The Impact of Distant Hurricane on Local Housing Markets

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1. Introduction

- Growing concerns about climate change and its impact on the economy
  - Sea level rising & more frequent extreme weather events (hurricanes, heatwaves, wildfires, etc.)
  - A potential treat to coastal urban areas is the occurrence of large-scale hurricanes
- Many prior studies focus on the impact of a major hurricane on the housing market in hurricane affected areas (e.g., Ortega and Taşpınar, 2018; Yi and Choi 2020)
- We investigate a different unanswered question: does the occurrence of a large-scale *distant* hurricane affect the local housing market in *unaffected* areas.

1. Introduction

- Research question: is the capitalization of flood risk into the local housing values affected by the occurrence of a large-scale *distant* hurricane?
- Why choose this perspective?
  - The price discount, if any, would not be attributed to any physical damage or reduced amenities brought by the hurricane
  - Instead, the price discount may be attributed to
    - an update of homeowners' perception of flood risk in the local housing market
    - an increase in local homeowners' concerns over the financial stability of the National Flood Insurance Program (NFIP)

1. Introduction

- Study areas: Miami-Dade County, FL
  - A coastal county vulnerable to hurricanes
  - No disastrous hurricanes directly and severely struck it from 2006 to 2014
- Subject event: Hurricane Sandy (from Oct. 22nd, 2012 to Nov. 2nd, 2012)
  - It brought disastrous consequences to the Atlantic Seaboard, but not to Miami-Dade
  - It was the second-costliest hurricane on record in the U.S. then with extensive media coverage
  - When it occurred, it had been at least 7 years since Miami-Dade was hit directly by a series of hurricanes in years 2004 and 2005

1. Introduction

- We investigate
  1. whether the capitalization of flood risk into housing value varies over time
     - A hedonic price model
  2. whether the occurrence of a disastrous but distant hurricane would alter the relationship between a property's flood risk exposure and its value
     - A Diff-in-Diff analysis (houses in high flood risk zones vs. houses in moderate-to-low flood risk zones)
- We provide and examine several possible explanations for our empirical findings.

1. Introduction

- We found
  1. A clear pattern of time-varying relationship between flood risk exposure and property values
  2. The occurrence of Hurricane Sandy significantly altered the relationship between a property's flood risk exposure and its value, but only for a short period of time (a quarter).

