O'NEILL
SCHOOL OF PUBLIC AND
ENVIRONMENTAL AFFAIRS

Flood Zoning Policies and Residential Housing Characteristics in Texas

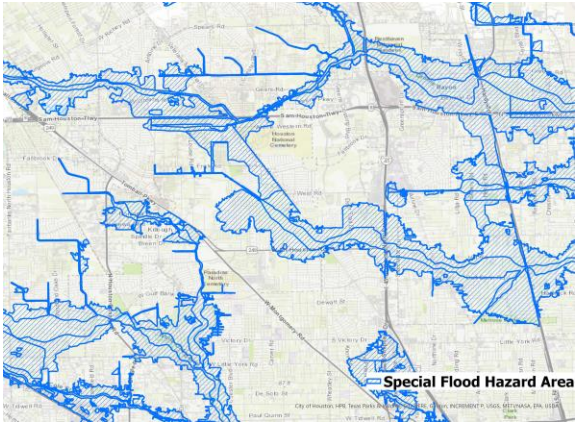
Douglas Noonan – O'Neill School of Public and Environmental Affairs, Indiana University-Purdue University Indianapolis

Lilliard Richardson – School of Public Policy, The Pennsylvania State University

Pin Sun – School of Applied Economics, Renmin University of China

Building Underwater

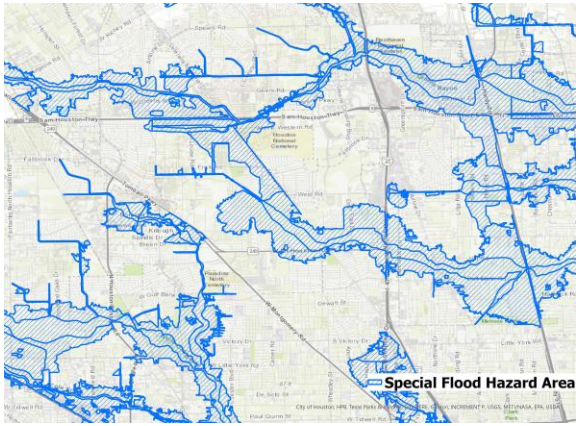
- 1980-2022 floods caused **$1.5+ trillion** in economic losses (NOAA 2023)

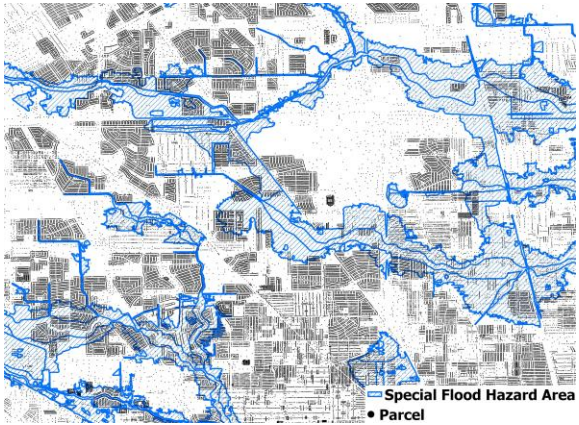


- How effective is the “flood zone” approach?

Building Underwater

- 1980-2022 floods caused **$1.5+ trillion** in economic losses (NOAA 2023)
- **41 million** Americans living in high flood risk areas (Wing et al. 2018)
- How effective is the “flood zone” approach? How do housing markets respond to flood-zone status?





What we find

We leverage big data in Texas to examine housing on either side of 100-year floodplain boundaries

1. Flood risk is smooth at the boundaries (though regulations are not)
2. Housing value premium inside SFHAs only for inland counties
3. Housing attributes are smooth at the boundaries

SECTION 1

Motivation

Flooded with competing narratives, confounders

1. Housing and flooding in the USA

Flooded with competing narratives, confounders

1. Housing and flooding in the USA

Flood damages rising.	Exposure rising.
Under-priced insurance.	Insurance very costly, burdensome.
Information improving.	Yet people ignore flood risk and build / move underwater anyway.

– Are housing markets responsive to flood zones? (If so, how?) Do we ignore them? Do our deterrence and support offset?

