at 8 and 9 months after the policy change visible in Figure 5 is not simply a COVID-19 effect.

[14] https://www.npr.org/2020/08/26/905551631/major-real-estate-website-now-shows-flood-risk-should-they-all, https://www.redfin.com/news/redfin-users-interact-with-flood-risk-data/

[15] Another possible explanation comes from an expansion of Texas's flood disclosure requirements that came into effect in January 2021. This required landlords to disclose flood risk to renters, a significant expansion but one that may not have immediately moved the market for single-family homes. In addition, the 2020 to 2021 period is complicated by the presence of COVID-19, which had significant effects on local economics and housing markets. While COVID-19 does appear to have had an impact on the metro/rural submarkets and Texas's stay-at-home policy likely impacted time on market, there still appears to be some systematic variation by flood risk even controlling for these factors.



Panel A Panel B

Panel C Panel D

Figure 6 Event study for log (sale price) for properties in 500-year flood zones vs. properties outside of flood zones without a 2017 policy

Figures 6 and 7 compare pricing dynamics for 500-year and 100-year properties to this control group, respectively (Table A4 provides DiD coefficients for the same comparisons for log of sales price). In each figure, Panel A compares all properties in each respective flood zone to only those properties outside of flood zones without a matched policy in 2017. Each subsequent panel restricts the sample of properties within a flood zone based on 2017 policy and claim status, with Panel B limited to properties with no matched 2017 policy, Panel C to properties with a matched 2017 policy but no claim, and Panel D to properties with a matched 2017 claim.

In general, properties in 500-year flood zones within Harvey-impacted zip codes experience a similar decline relative to the control group. Comparing to just properties outside of flood zones without a 2017 policy (Panel A in Figure 8), properties in 500-year zones declined in the earliest part of the pre-period (and coinciding with Harvey) before stabilizing in the year before the policy change. The relative decline for 500-year properties was largest for those that matched to a 2017 policy but showed no claim (Panel C in Figure 8)—those likely to have required disclosure beforehand, but only on insurance coverage and not on flood zone status or flood history. Again, however, the largest declines for this group come starting 20 months after the policy. For properties with no 2017 policy (least likely to have previously disclosed, in Panel B in Figure 8), the effect was smaller but more quickly felt and consistent across the post period. For this group of properties, the DiD estimate reveals a relative price drop of 1.9 percent, equating to around a $7,700 price decrease relative to the average price for properties in Harvey-impacted zip codes without a 2017 claim. Finally, for properties in 500-year zones with a Harvey claim (Panel D in Figure 8)—properties that definitely would have had to disclose for any transaction after Harvey—

prices experienced a small, statistically insignificant decline with a pattern more similar to the other always treated group: properties in 100-year flood zones.

For 100-year zone properties, there is a fairly consistent increase in prices relative to properties outside of flood zones with no 2017 claim across the post period. This increase is pronounced for properties that do not match to a 2017 policy, seen in Figure 9 Panel B (increasing a statistically significant 3.6 percent relative to the non-flood zone control group), and for properties with a matched 2017 policy but no claim (increasing 2.5 percent relative to control, in Panel C), while properties that had a claim in 2017 show a statistically insignificant 1.0 percent decline after the policy change (in Panel D). This suggests that prices rose in response to the increased salience for always treated properties in flood zones with no matched insurance or no claim, i.e. properties least likely to disclose a flood history alongside insurance and flood zone disclosures.