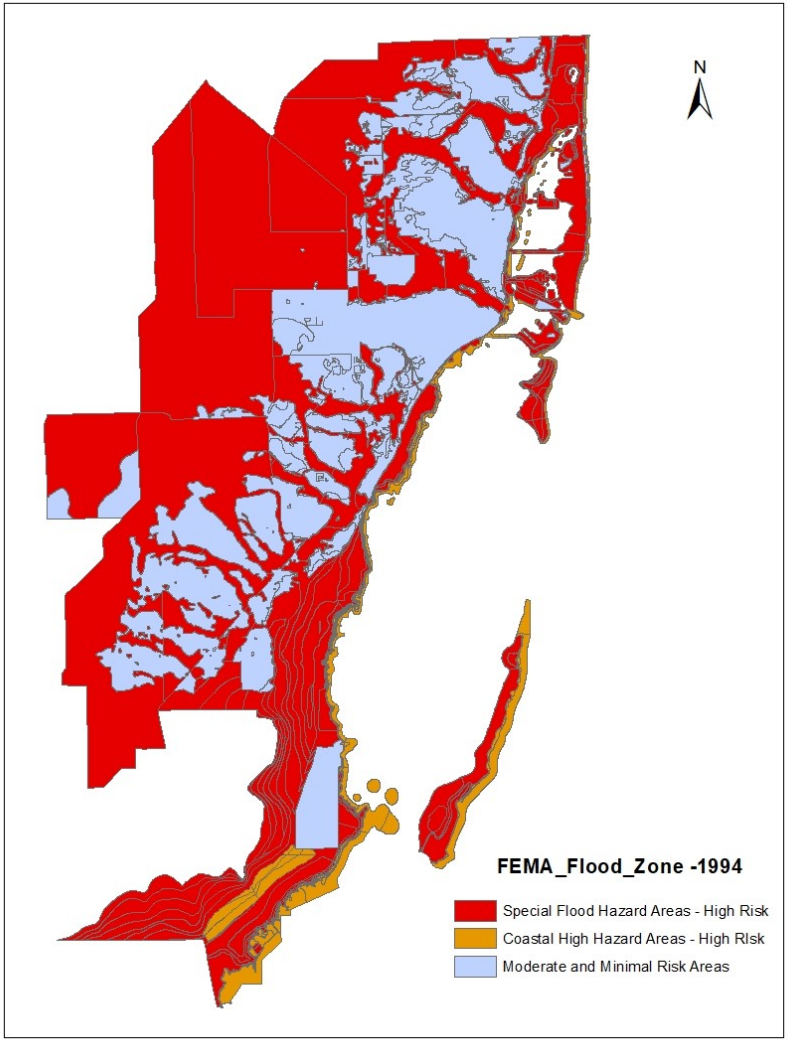
2. Data

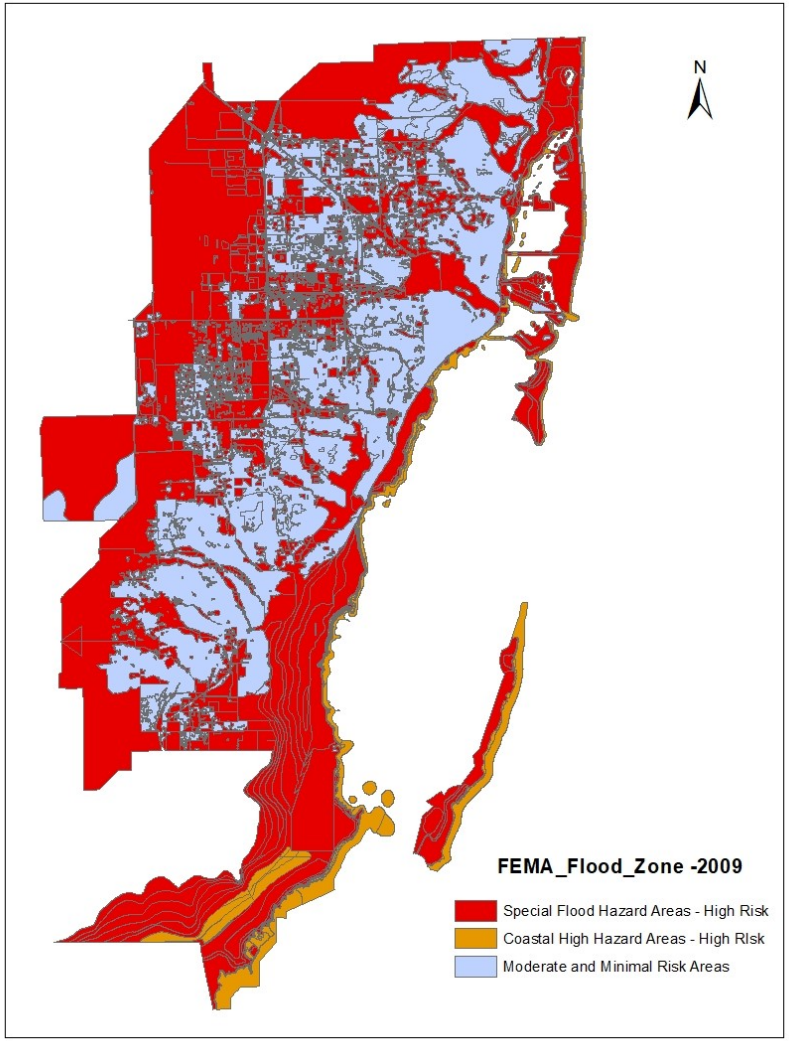
- Housing data - RealtyTrac
  - Transaction data: sales of single-family dwellings in Miami-Dade from January 2005 to December 2014
  - Annual assessment data: information on property characteristics and location
- Flood risk data - FEMA Flood Insurance Rate Map (FIRM)
  - High flood risk zones vs. moderate-to-low flood risk zones
  - Two versions of the FIRM for Miami-Dade during our study period: the old (1994) version & the updated (2009) version
- Sea level rising (SLR) risk data - SLR raster data map by the National Oceanic and Atmospheric Administration (NOAA)