Flooded with competing narratives, confounders

1. Housing and flooding in the USA
2. Price effects are muddied in hedonics
   - Regs and flood zones observable. Often a (poor) proxy for flood risk.
   - Flood risk correlated with (unobservable) amenities.
   - Flood-zone **ambiguity**: higher costs, insurance, restricted supply, more information, lower demand, (public) flood protection

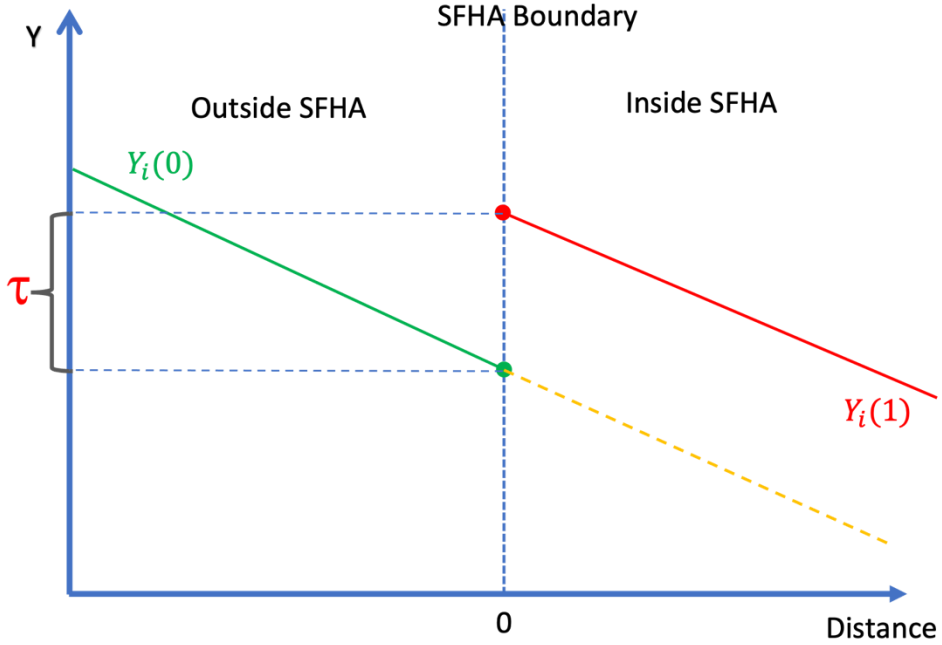
Flooded with competing narratives, confounders

1. Housing and flooding in the USA
2. Price effects are muddied in hedonics

- Isolate the policy effects of floodplain regulation via 100-year floodplains (Special Flood Hazard Areas – SFHAs)
- Focus on the boundary effects
  - Hold (correlated) amenities fixed. Hold (correlated) risk fixed.
  - Policy effects may manifest in prices, housing characteristics, etc.

SECTION 2

Methods


Y
SFHA Boundary
Outside SFHA
Inside SFHA
$Y_i(0)$
τ
$Y_i(1)$
0
Distance

Empirical approach

1. Regression discontinuity design

$$\tau = \mathrm{E}[Y_i(1) - Y_i\ (0) \mid T_i\ = 0]$$

with tract-level fixed effects and controlling for flood risk
with and without #rooms, #bathrooms, #bedrooms, #stories, sq. ft, acres

errors clustered at the county level

Empirical approach

1. Regression discontinuity design
2. Hedonic price method as a comparison

$$Y_i = \alpha_0 + \alpha_1 I_i + \alpha_2 D_i + \alpha_3 I_i \times D_i + \gamma' X_i + \epsilon_i,$$

I_i = indicator for SFHA status D_i = distance to boundary

- Identify implicit price of flood-zone status, of flood risk.
- Control for correlated amenities with tract-level fixed effects, risk
- Limit sample to observations near boundaries.

Empirical approach

Housing attributes

- number of rooms
- number of bathrooms
- number of bedrooms
- number of stories
- square footage
- acreage

- In the price RDD model, estimate with and without these controls (i.e., test if policy impacts price *through* these attributes)
- Repeat the RDD analysis, separately, for each of these.

Empirical approach

Regional variation

- Coastal areas may operate differently than inland areas
  - Texas has a lot of both
  - May be variation in flood zone designations / map updating (Wilson & Kousky 2019)

➢ Estimate separately for coastal vs. inland.