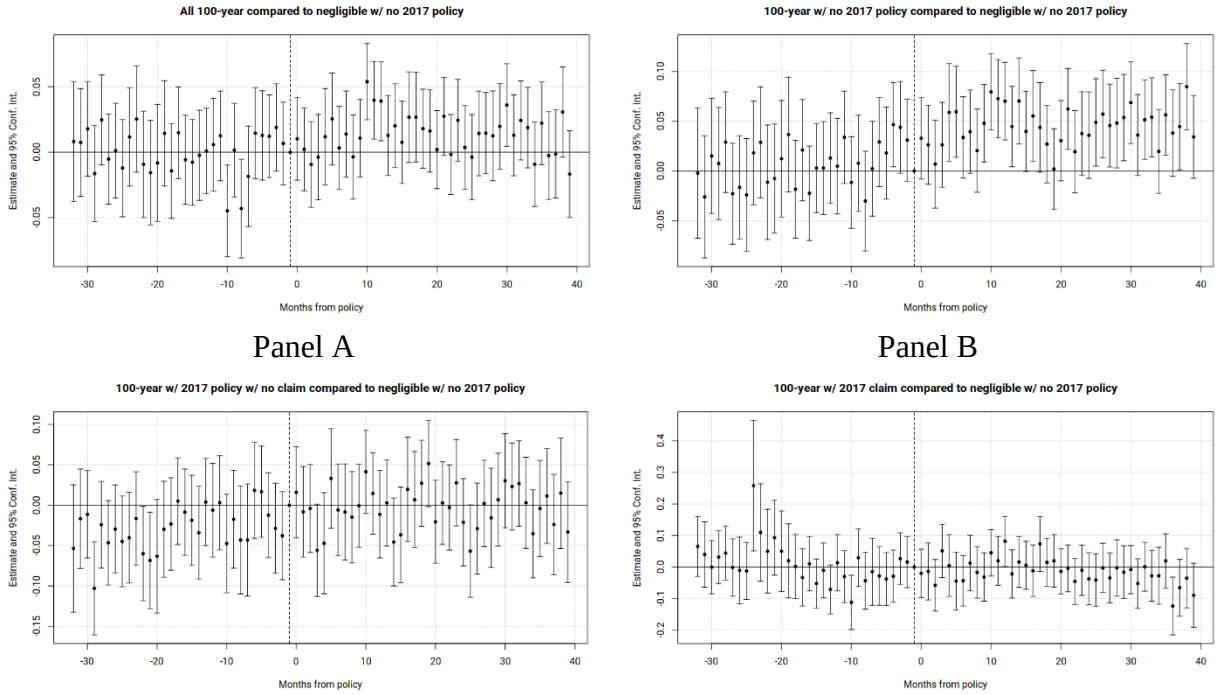


Figure 7 Event study for log (sale price) for properties in 100-year flood zones vs properties outside of flood zones without a 2017 policy

Since properties in 100-year flood zones are required to have insurance, failure to match insurance could mean that the property did not match due to challenges joining FEMA data with our internal CU data or because the property moved into a 100-year zone after August 2017. Some may also have been in violation of the insurance requirement, which could lead to misunderstandings about the property's risk or the flood insurance requirement during disclosure. However, we cannot say for certain that this group are uninsured properties in SFHAs. However, for properties for which we do have policy match but no observed 2017 claim, there appears to be a benefit to greater attention on that fact in the disclosure form. Especially in the post-Harvey period, properties in 100-year zones that show no disclosure of a flooding history may be seen as safer by buyers. When a property is already disclosing that it has a flood history, e.g. those with claims in Harvey, there

is no benefit to being in a 100-year zone relative to a property outside of a flood zone with no history of insurance or claims.

Table A3 in the appendix gives the DiD results of weeks on market on flood zone. Based on robustness checks around flooding events, it is likely that statistically significant results here are related to either delayed direct effects from flooding or from the unique feature of high flood risk markets, which may be coastal or have a higher share of secondary homes. Properties in 100-year flood zones take longer to sell, but all DiD coefficients are within a week after controlling for property and location characteristics. Properties in 500-year flood zones, generally sold quicker after the policy, but only by less than a quarter of a week.

4.1 Insurance effects

The above analysis considers how the disclosure law change impacted sales prices. In addition to increasing awareness of flood risk that can be capitalized into prices, the disclosure change may also have impacts on the decision of homebuyers to purchase flood insurance. While we cannot identify the insurance purchase decisions of our sales transactions dataset, we can use the public National Flood Insurance Program policies data available from FEMA to explore how the composition of policies by flood zone changed after the policy.