2. Data

- Amenities measures
  - Water front amenities (distance from the coastline, lake amenities, etc.) - GIS shapefiles of shoreline and all lakes by the county
  - Property elevation - a national map of 1-meter Digital Elevation Model (DEMs) by the United States Geological Survey (USGS)
- Other data - 2010 census survey data (e.g., demographic characteristics)

Flood Risk Zones (1994 version vs. 2009 version)





3. Empirical Analysis

Q1: Does the impact of flood risk exposure on property sale price vary over time?

$$LnP_{itz} = \boldsymbol{\alpha}_t + \boldsymbol{\alpha}_{\boldsymbol{z}} + \sum_{t=2005}^{2014} \beta_t H\_FR_{it} \times SaleYear_t + \gamma' \boldsymbol{X}_{itz} + \varepsilon_{itz} \quad (1)$$

- LnP_{itz}: log of the sale price of property i
- $\boldsymbol{\alpha}_t$: sale year-quarter fixed effects (FE)
- $\boldsymbol{\alpha}_{\boldsymbol{z}}$: neighborhood (zip code) fixed effects (FE)
- H_FR_{it}: indicates whether property i is located at a high-flood risk zone upon sale at time t
- $SaleYear_t$: indicates whether a sale occurred in year t
- $\boldsymbol{X}_{itz}$: a vector of covariates

3. Empirical Analysis

Q2: Does Hurricane Sandy impact the local housing market at Miami-Dade?

- Post event: a sale occurring in Nov. 2012 or later
  - with post event year dummies

$$LnP_{itz} = \boldsymbol{\alpha}_t + \boldsymbol{\alpha}_z + \delta_0 H\_FR_{it} + \sum_{l=1}^{2} \lambda_l H\_FR_{it} \times Post\_Y_{lt} + \vartheta Post_t + \gamma' \boldsymbol{X}_{itz} + \varepsilon_{itz} \quad (2)$$

- $Post\_Y_{lt}$ (l=1, 2) indicates whether the housing sale at time t occurred within the first or second year of event occurrence

  - with post event quarter dummies

$$LnP_{itz} = \boldsymbol{\alpha}_t + \boldsymbol{\alpha}_z + \delta_0 H\_FR_{it} + \sum_{l=1}^{8} \lambda_l H\_FR_{it} \times Post\_Q_{lt} + \vartheta Post_t + \gamma' \boldsymbol{X}_{itz} + \varepsilon_{itz} \quad (3)$$

- $Post\_Q_{lt}$ (l=1-8) indicates whether housing sale at time t occurred within the l-th quarter of event occurrence.

4. Results

Q1: Does the impact of flood risk exposure on property sale price vary over time?

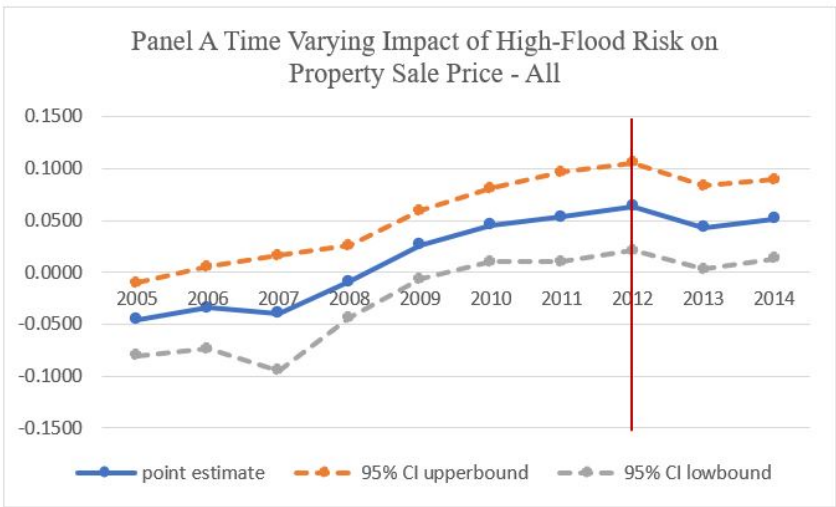
Table 2 Hedonic Model - The Time- Varying Impact of High-Flood Risk on Property Sale Price

