Damage vs. Risk Perception: How Do House Prices Recover After Hurricanes?

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Motivation

- Floods increase in frequency and magnitude and are the most costly among natural disasters in the US (NOAA)
  - Cost of damages: \$170 billion for Katrina, \$74 billion for Sandy, \$131 billion for Harvey
  - Damage to residential, commercial properties, infrastructures, disruption in businesses, etc.,

- Floods cause house prices decline. ◂ More
  - Change in risk perception
  - Direct damage

- Persistence puzzle:
  - Negative persistent effects on property values: Gibson & Mullins (JEEM 2020), Ortega & Taspinar (JUE 2018)
  - Temporary effects: Zhang (RSUE 2016), Atreya et al. (2013), Bin & Landry (JEEM 2013)

Research Question

- Research questions:
  - What is the housing market reaction following a major hurricane event?
  - Is this reaction persistent?
  - Which factors might explain this persistence/ impersistence?

Hypotheses

- **Price effect is transitory:**
  - If hurricane does not change risk perception, the impacts of hurricane will reflect the costs of damage and rebuild

- **Price effect is permanent:**
  - If hurricane changes risk perception, the impacts of hurricane on house price will be permanent

This Paper

- Utilize Hurricane Sandy as a quasi-experiment to study house price dynamics:
  - Study the 16 affected counties in New Jersey over 20 years
    Sandy and NJ
  - Examine damaged and non-damaged properties in floodplain
  - Similarly, damaged and non-damaged properties out of floodplain

- Resolve the persistence puzzle:
  - Combine ZTRAX, damage assessment, and building permit data
  - Determine the extent of remodeling and rebuilding
  - Show that price rebound is explained by housing renovation and rebuilding

- Test for change in risk perception:
  - Compare flood insurance take-up rate affected and non-affected areas within floodplain

Preview of Findings

- No persistent penalty on damaged floodplain properties
- The drop in housing price is largely driven by direct damage:
  - Severely-damaged properties face an immediately sharp decline (31%) in price, and take longer to recover
  - Less-severely-damaged properties face a smaller decline (12%) and recover faster
- Extent of spending on renovating and rebuilding is associated with extent of damage
  - The most significant spending on rebuilding and renovating on properties with major damage

Literature Review

- Temporary effects of floods, hurricanes on property values:
  - Hallstrom & Smith (2005); Atreya et al. (2013); Bin & Landry (2013); Zhang (2016)
    - Explain the recovery in house prices due to people forgetting about floods (Do not study empirically)

- Negative persistent effects of floods, hurricanes on property values:
  - Ortega & Taspinar (2018), Gibson & Mullins (2020)
    - Describe the negative effects due to individuals permanently changing their risk perceptions
    - This effect might be driven by the flood insurance reforms

Flood insurance reforms

Contributions: Explain prices drop follow by prices recovery empirically

- Isolate the price effects due to direct damages
- Link damage properties to building permits
- Use flood insurance take-up rates to show risk perception does not change

Data

4 main sources of data:

- Floodplain maps
  - Historical floodplain map: FEMA Q3 Flood data, NFHL Inventory Table
  - Current floodplain map: Nation Flood Hazard Layer (NFHL)
  - Final data include 83% of all communities in 16 counties

- Historical Damage Assessment data from FEMA
  - Damaged properties and to what extend: affected, minor, major, destroyed
  - Assessment is conducted using high-resolution post-event imagery

- Housing prices data are from Zillow Transaction and Assessment Dataset (ZTRAX) more details

- Building permits from NJ DCA (2010-2019) more details

Supplemental Data

- New Jersey statewide parcel map
- 2010 TigerLine shapefile (block group and tract boundaries)
- New Jersey Coastline
  - From DEP, version 20090116
- Flood insurance data from Open FEMA

Empirical Strategies

- To study the effect of Sandy on housing market in floodplains, I apply DiD estimation:

$$\begin{aligned}\log(P_{ibt}) = \alpha + \beta Damage_i \times PostS_t + \gamma Damage_i \\ + \theta \mathbf{X}_{it} + \lambda_{1t} WaterFront_i + \lambda_{2t} WalkingDist_i \\ + \lambda_{3t} BikingDist_i + \lambda_{4t} DrivingDist_i + \alpha_b + \epsilon_{ibt}\end{aligned} \quad (1)$$

  - $\log(P_{ibt})$: log price house i in block group b, sold in year t
  - $Damage = 1$ if house i damaged
  - $PostS = 1$ if sold after Sandy
  - X_{it}: controls for housing characteristics
  - λ_t: year fixed effects vary by distance to the coastline
  - α_b: block group fixed effects
  - ϵ_{ibt}: error terms

Empirical Strategies

- To assess the validity of the parallel trend assumption, I estimate the event study coefficients β_t:

$$\begin{aligned} \log(P_{ibt}) = & \sum_{y=2000}^{2019} \beta_t 1[t = y] \times \text{Damage}_i + \theta \mathbf{X}_{it} \qquad (2) \\ & + \lambda_{1t} \text{WaterFront}_i + \lambda_{2t} \text{WalkingDist}_i \\ & + \lambda_{3t} \text{BikingDist}_i + \lambda_{4t} \text{DrivingDist}_i + \alpha_b + \epsilon_{ibt} \end{aligned}$$

- Key identification assumption: in the absence of Sandy, damaged and non-damaged properties would have had same trend in prices

Summary Statistics

Table: Summary Statistics: Zillow Sale Transaction Dataset

	Floodplain		Non-Floodplain	
	Damaged	Non-Damaged	Damaged	Non-Damaged
house price (thousands)	517.58 (362.35)	358.24 (312.11)	414.56 (339.24)	292.57 (206.29)
log(houseprice)	6.00 (0.76)	5.54 (0.88)	5.73 (0.81)	5.45 (0.73)
house age	33.47 (31.69)	42.67 (31.92)	52.66 (35.31)	45.41 (31.78)
distance to beach (yards)	283.13 (273.76)	3,602.97 (6,699.33)	752.98 (1,419.16)	7,635.55 (7,212.39)
lot size (acres)	0.44 (3.91)	0.39 (1.69)	0.36 (3.20)	0.37 (1.39)
bedrooms	3.67 (1.16)	3.24 (0.99)	3.26 (1.24)	3.17 (1.41)
bathrooms	2.39 (1.13)	2.47 (1.08)	2.61 (1.27)	2.51 (1.02)
Observations	33,360	72,524	2,454	1,026,423