Table 3 Logit model odds ratios for probability policy is for property in 500-year zone

	(1)	(2)	(3)	(4)
	All ratings	All ratings	500-year and negligible	500-year and 100-year
Post	0.97***	1.29***	1.16***	1.42***
Share 500-year		7.78***	7.19***	9.67***
Share 100-year		0.28***	0.86***	0.02***
Observations	3,450,227	3,450,227	2,706,686	852,241
McFadden Pseudo R^2	0.00	0.22	0.24	0.39
Controls?	N	Y	Y	Y

**** p<0.001, ** p<0.01, * p < 0.05. Standard errors given in parentheses.*

Table 3 presents results from the logit model of probability that a policy is for a property in a 500-year zone. The first two columns run the model on the full sample of policies with effective dates between January 2017 and December 2021. The final two columns estimate the change in likelihood that a policy is for a property in a 500-year zone relative to properties with negligible risk and properties in 100-year zones, respectively. Across all policies and controlling for policy cost and tract housing stock characteristics, a policy was 29 percent more likely to be for a property in a 500-year zone after the disclosure change than before. Most of this difference comes from the relative likelihood that a property is in a 500-year or 100-year flood zone: while 500-year properties are 16 percent more likely than negligible risk properties in the post period, policies are 1.4 times more likely to be for a 500-year property than a 100-year property after the change.

5. Conclusion

Texas's expanded flood disclosure requirements in September 2019 may have resulted in some new capitalization of flood risk, but it is challenging to determine exactly to what extent. Using a

combination of difference-in-differences and event studies, we find that prices in 500-year flood zones, a group of properties that were likely to have been newly impacted by the policy, fell 4.2 percent compared to properties outside of flood zones following the policy change. However, most price divergence occurred 20 months after the policy was introduced, a timing that is observed for properties in either 500-year or 100-year zones and that coincides with the release of First Street Foundation flood risk scores on Redfin and Realtor.com. This casts doubt on whether it was the policy that drove this observed capitalization of flood risk.

That said, different types of flood risk disclosure are likely to have different effects. This is true not only between state mandates and voluntary disclosure on Redfin, but between the individual disclosures required by the state. In Texas, properties in 500-year zones that very likely never had to disclose before do show some evidence of capitalization shortly after the policy went into effect, but those with previous disclosure requirements less so. Focusing on a set of properties that are least likely to have had to previously disclose, namely properties in Harvey-impacted zip codes that were seen to not have an insurance policy in place. We see that in comparing properties in 500-year flood zone properties without a 2017 insurance policy to only those outside of a flood zone without a 2017 insurance policy, prices decline 1.9 percent. This is equivalent to a price decline just under $7,700 relative to similar properties outside of flood zones at the mean price for properties in 500-year flood zones. Further, this price decline coincides with the timing of the policy enactment and is consistent throughout the whole pos-policy implementation period. This is in line with or slightly below previous estimates of flood risk capitalization rates in 100-year flood zones, suggesting relatively consistent risk pricing when buyers are aware of those risks. For properties in 100-year zones, the effect of increased salience of flood zones on the disclosure may be to create a false sense of security if the property does not specifically disclose a history of flooding.

If the price declines in high flood risk areas come from Redfin, what role does Texas's flood disclosure policy play? Salience is shown to play a key role in flood risk capitalization, but there may be tradeoffs between timeliness and relevance of risk information. A key difference between Redfin and Realtor.com's risk scores and the Texas disclosure mandate is the timing of when buyers learn about flood risk. In the former, flood risk is a part of the initial search process and may steer market participants to less risky properties. The disclosure, however, typically comes at the point that buyers may be finalizing their offer to purchase a home. In addition, the specifics of the disclosure matter: providing information about flood zone status may be insufficient if there is not also disclosure about insurance coverage or past flood events.

Another difference, however, is that the disclosure mandate provides specific information about the property and its history of flooding, while the flood risk score provides only a broad overview of risk. As a result, the combination of the two may be particularly important in driving market outcomes. To better understand the effect of state risk disclosure mandates, additional research is necessary to disentangle the effects of specific disclosures and broader risk measures.