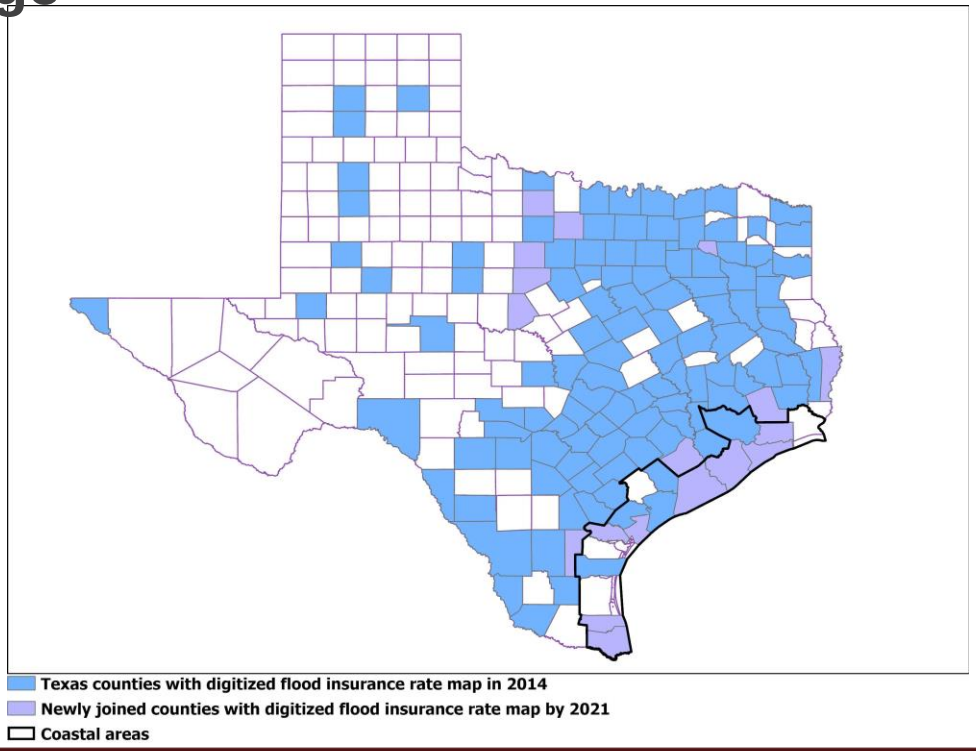
SECTION 3

Data

Data sources

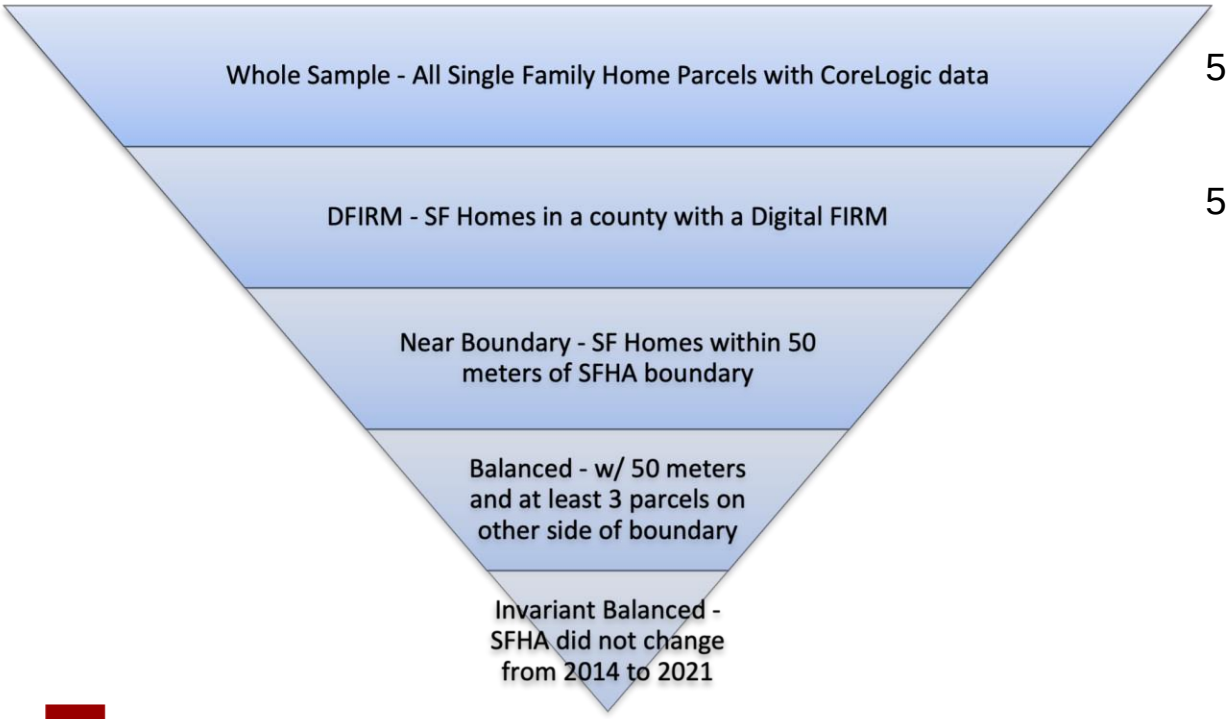
1. **First Street Foundation** – flood risk
   prob. of ≥15cm flood over the next 20 years
2. **CoreLogic** (2021) – property-level (assessed values)
3. **DFIRMs** from FEMA's National Flood Hazard Layer
   (obtained in 2014, 2021)