Estimation Results

Table: Effect of Hurricane Sandy on House Prices in Floodplain

	(1) log(houseprice)	(2) log(houseprice)	(3) log(houseprice)	(4) log(houseprice)
damage x postS	0.087***	0.087***	0.087***	0.092***
	(0.019)	(0.018)	(0.018)	(0.018)
damage	-0.005	-0.007	0.004	-0.001
	(0.021)	(0.021)	(0.021)	(0.023)
house age		-0.004***	-0.004***	-0.004***
		(0.000)	(0.000)	(0.000)
lotsize			0.006*	0.002
			(0.003)	(0.003)
cons	5.520***	5.622***	5.629***	5.531***
	(0.033)	(0.033)	(0.035)	(0.039)
Observations	105,639	104,455	95,766	95,766
FE	Block group	Block group	Block group	Tract
Year FE	Yes	Yes	Yes	Yes
R-squared	0.624	0.638	0.645	0.595

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

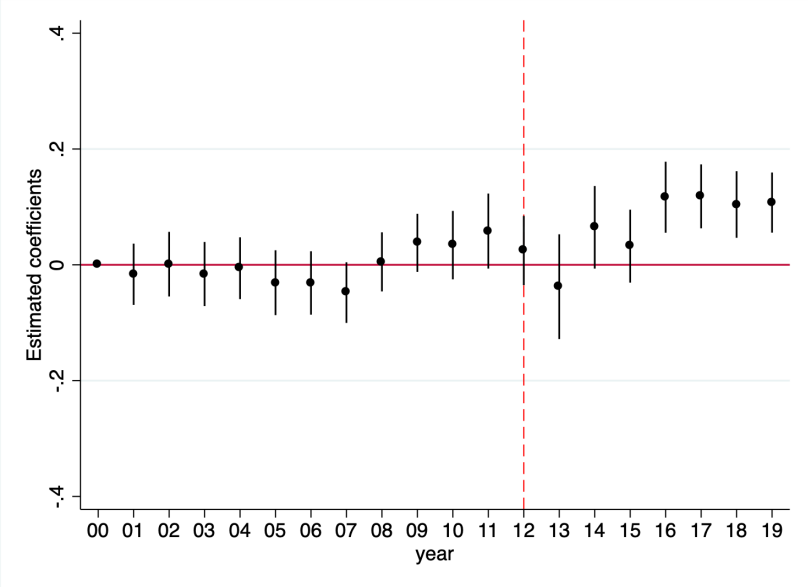
Estimation Results

Table: Effect of Hurricane Sandy on House Prices out of Floodplain

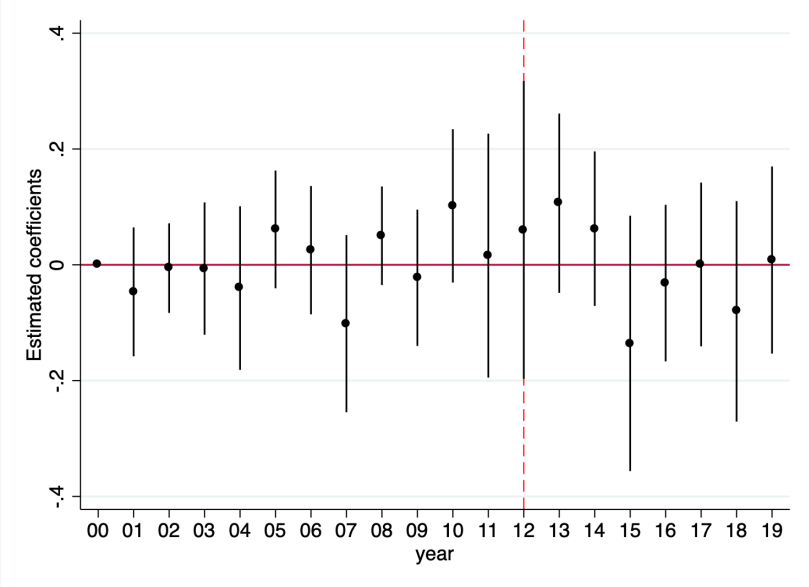
	(1) log(houseprice)	(2) log(houseprice)	(3) log(houseprice)	(4) log(houseprice)
damage x postS	0.014	0.023	0.021	0.017
	(0.031)	(0.032)	(0.034)	(0.034)
damage	0.088	0.069	0.066	0.108*
	(0.052)	(0.049)	(0.051)	(0.043)
house age		-0.005***	-0.005***	-0.005***
		(0.000)	(0.000)	(0.000)
lotsize			0.010***	0.010***
			(0.001)	(0.002)
cons	5.184***	5.343***	5.385***	5.362***
	(0.094)	(0.085)	(0.092)	(0.105)
Observations	1,028,674	992,099	939,932	939,932
FE	Block group	Block group	Block group	Tract
Year FE	Yes	Yes	Yes	Yes
R-squared	0.606	0.631	0.634	0.574

