SRE Economics Lecture 6

Climate and Real Estate (2)

Quantifying Climate Risks' Impacts on Real Estate Values

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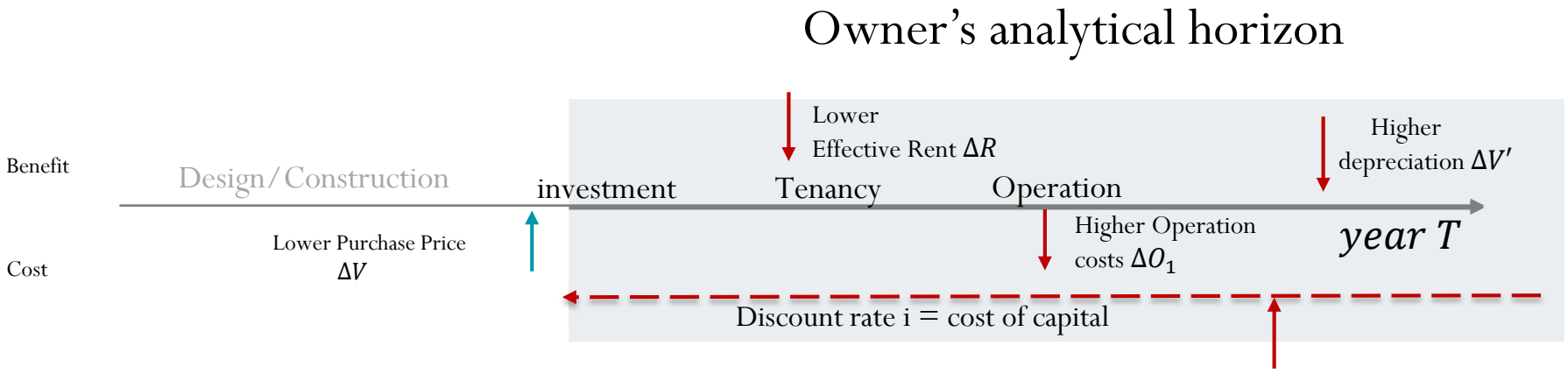
(MIT Center for Real Estate)

Outline

- Discounting climate risks: the role of belief
- Climate risks in housing markets: Hedonic and DID
- Climate risks in commercial real estate markets

DISCOUNTING CLIMATE RISKS: THE ROLE OF BELIEF

Life-Cycle Cost Analysis (LCCA)

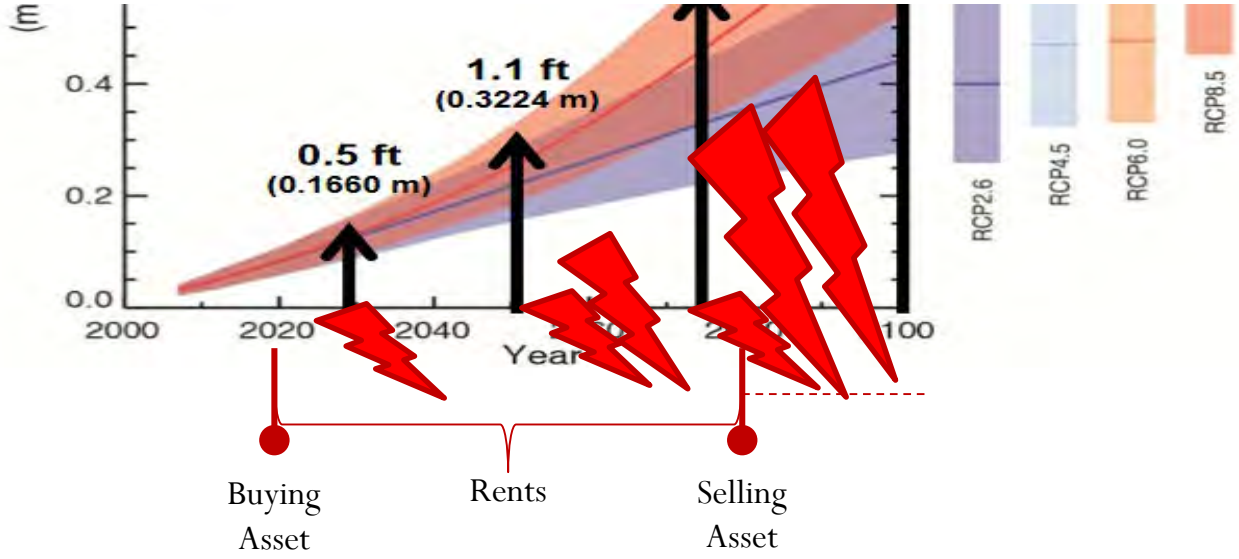


$$\sum_{t=0}^{T} \frac{\Delta R + \Delta O_1}{(1+i)^t} + \frac{\Delta V'}{(1+i)^T} > \Delta V ?$$

All about the future!