References

Atreya, Ajita, and Jeffrey Czajkowski. 2019. "Graduated flood risks and property price in Galveston County." *Real Estate Economics* 47 (3): 807-844.

Atreya, Ajita, Susana Ferreira, and Warren Kriesel. 2013. "Forgetting the flood? An analysis of the flood risk discount over time." *Land Economics* 89 (4).

Baldauf, Markus, Lorenzo Garlappi, and Constantine Yannelis. 2020. "Does climate change affect real estate prices? Only if you believe in it." *The Review of Financial Studies* 33 (3): 1256-1295.

Beltran, Allan, David Maddison, and Robert JR Elliot. 2018. "Is flood risk capitalised into property values?" *Ecological Economics* 146: 668-685.

Bernstein, Asaf, Matthew T. Gustafson, and Ryan Lewis. 2019. "Diaster on the horizon: The price effect of sea level rise." *Journal of Financial Economics* 134 (2): 253-272.

Bin, Okmyung, and Craig E. Landry. 2013. "Changes in implicit flood risk premiums: Empirical evidence from the housing market." *Journal of Environmental Economics and Management* 65 (3): 361-376.

Carrillo, Paul E., Eric R. de Wit, and William Larson. 2015. "Can tightness in the housing market help predict subsequent home price appreciation? Evidence from the United States and the Netherlands." *Real Estate Economics* 43 (3): 609-651.

de Chaisemartin, Clément, and Xavier D'Haultfœuille. 2023. "Two-way fixed effects and differences-in-differences estimators with several treatments." *Journal of Econometrics* 236 (2).

de Chaisemartin, Clement, and Xavier D'Haultfœuille. 2020. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects." *American Economic Review* 110 (9): 2964-96.

Duca, John V., and Anthony Murphy. 2021. *Why house prices surged as the COVID-19 pandemic took hold.* Dallas, TX: Federal Reserve Bank of Dallas. https://www.dallasfed.org/research/economics/2021/1228.aspx.

Fang, Lu, Lingxiao Li, and Abdullah Yavas. 2021. "The impact of distant hurricane on local housing markets." *The Journal of Real Estate Finance and Economics.*

Gibson, Matthew, Jamie T. Mullins, and Alison Hill. 2019. "Climate risk and beliefs: Evidence from New York floodplains."

Hsieh, Lin-Han Chiang. 2021. "Is it the flood, or the disclosure? An inquire to the impact of flood risk on residential housing prices." *Land Use Policy* 106.

Katz, Lily, Daryl Fairweather, and Sebastian Sandoval-Olascoaga. 2022. *Homebuyers with access to flood-risk data bid on lower-risk homes.* Redfin.

Keys, Benjamin J., and Philip Mulder. 2022. *Neglected no more: Housing markets, mortgage lending, and sea level rise.* National Bureau of Economic Research.

Kousky, Carolyn, Mark Palim, and Ying Pan. 2020. "Flood damage and mortgage credit risk: A case study of Hurricane Harvey." *Journal of Housing Research* 29 (51): 586-S120.

Livy, Mitchell R. 2022. "Assessing the housing price capitalization of non-destructurive flooding events." *Research in Economics.*

Ortega, Francesc, and Suleyman Taspinar. 2018. "Rising Sea Levels and Sinking Property Values: The effects of Hurricane Sandy on New York's housing market." *Journal of Urban Economics* 106: 81-100.

Pope, J.C. 2008. "Do seller disclosures affect property values? Buyer information and the hedonic model." *Land Economics* 84 (4): 551-572.

Roth, Jonathan. 2022. "Pretest with caution: Event-study estimates after testing for parallel trends." *American Economic Review: Inisghts* 4 (3): 305-22.

Roth, Jonathan, Pedro H.C. Sant'Anna, Alyssa Bilinski, and John Poe. 2022. *What's trending in difference-in-differences? A synthesis of the recent econometrics literature.* arXiv. https://arxiv.org/abs/2201.01194.