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Event Study Estimation



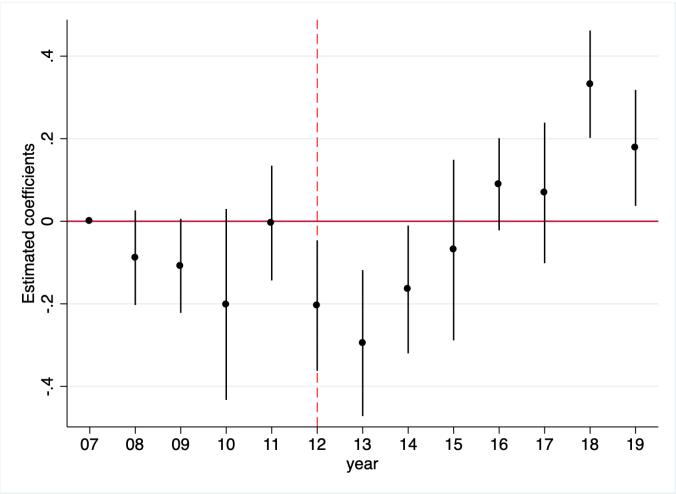
(a) Floodplain



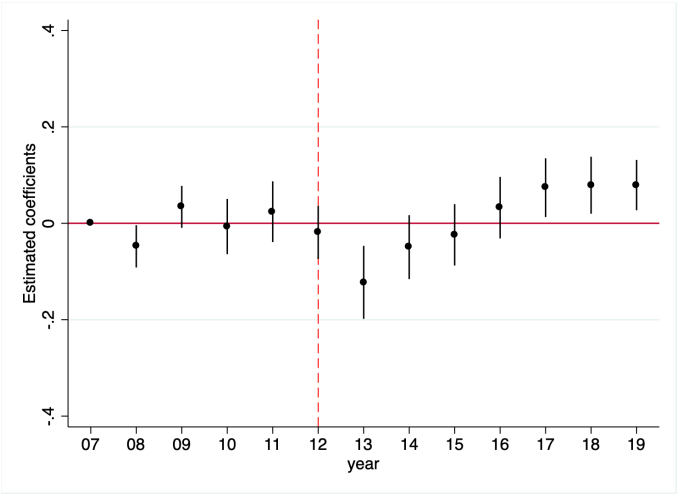
(b) Non-Floodplain

Figure: Event study, effects of Hurricane Sandy on prices of damaged properties in floodplain, out of floodplain More

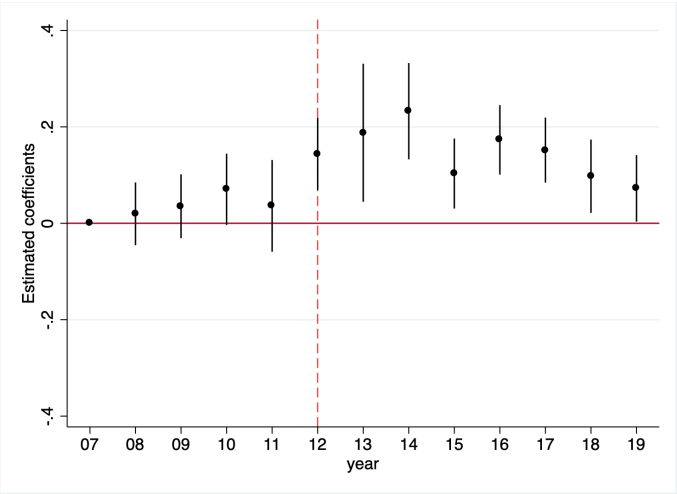
Heterogeneous Effects of Hurricane Sandy in Floodplain