Climate Risk is a Future Risk

Climate risk is future risk, not a present risk. Key parameters to understand an uncertain future

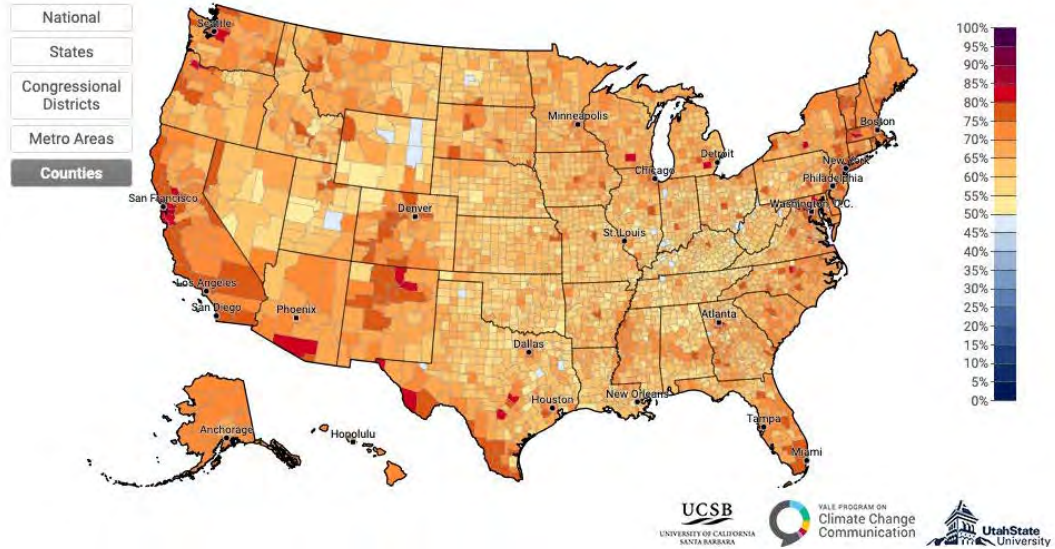


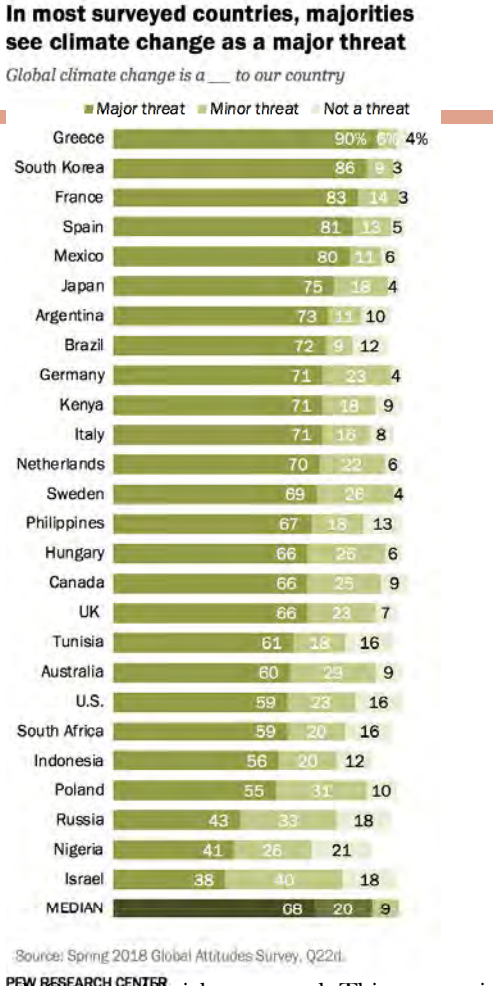
Current bid for asset = Present value of future cash flows – Present value of expected climate damages