Sirmans, Stacy, David Macpherson, and Emily Zietz. 2005. "The composition of hedonic pricing models." *Journal of Real Estate Economics* 13 (1): 1-44.

Sun, Liyang, and Sarah Abraham. 2021. "Estimating dynamic treatment effects in event studies with heterogeneous treatment effects." *Journal of Econometrics* 225 (2): 175-199.

Vigdor, Jacob. 2008. "The Economic Aftermath of Hurricane Katrina." *Journal of Economic Perspectives* 22 (4): 135-154.

Votsis, Athanasios, and Adriaan Perrels. 2016. "Housing prices and the public discosure of flood risk - a differences-in-differences analysis in Finland." *Journal of Real Estate Finance and Economics* 53 (4).

Zhang, Lei. 2016. "Flood hazards impact on neighborhood house prices: A spatial quantile regression analysis." *Regional Science and Urban Economics* 60 (C): 12-19.

Appendix

Flood disclosure forms

Figure A1 Flood-related component of Texas disclosure form prior to September 2019 (Panel a) and from September 2019 onwards (Panel b)

4. Are you (Seller) aware of any of the following conditions? Write Yes (Y) if you are aware, write No (N) if you are not aware.

__ Active Termites (includes wood-destroying insects)	__ Previous Structural or Roof Repair
__ Termite or Wood Rot Damage Needing Repair	__ Hazardous or Toxic Waste
__ Previous Termite Damage	__ Asbestos Components
__ Previous Termite Treatment	__ Urea formaldehyde Insulation
__ Previous Flooding	__ Radon Gas
__ Improper Drainage	__ Lead Based Paint
__ Water Penetration	__ Aluminum Wiring
__ Located in 100-Year Floodplain	__ Previous Fires
__ Present Flood Insurance Coverage	__ Unplatted Easements
__ Landfill, Settling, Soil Movement, Fault Lines	__ Subsurface Structure or Pits
__ Single Blockable Main Drain in Pool/Hot Tub/Spa*	__ Previous Use of Premises for Manufacture of Methamphetamine

If the answer to any of the above is yes, explain. (Attach additional sheets if necessary):_____

_____

_____

*A single blockable main drain may cause a suction entrapment hazard for an individual.

(a) Flood-related question from Texas disclosure form in effect prior to September 2019

6. Are you (Seller) aware of any of the following conditions?* Write Yes (Y) if you are aware, write No (N) if you are not aware.

__ Present flood insurance coverage
__ Previous flooding due to a failure or breach of a reservoir or a controlled or emergency release of water from a reservoir
__ Previous water penetration into a structure on the property due to a natural flood event
Write Yes (Y) if you are aware and check wholly or partly as applicable, write No (N) if you are not aware.

__ Located ( ) wholly ( ) partly in a 100-year floodplain (Special Flood Hazard Area-Zone A, V, A99, AE, AO, AH, VE, or AR)
__ Located ( ) wholly ( ) partly in a 500-year floodplain (Moderate Flood Hazard Area-Zone X (shaded))
__ Located ( ) wholly ( ) partly in a floodway
__ Located ( ) wholly ( ) partly in a flood pool
__ Located ( ) wholly ( ) partly in a reservoir
If the answer to any of the above is yes, explain (attach additional sheets as necessary):

* For purposes of this notice:

"100-year floodplain" means any area of land that:

(A) is identified on the flood insurance rate map as a special flood hazard area, which is designated as Zone A, V, A99, AE, AO, AH, VE, or AR on the map;

(B) has a one percent annual chance of flooding, which is considered to be a high risk of flooding; and

(C) may include a regulatory floodway, flood pool, or reservoir.

"500-year floodplain" means any area of land that:

(A) is identified on the flood insurance rate map as a moderate flood hazard area, which is designated on the map as Zone X (shaded); and

(B) has a two-tenths of one percent annual chance of flooding, which is considered to be a moderate risk of flooding.