(a) Major vs. Non-Damaged

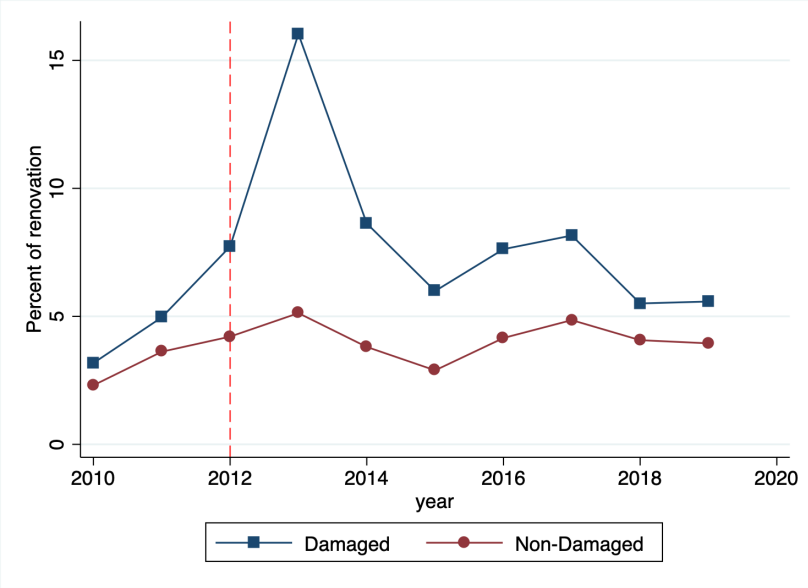


(b) Minor vs. Non-Damaged

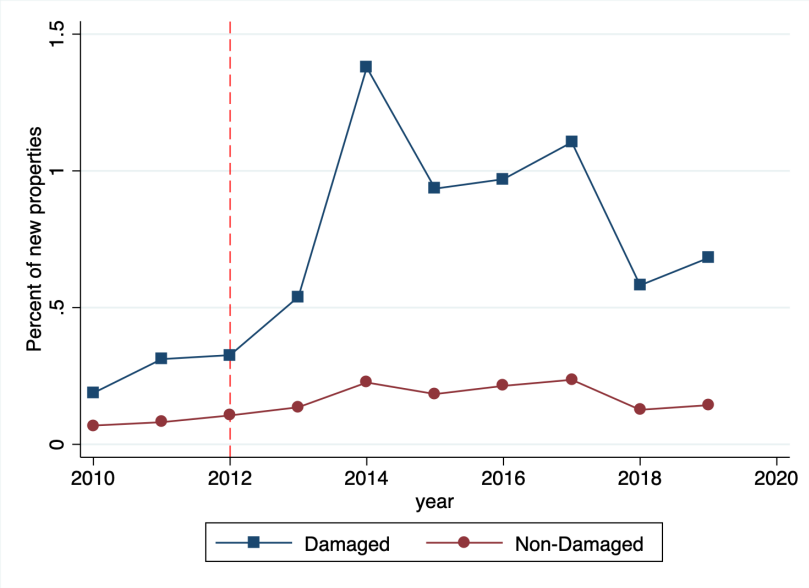


(c) Very Minor vs. Non-Damaged

Percent Renovated and Rebuilt



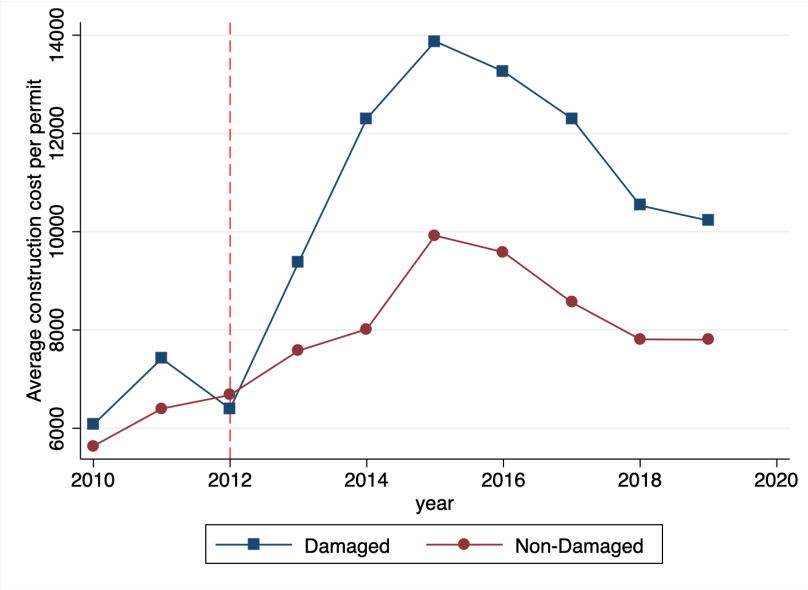
(a) Percent Renovated



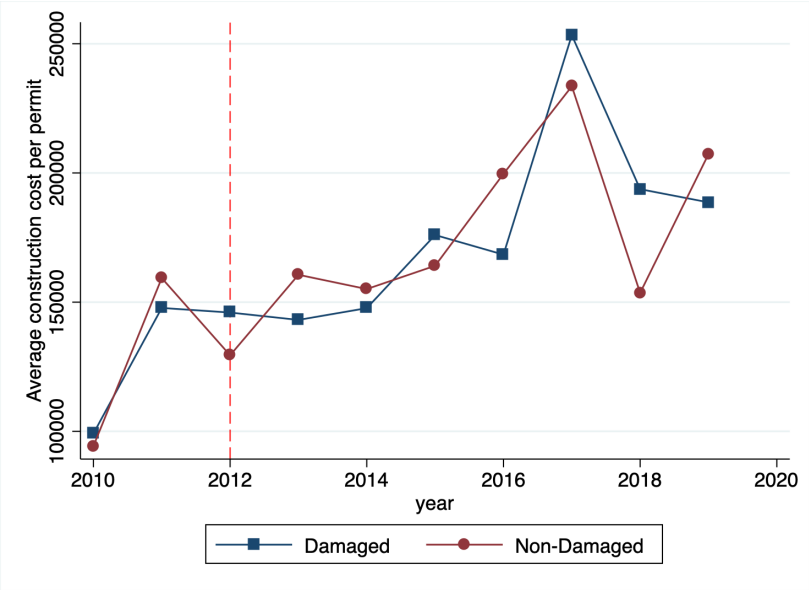
(b) Percent Rebuilt

Figure: Percent of Properties Renovated and Rebuilt in Floodplain

Renovation and Rebuilding Spending



(a) Average Spending on Renovation

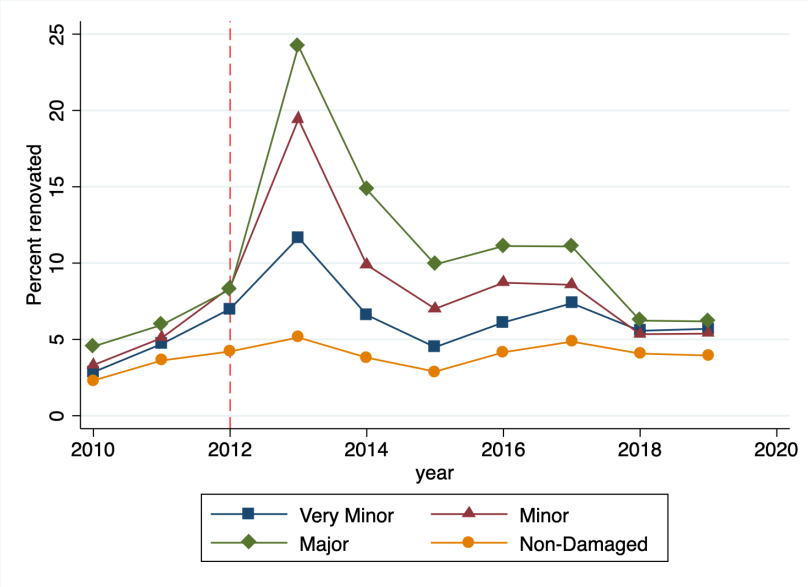


(b) Average Spending on Rebuilding

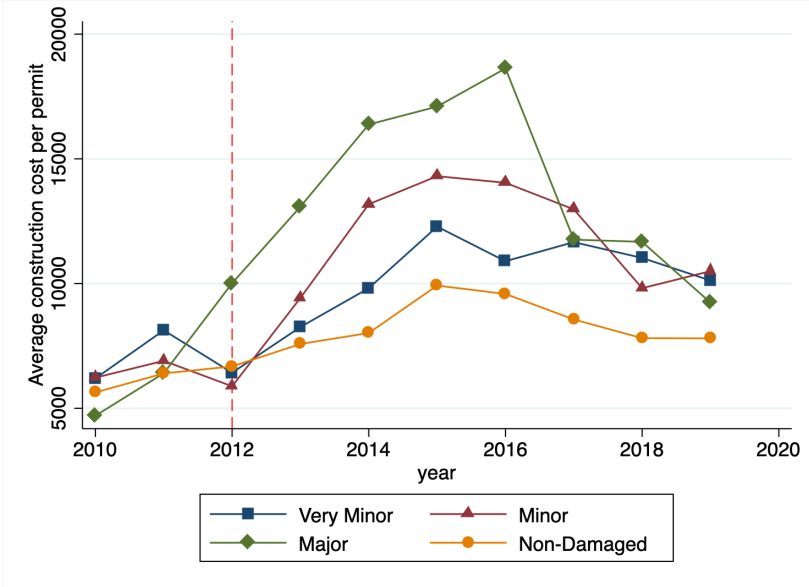
Figure: Average Spending Per Permit

Note: $\mathrm{AverageSpending}_{ijt} = \mathrm{TotalSpending}_{ijt}/\mathrm{TotalPermit}_{ijt}$.
Where $\mathrm{TotalSpending}_{ijt}$ is calculated by taking the sum of spending on all permits issued for damaged (non-damaged) properties in floodplain (non-floodplain) in year t. $\mathrm{TotalPermit}_{ijt}$ is calculated by taking the sum of all permits issued for damaged (non-damaged) properties in floodplain (non-floodplain) in year t.

Remodeling by Damage Levels



(a) Percent Renovated

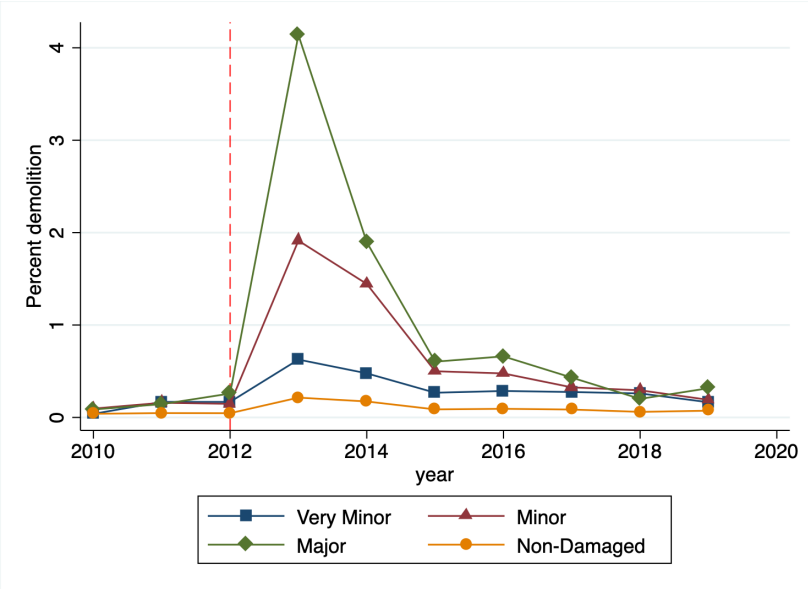


(b) Average Spending on Renovation

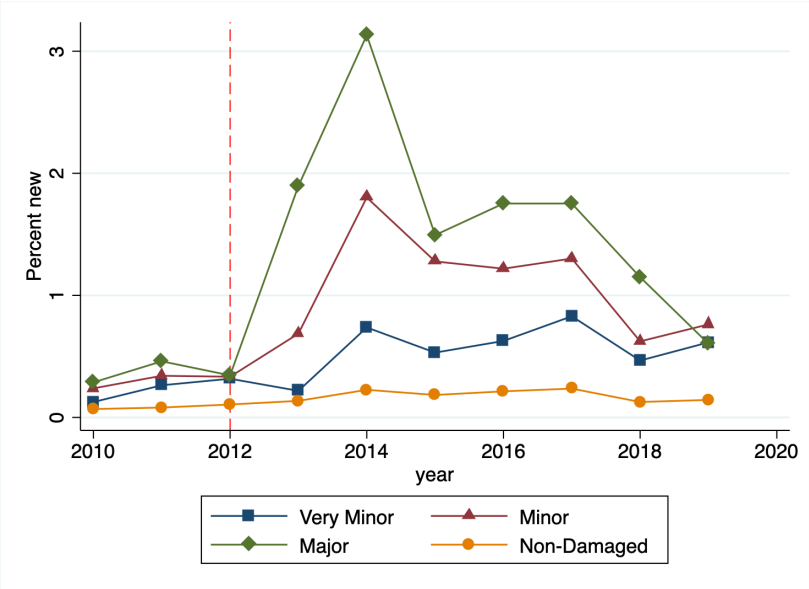
Figure: Average Renovation Spending Per Permit and Percent Renovated by Damage Levels in Floodplain

Note: The data in panel a and b are the percent renovated and average spending on renovation of properties reported damage extents as very minor, minor, major, and destroyed.

Demolishing and Rebuilding by Damage Levels



(a) Percent Demolished



(b) Percent Rebuilt

Figure: Percent of Properties Demolished and Rebuilt by Damage Levels

Note: The data in panel a and b are the percent demolished and percent rebuilt of properties reported damage extents as very minor, minor, major, and destroyed.