Costs of damages x {**BELIEF**} / {Discount Rate}

Beliefs in Global Warming

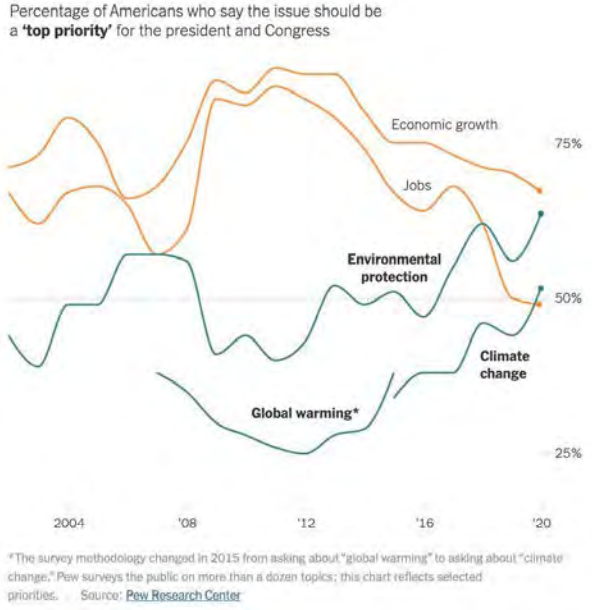
Adults who think global warming is happening, difference from national average (72%), 2021

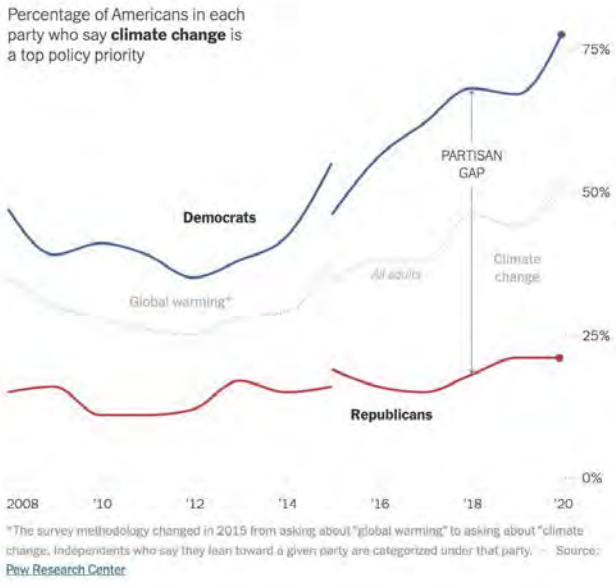


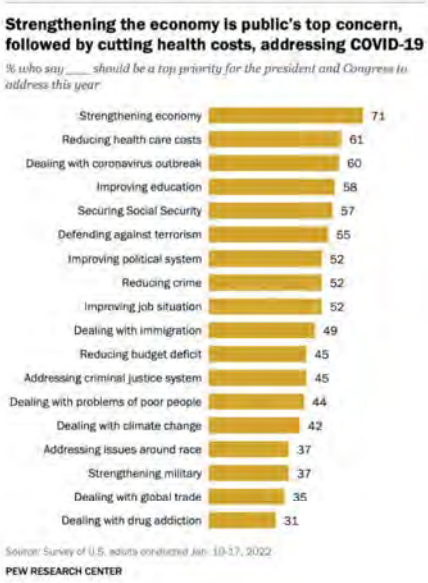


Source: Yale Climate Opinion Maps 2021

Climate Change Rises as a Public Priority. But It's More Partisan Than Ever. (By Nadja Popovich, Feb. 20, 2020, NY TIMES)







Does Climate Change Affect Real Estate Prices? Only If You Believe in It!

- Flood risk in the US: Climate experts predict that approximately two percent of U.S. homes -- worth $882 billion -- are at risk of being underwater by 2100; in low-lying coastal regions such as Florida and Hawaii, between 10 and 12 percent of homes could be inundated.

- Study Setting:
  - This paper uses housing transactions from 1997 to 2017, as well as detailed home characteristics from more than 374 million public records across over 2,750 counties in Florida.
  - UnderWater: A dummy equals one if the home falls into a future flood zone
  - Beliefs about climate change: County level Yale Climate Opinion Maps 2016

Source: Baldauf M. *et al.* "Does climate change affect real estate prices? Only if you believe in it." *Review of Financial Studies* 2019.

Does Climate Change Affect Real Estate Prices? Only If You Believe in It!