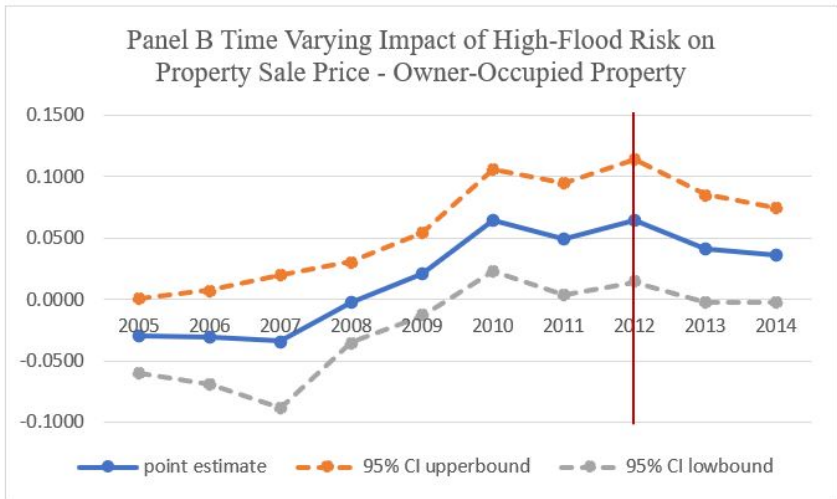
	(1) - All		(2) - All		(3)- Owner-occupied Property	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Flood Risk						
High flood risk (0,1)	0.0073	0.0090				
High flood risk × sale year interaction						
High flood risk × sale year 2005			-0.0450**	0.0180	-0.0296*	0.0155
High flood risk × sale year 2006			-0.0338*	0.0202	-0.0305	0.0195
High flood risk × sale year 2007			-0.0393	0.0282	-0.0338	0.0278
High flood risk × sale year 2008			-0.0095	0.0178	-0.0029	0.0169
High flood risk × sale year 2009			0.0264	0.0168	0.0212	0.0173
High flood risk × sale year 2010			0.0460**	0.0181	0.0650***	0.0213
High flood risk × sale year 2011			0.0537**	0.0220	0.0497**	0.0231
High flood risk × sale year 2012			0.0635***	0.0216	0.0643**	0.0255
High flood risk × sale year 2013			0.0431**	0.0206	0.0416*	0.0225
High flood risk × sale year 2014			0.0512***	0.0193	0.0364*	0.0196
Structural Characteristics	Y		Y		Y	
Location Characteristics	Y		Y		Y	
Demographic Characteristics	Y		Y		Y	
Sale year-quarter FE	Y		Y		Y	
Zip code FE	Y		Y		Y	
Clustered s.e.	Zip code		Zip code		Zip code	
# of Observations	54,849		54,849		40,607	
Adjusted R^2	0.8567		0.8573		0.8630	

4. Results

Q1: Does the impact of flood risk exposure on property sale price vary over time?

- Figure 5 Time-Varying Impact of High-Flood Risk Exposure on Property Sale Price





4. Results

Q2: Does Hurricane Sandy impact the local housing market at Miami-Dade?

Table 4 Hurricane Sandy Diff-in-Diff Analysis

	(1)		(2)		(3)		(4)	
Variable	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Intercept	6.7385***	0.4613	6.7290***	0.4610	6.7805***	0.4640	6.7707***	0.4642
High flood risk (0,1)	0.0365**	0.0152	0.0366**	0.0152	0.0393**	0.0168	0.0393**	0.0168
High flood risk × post event 1st year	-0.0255**	0.0119			-0.0250*	0.0137		
High flood risk × post event 2nd year	-0.0170	0.0152			-0.0233	0.0162		
High flood risk × post event 1st quarter			-0.0448***	0.0165			-0.0435**	0.0188
High flood risk × post event 2nd quarter			-0.0149	0.0152			-0.0219	0.0181
High flood risk × post event 3rd quarter			-0.0210	0.0133			-0.0236	0.0166
High flood risk × post event 4th quarter			-0.0245*	0.0141			-0.0157	0.0171
High flood risk × post event 5th quarter			-0.0224	0.0189			-0.0213	0.0208
High flood risk × post event 6th quarter			-0.0210	0.0184			-0.0329*	0.0194
High flood risk × post event 7th quarter			-0.0121	0.0150			-0.0180	0.0174
High flood risk × post event 8th quarter			-0.0132	0.0194			-0.0218	0.0199
Structural Characteristics	Y		Y		Y		Y	
Location Characteristics	Y		Y		Y		Y	
Demographic Characteristics	Y		Y		Y		Y	
Sale year-quarter FE	Y		Y		Y		Y	
Zip code FE	Y		Y		Y		Y	
Clustered s.e.	Zip code		Zip code		Zip code		Zip code	
Sample	All		All		Owner-occupied property		Owner-occupied property	
# of Observations	22,031		22,031		14,743		14,743	
Adjusted R^2	0.8786		0.8787		0.8875		0.8875	