"Flood pool" means the area adjacent to a reservoir that lies above the normal maximum operating level of the reservoir and that is subject to controlled inundation under the management of the United States Army Corps of Engineers.

"Flood insurance rate map" means the most recent flood hazard map published by the Federal Emergency Management Agency under the National Flood Insurance Act of 1968 (42 U.S.C. Section 4001 et seq.).

"Floodway" means an area that is identified on the flood insurance rate map as a regulatory floodway, which includes the channel of a river or other watercourse and the adjacent land areas that must be reserved for the discharge of a base flood, also referred to as a 100-year flood, without cumulatively increasing the water surface elevation more than a designated height.

"Reservoir" means a water impoundment project operated by the United States Army Corps of Engineers that is intended to retain water or delay the runoff of water in a designated surface area of land.

7. Have you (Seller) ever filed a claim for flood damage to the property with any insurance provider, including the National Flood Insurance Program (NFIP)?* __ Yes __ No. If yes, explain (attach additional sheets as necessary):

*Homes in high risk flood zones with mortgages from federally regulated or insured lenders are required to have flood insurance. Even when not required, the Federal Emergency Management Agency (FEMA) encourages homeowners in high risk, moderate risk, and low risk flood zones to purchase flood insurance that covers the structure(s) and the personal property within the structure(s).

8. Have you (Seller) ever received assistance from FEMA or the U.S. Small Business Administration (SBA) for flood damage to the property? __ Yes __ No. If yes, explain (attach additional sheets as necessary):

(b) Flood-related questions from Texas disclosure form in effect from September 2019

Appendix Tables

Table A1 Summary statistics – Harvey-impacted transactions. Standard deviations for means shown in parentheses.

	Total - Insurance status	No policy	Policy, No claim	Policy, Claim
Transactions	656,115	548,909	87,437	19,769
Sale price (Average)	$336,956 (352.51)	$324,615 (359.76)	$406,906 (1,252.81)	$370,230 (2,241.78)
Sale price (Median)	$272,500	$267,000	$310,000	$277,000
Days on market (Average)	53 (0.10)	54 (0.11)	49 (0.26)	57 (0.56)
Days on market (Median)	25	25	21	31
Age (Average)	23 (0.03)	22 (0.03)	29 (0.07)	36 (0.13)
Age (Median)	17	15	24	39
Total bedrooms	3 (0.001)	3 (0.001)	3 (0.003)	3 (0.006)
Total bathrooms	2.1 (0.001)	2.1 (0.001)	2.1 (0.003)	2.1 (0.006)

Gross living area	2,312 (1.20)	2,282 (1.28)	2,490 (3.65)	2,361 (7.52)
County flood declaration w/in previous 6 months	44.2% (0.001)	44.2% (0.001)	44.0% (0.002)	45.0% (0.004)
Flood zone				
Negligible	76.8% (0.0006)	81.1% (0.0006)	61.0% (0.0017)	27.1% (0.0028)
500-year/levee	14.3% (0.0004)	13.4% (0.0004)	17.3% (0.0012)	25.9% (0.0029)
100-year	8.9% (0.0003)	5.5% (0.0003)	21.7% (0.0012)	47.0% (0.0034)
Area type				
Metropolitan	94.5% (0.0003)	95.1% (0.0003)	92.3% (0.0009)	89.7% (0.0022)
Micropolitan	3.3% (0.0002)	2.7% (0.0002)	6.7% (0.0008)	4.3% (0.0014)
Small town	1.4% (0.0001)	1.6% (0.0002)	0.6% (0.0003)	0.8% (0.0007)
Rural	0.7% (0.0001)	0.6% (0.0001)	0.4% (0.0002)	5.2% (0.0016)
Condition				
New property	20.4% (0.0005)	23.9% (0.0006)	2.9% (0.0006)	1.7% (0.0009)
No major repairs needed	79.0% (0.0005)	75.5% (0.0006)	96.9% (0.0006)	95.6% (0.0015)
Significant repairs needed/damaged	0.6% (0.0001)	0.6% (0.0001)	0.2% (0.0002)	2.6% (0.0011)
Quality				
Highest quality	51.8% (0.0006)	50.9% (0.0007)	57.4% (0.0017)	50.8% (0.0036)
Meets or exceeds code	47.6% (0.0006)	48.4% (0.0007)	42.3% (0.0017)	48.4% (0.0036)
Minimum standards, inexpensive material	0.7% (0.0001)	0.7% (0.0001)	0.3% (0.0002)	0.7% (0.0006)
Lowest quality	0.0% (0.0000)	0.0% (0.0000)	0.0% (0.0000)	0.0% (0.0001)
Location				
Adverse	1.1% (0.0001)	1.1% (0.0001)	1.0% (0.0003)	2.0% (0.0010)
Neutral	95.8% (0.0002)	96.2% (0.0003)	94.1% (0.0008)	92.8% (0.0018)
Beneficial	3.1% (0.0002)	2.7% (0.0002)	4.9% (0.0007)	5.3% (0.0016)