Remodeling and Rebuilding

Estimation of the construction spending on damaged properties relative to non-damaged properties:

$$\begin{aligned} Spending_{izt} = \alpha + \beta Damage_i \times PostS_t + \gamma Damage_i \\ + \theta Age_{it} + \alpha_z + \alpha_t + \epsilon_{izt} \end{aligned} \quad (3)$$

and

$$\begin{aligned} Spending_{izt} = &\kappa_1 VeryMinor_i + \kappa_2 Minor_i + \kappa_3 Major_i \\ &+ \eta_1 VeryMinor_i \times PostS_t + \eta_2 Minor_i \times PostS_t \\ &+ \eta_3 Major_i \times PostS_t + \theta Age_{it} + \alpha + \alpha_z + \alpha_t + \epsilon_{izt} \end{aligned} \quad (4)$$

where:

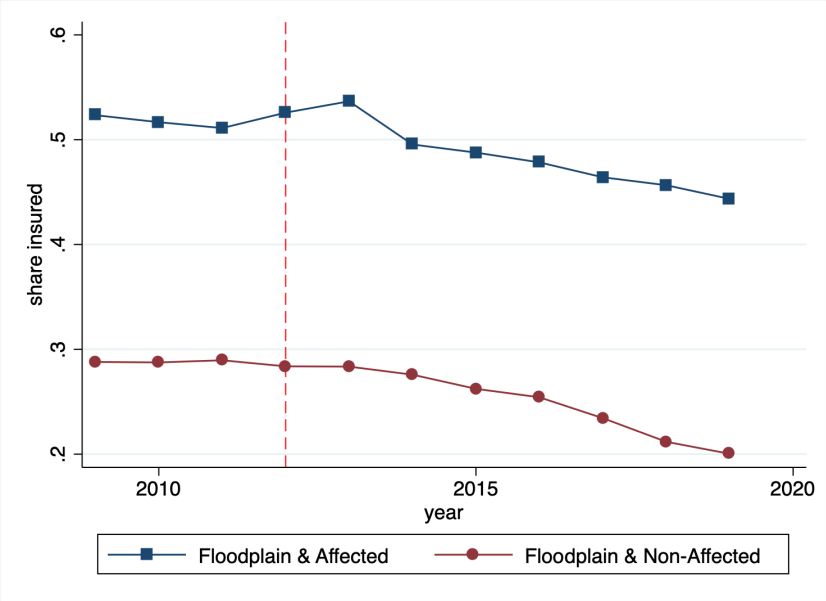
- $Spending_{izt}$: spending on renovation or rebuilding of house i in zip code z at year t
- α_z, α_t: zip code and year fixed effects

Estimation Results: Construction Spending

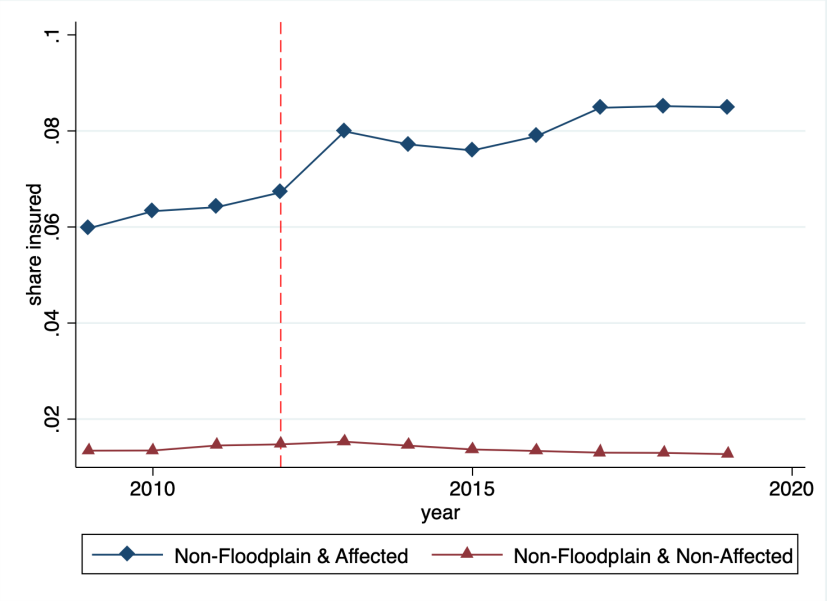
Table: Construction Spending on Damaged Properties

	Floodplain		Non-Floodplain
	spending	spending	spending
damage x postS	10381***		-2499
	(1275)		(3639)
damage	-2014*		5795
	(922)		(3618)
house age	15**	15**	-1
	(5)	(5)	(1)
very_minor		-1863	
		(1363)	
minor		-2718*	
		(1099)	
major		1035	
		(2660)	
very_minor x postS		6226**	
		(1937)	
minor x postS		11440***	
		(1404)	
major x postS		22192***	
		(4726)	
cons	9642***	9659***	8576***
	(885)	(878)	(336)
N	112,491	112,491	871,858
FE	zip code	zip code	zip code
Year FE	Yes	Yes	Yes
R-squared	0.060	0.061	0.036

Flood Insurance Take-Up Rates



(a) Floodplain



(b) Non-Floodplain

Figure: Share of Properties has Flood Insurance Aggregated by Census Tract

The Price Dynamics by Damage Levels

Table: Price Dynamics by Damage Levels

	(1) Average Price Before Sandy (000s)	(2) Immediately ΔPrice after Sandy	(3) Construction Spending (000s)	(4) Average ΔPrice 7 years after Sandy
Non_damaged	$350.11 (303.99)			
Very Minor	$561.41 (391.15)	20%	$6.23	4.2%
Minor	$434.24 (288.4)	-12%	$11.44	13%
Major	$419.20 (323.09)	-31%	$22.19	27.7%

Conclusions

- There is no persistent penalty for damaged properties in floodplains
  - Hurricanes do not permanently heighten individuals risk perception
- The immediate decline in housing prices is most likely due to direct damages
- Remodeling and rebuilding explain the recovery in house prices