5. Mechanism

- Possible explanations
  1. Flood insurance rate might be updated?
  2. Local storms
  3. Home buyers' concern over the NFIP
  4. Home buyers' perception of flood risk

5. Mechanism

1. Flood insurance rate might be updated?
   - The flood insurance rate is based on the Flood Insurance Rate Map (FIRM).
   - The most recent FIRM in Miami-Dade was released in Sept. 2009, and is still effective.
   - Insurance companies do not have a valid scientific reason to justify an increase in flood insurance rate upon the occurrence of a distant hurricane.
   - If the effect was due to an update of flood insurance rate, the effect would last for a much longer period of time.

5. Mechanism

2. Local storms
   - Miami-Dade might have been affected by some local storms during the regular hurricane seasons and/or Hurricane Isaac.
     - Hurricane Isaac passed over Cuba and the Keys in August 2012
     - The total precipitation in 2012 peaked in August
   - A placebo test
     - post event: a sale occurring in Sept. 2012 or later

5. Mechanism

2. Local storms

- placebo test results

Table 5 Placebo Test

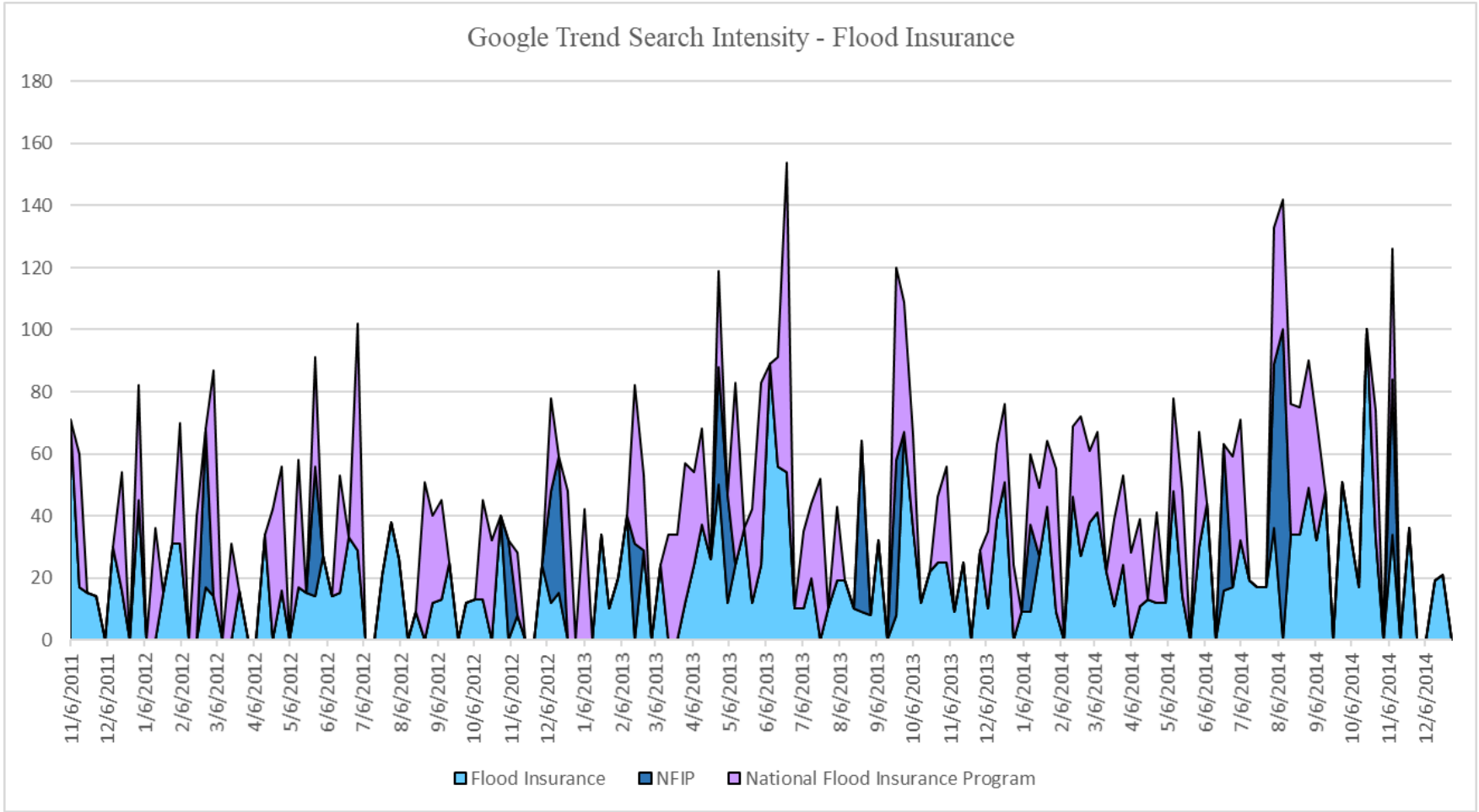
	(1)		(2)	
Variable	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Intercept	6.7239***	0.4618	6.7576***	0.4687
High flood risk (0,1)	0.0228	0.0151	0.0307*	0.0181
High flood risk × post event 1st quarter	-0.0086	0.0181	-0.0196	0.0210
High flood risk × post event 2nd quarter	-0.0066	0.0181	-0.0130	0.0203
High flood risk × post event 3rd quarter	-0.0066	0.0157	-0.0194	0.0181
High flood risk × post event 4th quarter	-0.0218	0.0156	-0.0146	0.0175
High flood risk × post event 5th quarter	-0.0031	0.0158	-0.0067	0.0191
High flood risk × post event 6th quarter	-0.0166	0.0187	-0.0310	0.0215
High flood risk × post event 7th quarter	-0.0057	0.0173	-0.0112	0.0203
High flood risk × post event 8th quarter	0.0028	0.0172	-0.0088	0.0206
Structural Characteristics	Y		Y	
Location Characteristics	Y		Y	
Demographic Characteristics	Y		Y	
Sale year-quarter FE	Y		Y	
Zip code FE	Y		Y	
Clustered s.e.	Zip code		Zip code	
N. clusters	71		71	
Sample	All		Owner-occupied property	
Adjusted R^2	0.8794		0.8875	
Observation number	21,290		14,250	