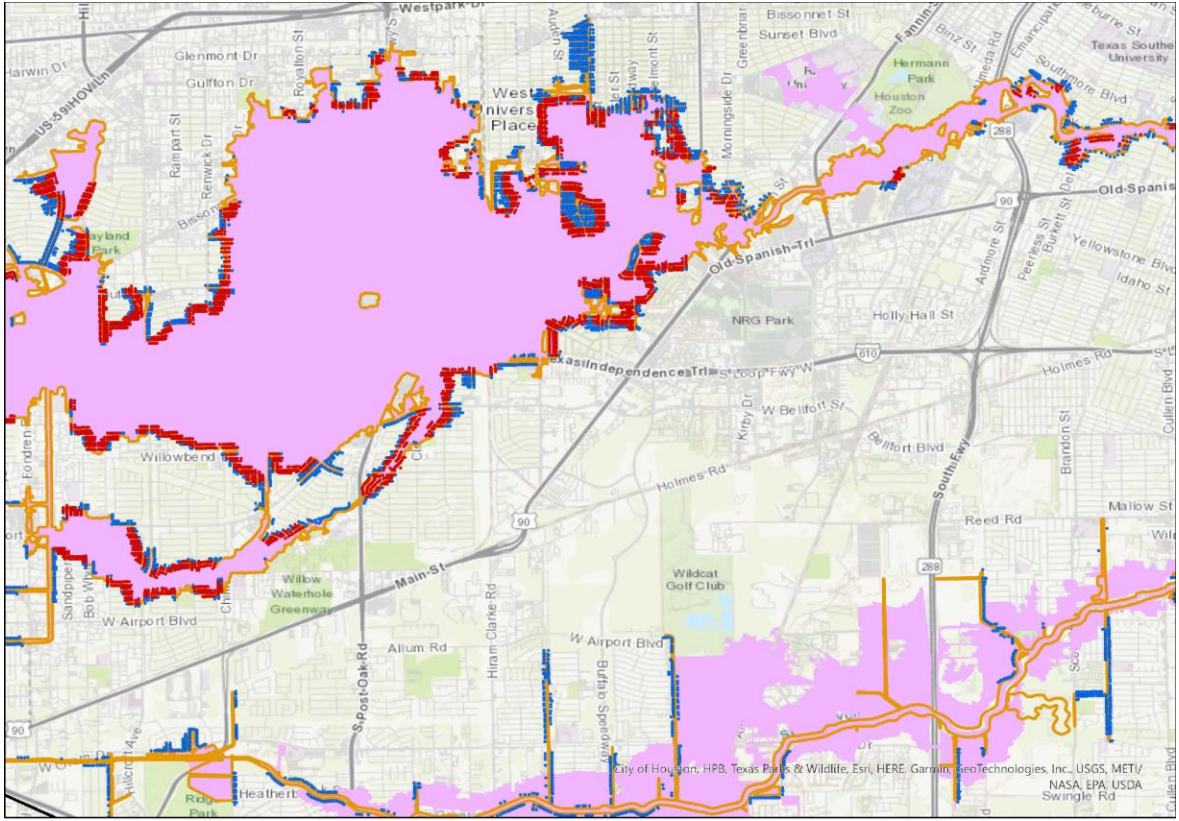
Data coverage



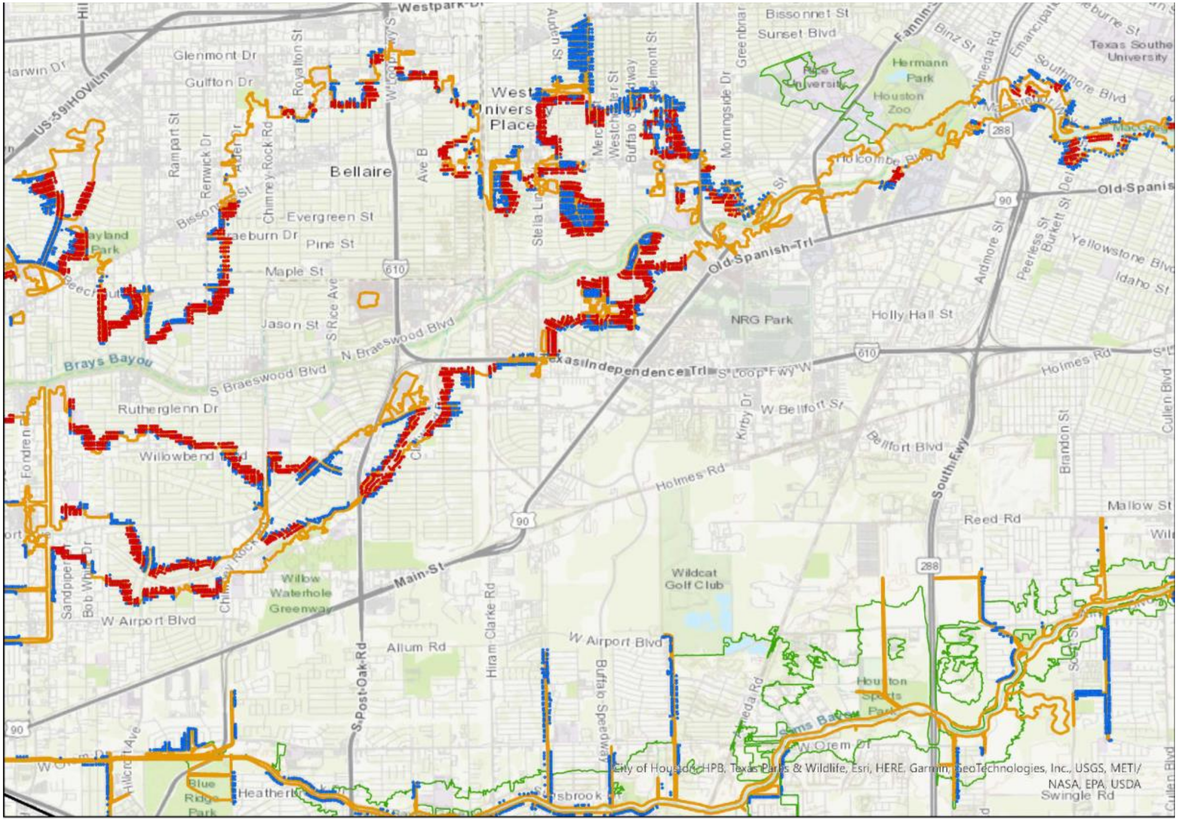
Data restrictions

1. Start with all single-family residential parcels with CoreLogic data
2. Limit to counties with DFIRMs
3. Limit to houses within 50m of SFHA boundary
4. Limit to houses with at least 3 observations on the other side of boundary
5. Limit to observations with distance-to-closest SFHA boundary the same in 2014, 2021


N
Whole Sample - All Single Family Home Parcels with CoreLogic data
5,609,200
DFIRM - SF Homes in a county with a Digital FIRM
5,432,839
Near Boundary - SF Homes within 50 meters of SFHA boundary
408,966
Balanced - w/ 50 meters and at least 3 parcels on other side of boundary
87,881
Invariant Balanced - SFHA did not change from 2014 to 2021
74,900



- Floodplain boundaries in 2021
- Special Flood Hazard Areas in 2014
- Parcels near invariant balanced floodplain boundaries
- Unbalanced Parcels