Table A2 Differences-in-differences results for log(sale price) by FeZ classification

	(1)	(2)	(3)	(4)
	All ratings	All ratings	500-year and negligible	500-year and 100-year
Post	0.230***	0.017***	0.017***	0.034***
	(0.0008)	(0.0010)	(0.0010)	(0.0040)
500-year	-0.001	0.038***	0.042***	-0.016***
	(0.0027)	(0.0014)	(0.0014)	(0.0025)
100-year	-0.045***	0.087***		
	(0.0037)	(0.0022)		
Post * 500-year	-0.035***	-0.043***	-0.042***	-0.037***
	(0.0034)	(0.0017)	(0.0017)	(0.0030)
Post * 100-year	0.037***	-0.004		
	(0.0047)	(0.0027)		
Observations	2,193,661	2,193,661	2,108,997	217,225
Adj. R^2	0.04	0.75	0.75	0.75
Controls?	N	Y	Y	Y
CBSA & Year FE?	N	Y	Y	Y

**** p<0.001, ** p<0.01, * p < 0.05. Heteroskedastic robust standard errors given in parentheses. Controls include all property characteristics included in Table 1.*

Table A3 Differences-in-differences result for weeks on market by FeZ classification

	(1)	(2)	(3)	(4)
	All ratings	All ratings	500-year and negligible	500-year and 100-year
Post	-2.00***	0.09**	0.08**	0.06
	(0.0127)	(0.0312)	(0.0316)	(0.1204)
500-year	0.95***	0.23***	0.25***	-1.09***
	(0.0442)	(0.0420)	(0.0421)	(0.0699)
100-year	2.22***	1.40***		
	(0.0607)	(0.0570)		
Post * 500-year	-0.29***	-0.23***	-0.23***	0.11
	(0.0538)	(0.0501)	(0.0502)	(0.0835)
Post * 100-year	-0.20**	-0.35***		
	(0.0742)	(0.0690)		
Observations	2,132,871	2,132,871	2,050,972	210,779
Adj. R^2	0.02	0.16	0.16	0.16
Controls?	N	Y	Y	Y
CBSA & Year FE?	N	Y	Y	Y

**** p<0.001, ** p<0.01, * p < 0.05. Heteroskedastic robust standard errors given in parentheses. Controls include all property characteristics included in Table 1.*

Table A4 Difference-in-differences regressions for log(sale price) by NFIP policy and claim status in Harvey-impacted zip codes