Event Study Estimation

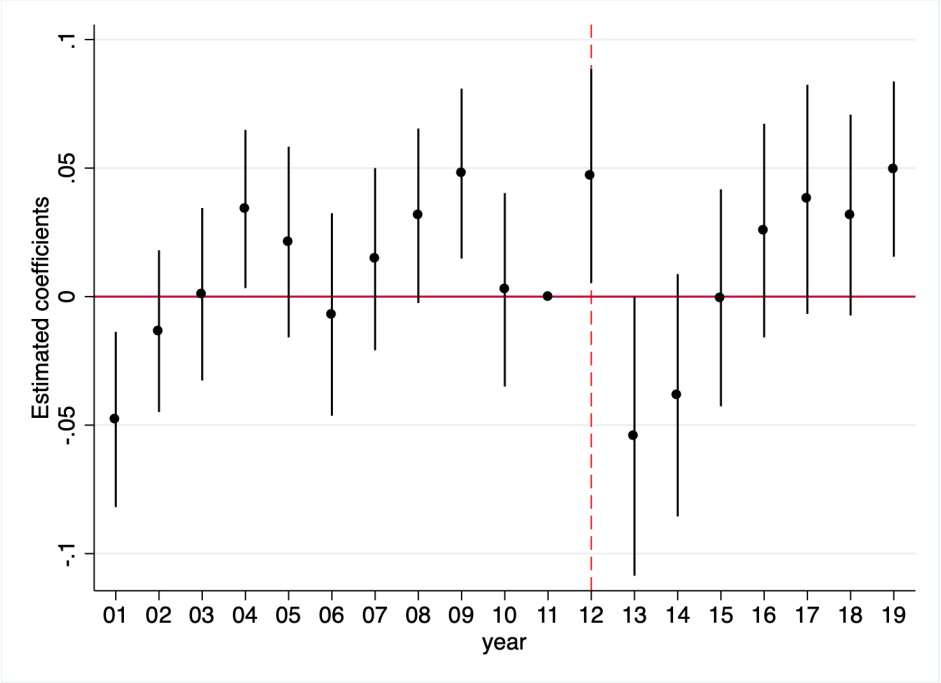


Figure: Event Study, Effects of being Located in Floodplain

Note: Treatment group includes all properties in floodplains.Comparison group includes all properties out of floodplains

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Average House Price by Floodplain Status

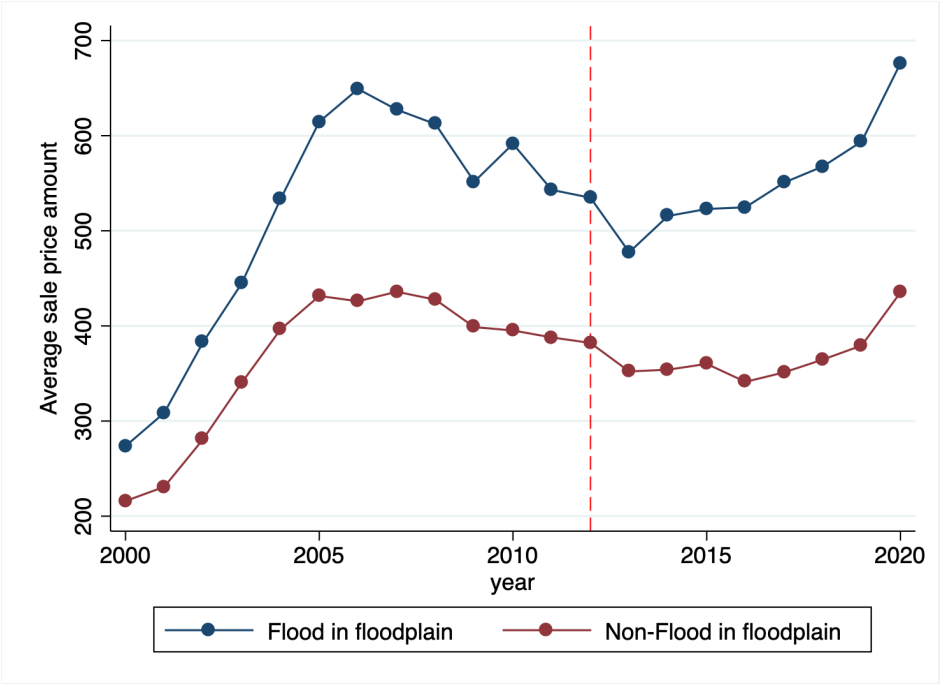
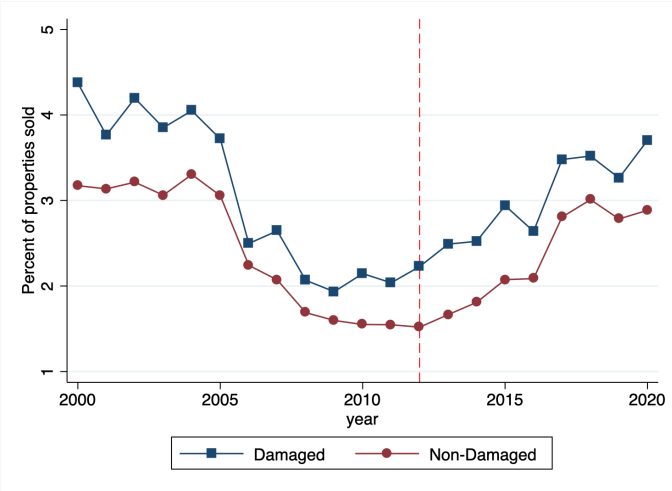
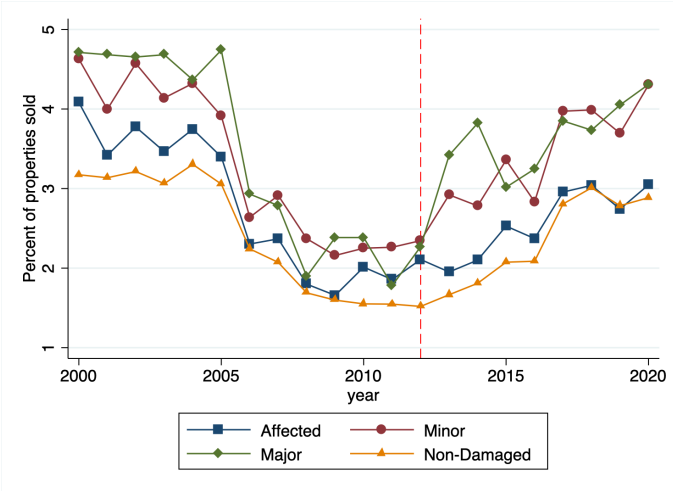