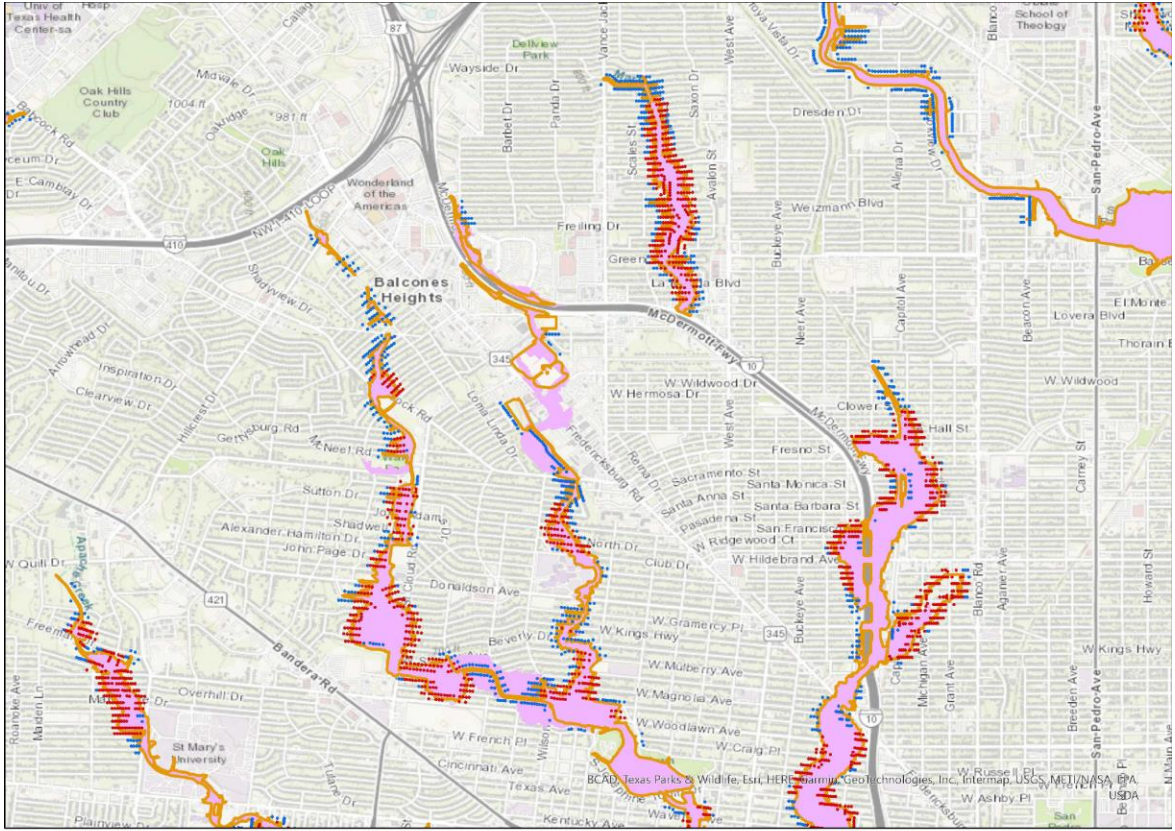


— Floodplain boundaries in 2021

— Floodplain boundaries in 2014

• Parcels near invariant balanced floodplain boundaries

• Unbalanced Parcels

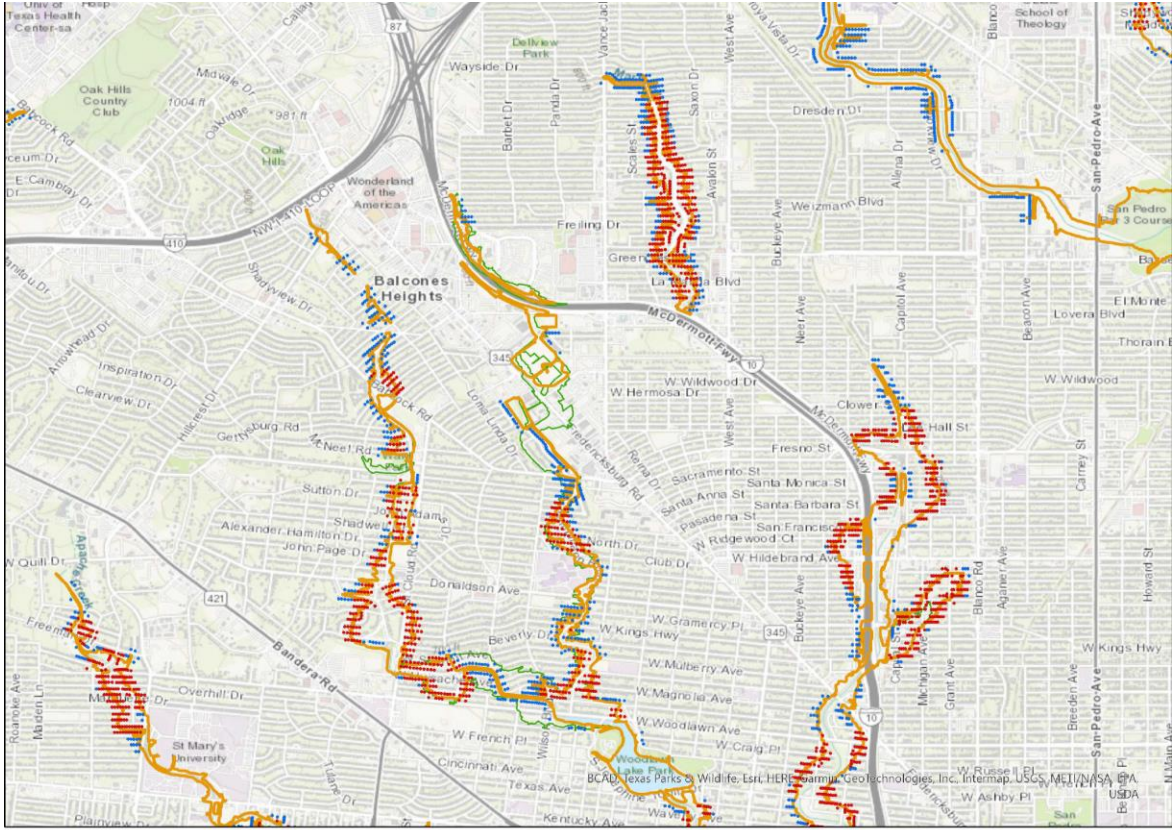


— Floodplain boundaries in 2021

Special Flood Hazard Areas in 2014

● Parcels near invariant balanced floodplain boundaries

● Unbalanced Parcels



— Floodplain boundaries in 2021

— Floodplain boundaries in 2014

● Parcels near invariant balanced floodplain boundaries

● Unbalanced Parcels

Higher risk as we narrow the sample

		(1) Whole Sample		(2) DFIRM		(3) Near Boundary		(4) Balanced		(5) Invariant Balanced	
		mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Coast	FSF risk	0.07	0.17	0.07	0.17	0.14	0.23	0.18	0.25	0.14	0.22
	Observations	1,039,085		1,038,839		175,407		32,503		25,400	
Inland	FSF risk	0.03	0.14	0.03	0.14	0.10	0.24	0.16	0.28	0.16	0.28
	Observations	4,256,847		4,086,855		586,445		55,378		49,500	

Higher risk inside SFHAs

Differences in flood risk for parcels inside vs. outside SFHA

	100*m*	50*m*	20*m*	10*m*	5*m*
FSF risk (coastal)	-0.189***	-0.144***	-0.103***	-0.0447***	-0.0198**
	(-142.93)	(-78.73)	(-35.56)	(-9.97)	(-3.01)
N	224,312	129,609	61,018	23,118	10,054
FSF risk (inland)	-0.180***	-0.127***	-0.0520***	-0.0178***	-0.00695
	(-198.86)	(-98.62)	(-25.28)	(-5.83)	(-1.59)
N	635,326	330,740	132,943	53,956	25,553

t statistics in parentheses
$* p < 0.05$, $** p < 0.01$, $*** p < 0.001$

SECTION 4

Results

Hedonic results

1. Full sample … and near-boundary sample
   - Price **discount** (2%) for SFHA status for **coastal** counties **only**
   - Price effect vanishes when we narrow the sample to near-boundary parcels

   - Whole sample: $\beta_{RISK} > 0$ for inland; $\beta_{RISK} = 0$ for coastal
   - Near-boundary only: $\beta_{RISK} > 0$ for coastal; $\beta_{RISK} = 0$ for inland