	500-Year or 100-year flood zone properties' 2017 policy and claim status (Control group for all columns contains negligible flood risk zone properties with no 2017 claim)			
	(1)	(2)	(3)	(4)
	All	**No 2017 policy**	**2017 policy no claim**	**2017 policy & claim**
Post	0.012***	0.011***	0.011**	0.010**
	(0.0021)	(0.0021)	(0.0022)	(0.0022)
500-year	0.019***	-0.002	0.120***	0.038***
	(0.0018)	(0.0018)	(0.0043)	(0.0072)
100-year	0.089***	0.026***	0.177***	0.124***
	(0.0027)	(0.0037)	(0.0041)	(0.0067)
Post * 500-year	-0.022***	-0.019***	-0.040***	-0.013
	(0.0022)	(0.0022)	(0.0055)	(0.0089)
Post * 100-year	0.017***	0.035***	0.025***	-0.010
	(0.0033)	(0.0045)	(0.0051)	(0.0081)
Observations	597,376	548,909	479,204	459,541
Adj. R^2	0.69	0.72	0.72	0.72
Controls?	Y	Y	Y	Y
CBSA & Year FE?	Y	Y	Y	Y

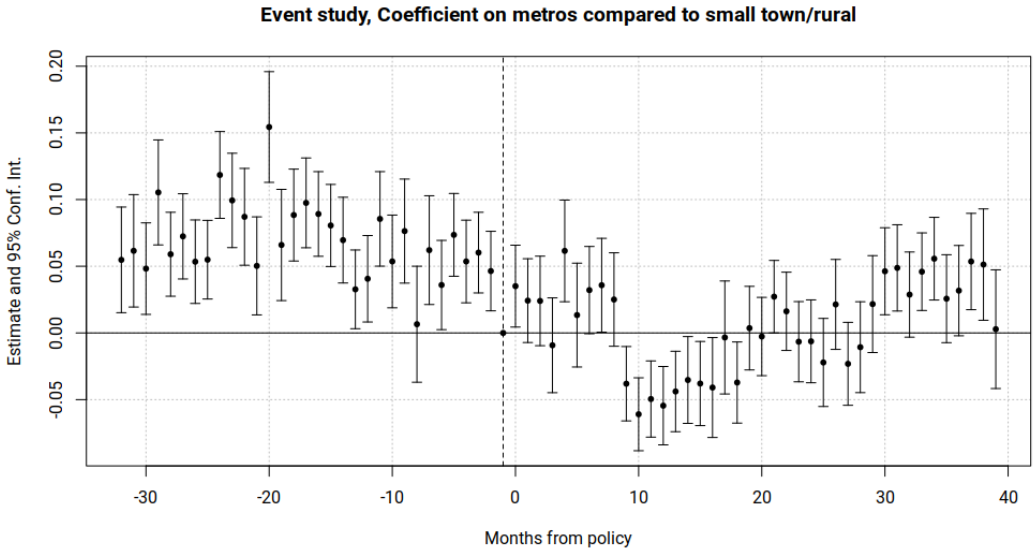
**** p<0.001, ** p<0.01, * p < 0.05. Heteroskedastic robust standard errors given in parentheses. Controls include all property characteristics included in Table 1.*

A

Covid robustness tests

Figures A5 and A6 plot event studies using metropolitan areas as the 'treatment' group compared to small town/rural areas and micropolitan areas, respectively. We use metropolitan areas as a measure of COVID treatment on housing submarkets based on the observed out-migration from metropolitans to small and non-metro areas during the peak 12 months of the pandemic.[16] As can be seen in both, the COVID-effect manifests as a decline in prices more during the peak COVID period of April through December 2020. Contrary to the results on 500-year flood zones, prices in submarkets affected by COVID migration patterns started to rise in January 2021 relative to micropolitan and small town/rural areas. Since 500-year zones are more likely to be in metropolitan areas and 100-year zones are less likely, if the main results on flood risk were driven by COVID-19, we expect to have found the same patterns observed for 500-year zones on metropolitan areas, but do not observe that here. In any case, we include controls for area type in our main regressions.

Figure A5 Event study on metropolitan areas compared to small-town areas



[16] See, e.g., https://www.brookings.edu/blog/the-avenue/2022/04/14/new-census-data-shows-a-huge-spike-in-movement-out-of-big-metro-areas-during-the-pandemic/ or https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2022/03/23/the-pandemic-prompted-people-to-move-but-many-didnt-go-far

Figure A6 Event study on metropolitan areas compared to micropolitan areas