5. Mechanism

3. Home buyers' concern over the NFIP
   - A nationwide concern by homeowners over the financial stability of the NFIP upon the occurrence of Hurricane Sandy
   - Weekly google trend search intensity index of keywords associated with flood insurance/NFIP by residents living in the Miami Metropolitan Area from Nov., 2011 to Nov., 2014
     - Numbers represent search interest relative to the highest point during this time window.

5. Mechanism

3. Home buyers' concern over the NFIP



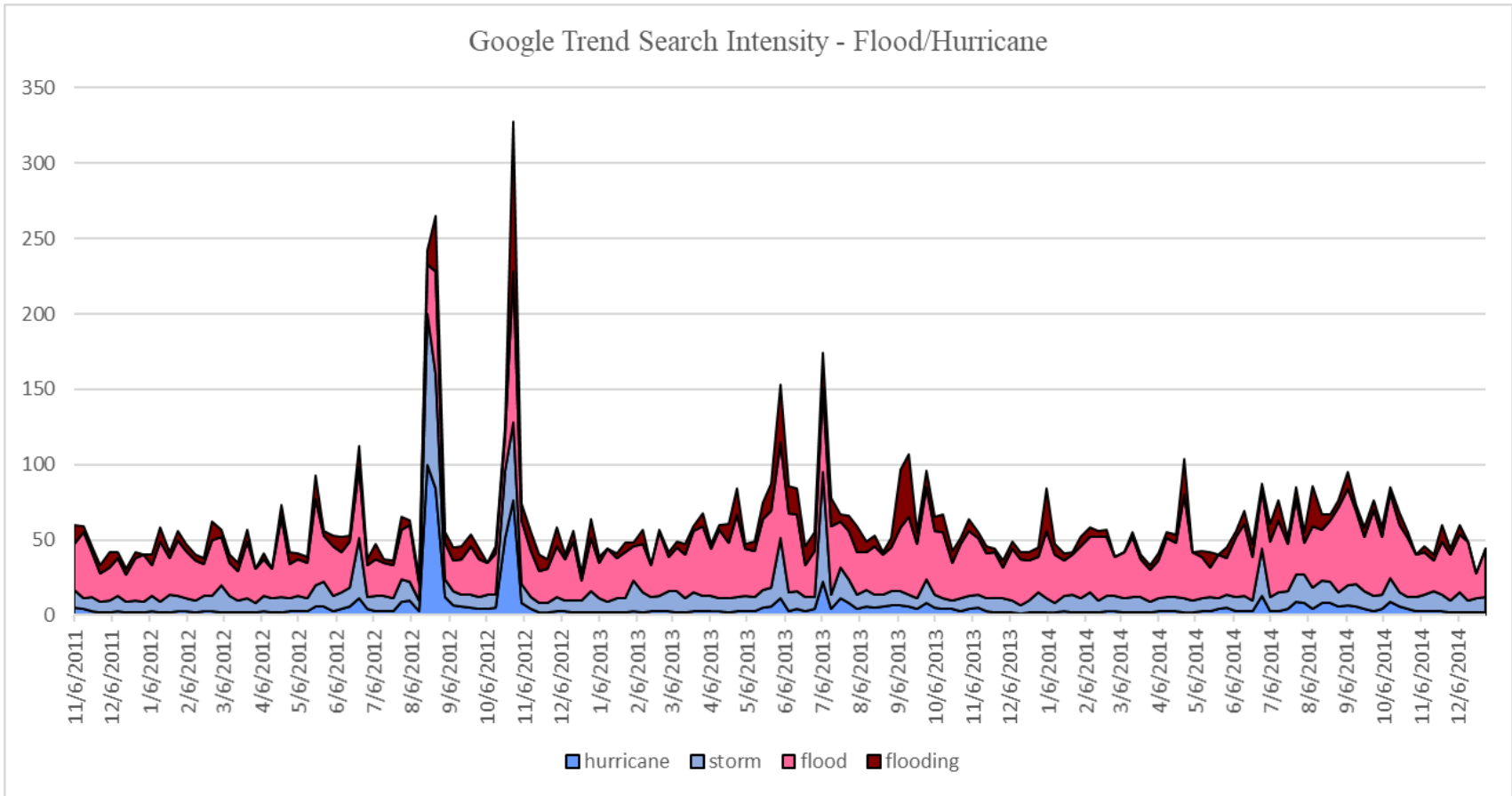
5. Mechanism

4. Home buyers' perception of flood risk
   - A destructive hurricane, although as a distant one, may alter homebuyers' awareness towards flood risk in Miami-Dade.
     - During a hurricane-peaceful period, local residents, especially those new immigrants to this region, might hold a subjective bias of the flood risk (Slovic, 2000; Kunda, 1990)
     - Both direct and indirect loss experience of extreme catastrophes would impact people's expectations concerning the likelihood of future events (Kamiya and Yanase, 2019; Gallagher, 2014)
       - Through media
       - Indirect experience –> the impact only lasts for a short period of time
     - Amnesia – people tend to quickly forget the lessons of a past disaster (Kousky et al., 2020; Gallagher, 2014; Atreya et al, 2015).

5. Mechanism

4. Home buyers' perception of flood risk

- Weekly google trend search intensity index of keywords associated with hurricanes and flooding by residents living in the Miami Metropolitan Area from Nov., 2011 to Nov., 2014



6. Subsample Analysis

Coastal subsample vs. inland subsample

- Coastal subsample (within 2.5 miles of the coastline)