RDD results

	(1) Coastal	(2) Inland	(3) Coastal	(4) Inland
Robust	0.0153	0.0251*	0.0067	0.0213***
	(0.0153)	(0.0134)	(0.0097)	(0.0079)
# of Obs	25,483	51,633	25,361	49,459
# of Obs outside SFHA	14,779	29,807	14,716	28,632
# of Obs within SFHA	10,704	21,826	10,645	20,827

Columns 1 and 2 only include tract-level fixed effects and FSF Risk as control variables. Columns 3 and 4, control variables include tract-level fixed effects, FSF Risk, number of rooms, number of bathrooms, number of bedrooms, number of stories, square footage and acreage.

Cluster-robust standard errors in parentheses; clustered at county level.

* p<0.1, ** p<0.05, *** p<0.01

RDD results

- Shows reverse results from a large-scale hedonic analysis
  - Hedonic
    - Price **discount** (2%) for SFHA status for **coastal** counties **only**
    - Price effect vanishes when we narrow the sample to near-boundary parcels
  - RDD
    - Price **premium** (2%) for SFHA status for **inland** counties **only**

RDD results: other housing attributes

τ (s.e.)	Risk	Imprv value	Land value	#Rooms	#Bath rooms	#Bed rooms	#story
Coastal	-0.017	0.020	0.002	0.085	-0.015	0.017	-0.009
	(0.014)	(0.030)	(0.014)	(0.075)	(0.043)	(0.039)	(0.022)
Inland	0.011	0.018	0.016	0.038	0.043*	0.025	0.007
	(0.011)	(0.016)	(0.015)	(0.098)	(0.023)	(0.026)	(0.012)

Results for models with county fixed effects.

RDD results: other housing attributes

τ (s.e.)	Year Built	Sq. Feet	Acres
Coastal	-0.203	0.005	0.022
	(0.694)	(0.013)	(0.018)
Inland	0.004	0.016	-0.011
	(0.013)	(0.010)	(0.016)

Results for models with county fixed effects.

Results

1. Risk is smooth at the boundaries
2. Housing attributes smooth at the boundaries
   - #Bathrooms for inland

Results

1. Robustness checks
   - Results not sensitive to alternative bandwidth selections; to using conventional, bias-corrected, or robust estimators
2. Robustness checks – extra control variables
   - Geographic controls (tract FEs, flood risk) in all models
   - Housing attributes do not account for price differences at boundary
   - *Observable* housing attributes do not vary at boundary

SECTION 5

Dynamics

Foreshadowing some dynamics

1. What about SFHA boundaries that **moved**?

Foreshadowing some dynamics

1. Housing attributes, DFIRMs observed in 2014, 2021
2. For each house, distance to their closest boundary either increased, decreased, stayed the same.

   Increase = expanding

   Decrease = contracting
3. Each boundary that moved (between 2014-2021) can be examined four ways:

a) Original boundary, before the move.
b) Final boundary, after the move
c) Original boundary, after the move
d) Final boundary, before the move

Foreshadowing some dynamics

		Expanding		Contracting	
		2014 lines	**2021 lines**	**2014 lines**	**2021 lines**
Year housing is observed	2014	Initial discontinuity		Initial discontinuity	
	2021		Final discontinuity		Final discontinuity

Foreshadowing some dynamics

		Expanding		Contracting	
		2014 lines	**2021 lines**	**2014 lines**	**2021 lines**
Year housing is observed	2014	Initial discontinuity	Drawn to (preexisting) discontinuity?	Initial discontinuity	Drawn to (preexisting) discontinuity?
	2021	Adj. to removal (insiders)	Final discontinuity	Adj. to removal (outsiders)	Final discontinuity

SECTION 6

Conclusions

Narrowing the sample

1. Looking only around boundaries in TX
2. Difference in coastal vs. inland counties
3. Comparable hedonics yields very different results
4. Risk is smooth
5. Other basic housing attributes smooth
6. Price premium for inland counties

Boundary effects

1. Flood zones yield higher prices in inland counties
    - Dallas, inland Houston
    - Assessed values?
2. Not newer, denser, bigger, taller, …
3. Effects on *unobservable* housing attributes?
4. Correlated amenities?
    - Better neighborhood quality inside?