Figure: Average House Price by Floodplain Status

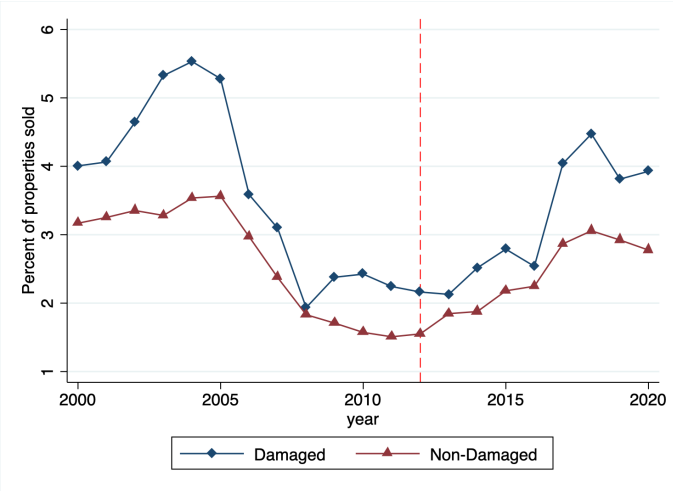
Percent of Properties Sold



(a) Floodplain



(b) Floodplain



(c) Non-Floodplain

Hurricane Sandy and New Jersey Map

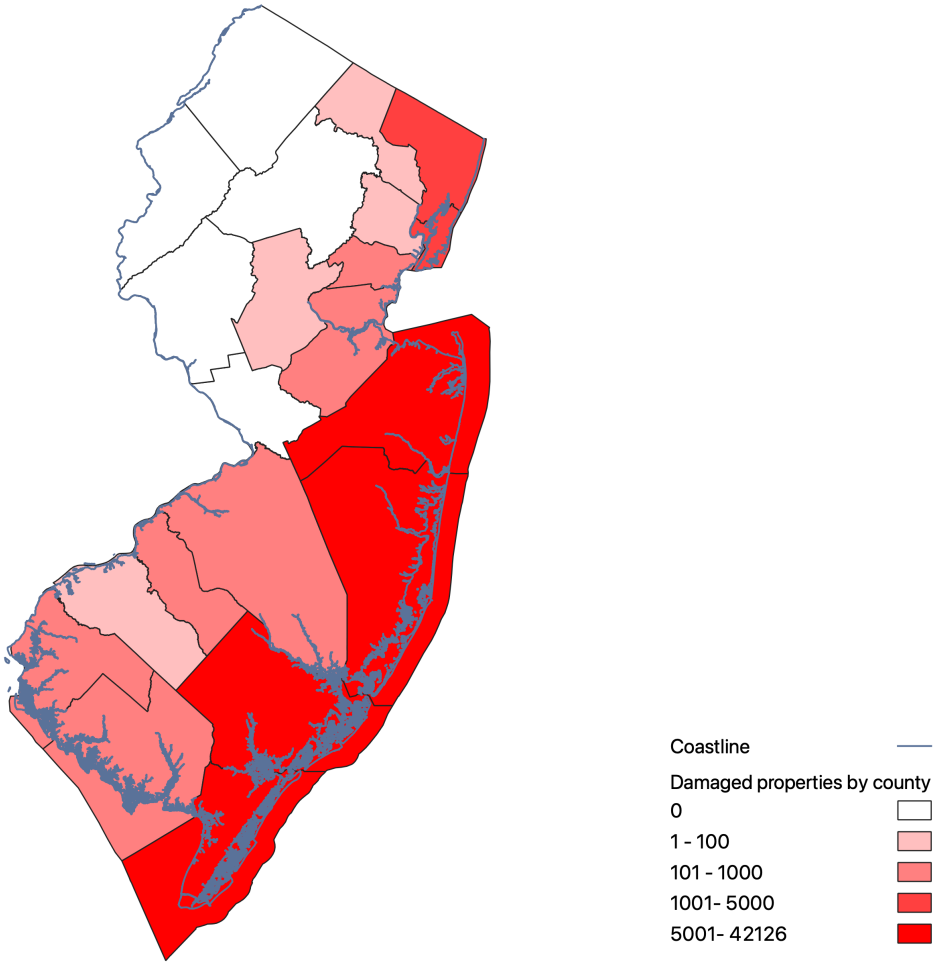


Figure: New Jersey and Extent of Sandy Damage by County

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Biggert-Waters 2012 Act, HFIAA 2014

- Biggert-Waters 2012 Act:
  - Phases out subsidies for new owners of "grandfathered" houses, properties experienced severe repetitive loss
  - From 2013, premium of those properties increases by 25% annually till it reaches the full risk rate
  - Established the minimum deductible for flood claims
- Homeowner Flood Insurance Affordability Act:
  - Extend the rate increase to all subsidized "grandfathered" properties
  - Premium increase between 5%-18% annually
- According to the National Association of Realtors:
  - Every $500 increase in premium translates to $10,000 reduction in property's value

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ZTRAX Database

- Zillow's Transaction and Assessment Database:
  - Includes sale transactions from 2000-2019
  - Tax account identifiers, geo-coordinates, tax year, tax amount
  - Property characteristics: year built, bedrooms, bathrooms, fireplace, kitchen, etc.,
  - **Limitation:** property characteristics only capture one time at the newest tax year (2019)
- Eliminate if transaction is family transfer, or foreclosure
- Only keep transactions for single family residential
- Trim 1% top and bottom price to remove outliers
- Trim 1% bottom year built to remove unreasonably low year built (i.e 1288)

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Building Permits Data

- Monthly report to DCA by municipalities
- Individual permit record:
  - Property tax block and tax lot number
  - Status (permit/certificate), date issue
  - Permit types: New, Addition, Alteration, Demolition
  - Fee relates to permits
  - Construction cost: value of construction involved in the permit reported by the applicant
- Restrict sample to 1 & 2 family houses only
- Merge each permit to each parcel with its flood damage and floodplain status

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Hurricane and Its Impacts

A lot in Deal, New Jersey, that was covered in debris after Superstorm Sandy is empty in 2017.

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