Table 6 Hurricane Sandy Diff-in-Diff Analysis - Coastal Property Subsample

	(1)		(2)		(3)		(4)	
Variable	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Intercept	2.6750**	1.1227	2.6588**	1.1276	2.7159***	0.9768	2.7017***	0.9776
High flood risk (0,1)	0.0780**	0.0323	0.0772**	0.0323	0.0998***	0.0342	0.0991***	0.0344
High flood risk × post event 1st year	-0.0256	0.0193			-0.0406*	0.0223		
High flood risk × post event 2nd year	-0.0111	0.0282			-0.0455	0.0278		
High flood risk × post event 1st quarter			-0.0674**	0.0328			-0.0842**	0.0354
High flood risk × post event 2nd quarter			-0.0273	0.0247			-0.0621**	0.0292
High flood risk × post event 3rd quarter			-0.0105	0.0201			-0.0293	0.0287
High flood risk × post event 4th quarter			-0.0078	0.0238			-0.0047	0.0276
High flood risk × post event 5th quarter			0.0001	0.0397			-0.0247	0.0425
High flood risk × post event 6th quarter			-0.0261	0.0356			-0.0578	0.0359
High flood risk × post event 7th quarter			-0.0320	0.0252			-0.0580**	0.0272
High flood risk × post event 8th quarter			0.0198	0.0372			-0.0355	0.0360
Structural Characteristics	Y		Y		Y		Y	
Location Characteristics	Y		Y		Y		Y	
Demographic Characteristics	Y		Y		Y		Y	
Sale year-quarter FE	Y		Y		Y		Y	
Zip code FE	Y		Y		Y		Y	
Clustered s.e.	Zip code		Zip code		Zip code		Zip code	
N. clusters	31		31		31		31	
Sample	Costal Property		Costal Property		Costal owner-occupied. property		Costal owner-occupied property	
# of Observations	8,106		8,106		5,656		5,656	
Adjusted R^2	0.8693		0.8695		0.8676		0.8678	

6. Subsample Analysis

Coastal subsample vs. inland subsample

- Inland subsample (beyond 2.5 miles of the coastline)

Table 7 Hurricane Sandy Diff-in-Diff Analysis - Inland Property Subsample

	(1)		(2)		(3)		(4)	
Variable	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Intercept	7.6750***	0.3427	7.6737***	0.3433	7.6002***	0.3868	7.5985***	0.3887
High flood risk (0,1)	0.0182	0.0149	0.0183	0.0149	0.0022	0.0179	0.0021	0.0178
High flood risk × post event 1st year	-0.0264*	0.0149			-0.0138	0.0169		
High flood risk × post event 2nd year	-0.0196	0.0153			-0.0071	0.0169		
High flood risk × post event 1st quarter			-0.0310*	0.0175			-0.0149	0.0191
High flood risk × post event 2nd quarter			-0.0156	0.0183			0.0030	0.0222
High flood risk × post event 3rd quarter			-0.0267	0.0169			-0.0178	0.0190
High flood risk × post event 4th quarter			-0.0320*	0.0181			-0.0204	0.0217
High flood risk × post event 5th quarter			-0.0333*	0.0178			-0.0144	0.0208
High flood risk × post event 6th quarter			-0.0228	0.0172			-0.0215	0.0194
High flood risk × post event 7th quarter			0.0013	0.0170			0.0114	0.0190
High flood risk × post event 8th quarter			-0.0251	0.0202			-0.0078	0.0225
Structural Characteristics	Y		Y		Y		Y	
Location Characteristics	Y		Y		Y		Y	
Demographic Characteristics	Y		Y		Y		Y	
Sale year-quarter FE	Y		Y		Y		Y	
Zip code FE	Y		Y		Y		Y	
Clustered s.e.	Zip code		Zip code		Zip code		Zip code	
N. clusters	51		51		51		51	
Sample	Inland property		Inland property		Inland owner-occupied property		Inland owner-occupied property	
# of Observations	13,818		13,818		9,029		9,029	
Adjusted R^2	0.8414		0.8415		0.8509		0.851	

7. Robustness Check

- The empirical results are consistent
  - with different controls of distance from the coastline (e.g., add an additional control of within 0.1 mile of the coastline)
  - after excluding properties in the islands

8. Conclusion

- We investigate whether the local housing market was affected by the occurrence of a destructive but distant hurricane
- We find
  - the capitalization of flood risk into house prices varies over time in Miami-Dade from 2005 to 2014
  - the occurrence of Hurricane Sandy did significantly change the relationship between a property's flood risk exposure and its value, but this shift only lasted for a short period of time
- Several possible explanations are provided
  - home buyers seem to update their perception of flood risk, although this update is a temporal one.
- The question of how a distant extreme event affects risk beliefs of local residents remains open. We hope the current study stimulates more studies in the near future.