- Hedonic model

$$\ln P_{it} = \alpha_{ced} + \alpha_y + \beta \text{UnderWater}_i + \gamma' X_i + \xi' X_z + \epsilon_{it}$$

  - *UnderWater*: effects in counties with high (above median) and low (below median) beliefs about global warming
  - β is negative. The absolute value is larger for climate change believers' neighborhoods.
- Results
  - A one standard deviation increase above the national mean in the percentage of climate change believers is associated with 7% larger decrease in housing prices for homes projected to be underwater.
  - Due to overaction by believers, underreaction by deniers, or a combination of both.

Source: Baldauf M. *et al.* "Does climate change affect real estate prices? Only if you believe in it." *Review of Financial Studies* 2019.

Better Information Helps

- Home Seller Disclosure Requirement
  - Mandate that home sellers provide buyers with detailed information of known material defects about the listed property by filling out a standardized form.
  - 26 states in the contiguous US implemented the disclosure requirement between 1992 and 2003 with an explicit question on flood risk.

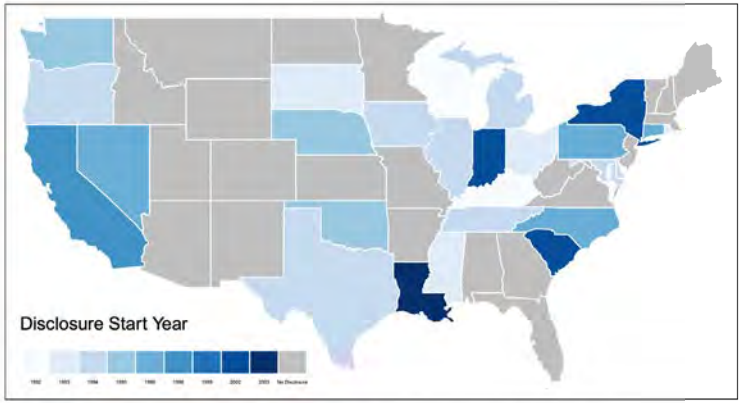


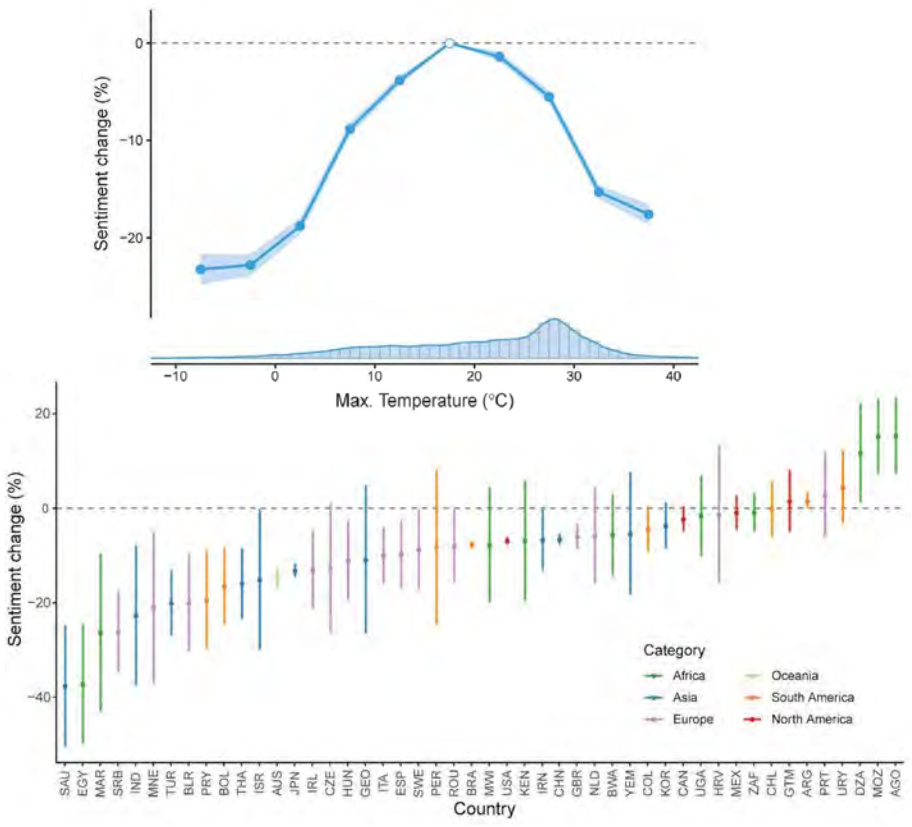
Figure 2.1: The Disclosure Requirement Implementation over Time

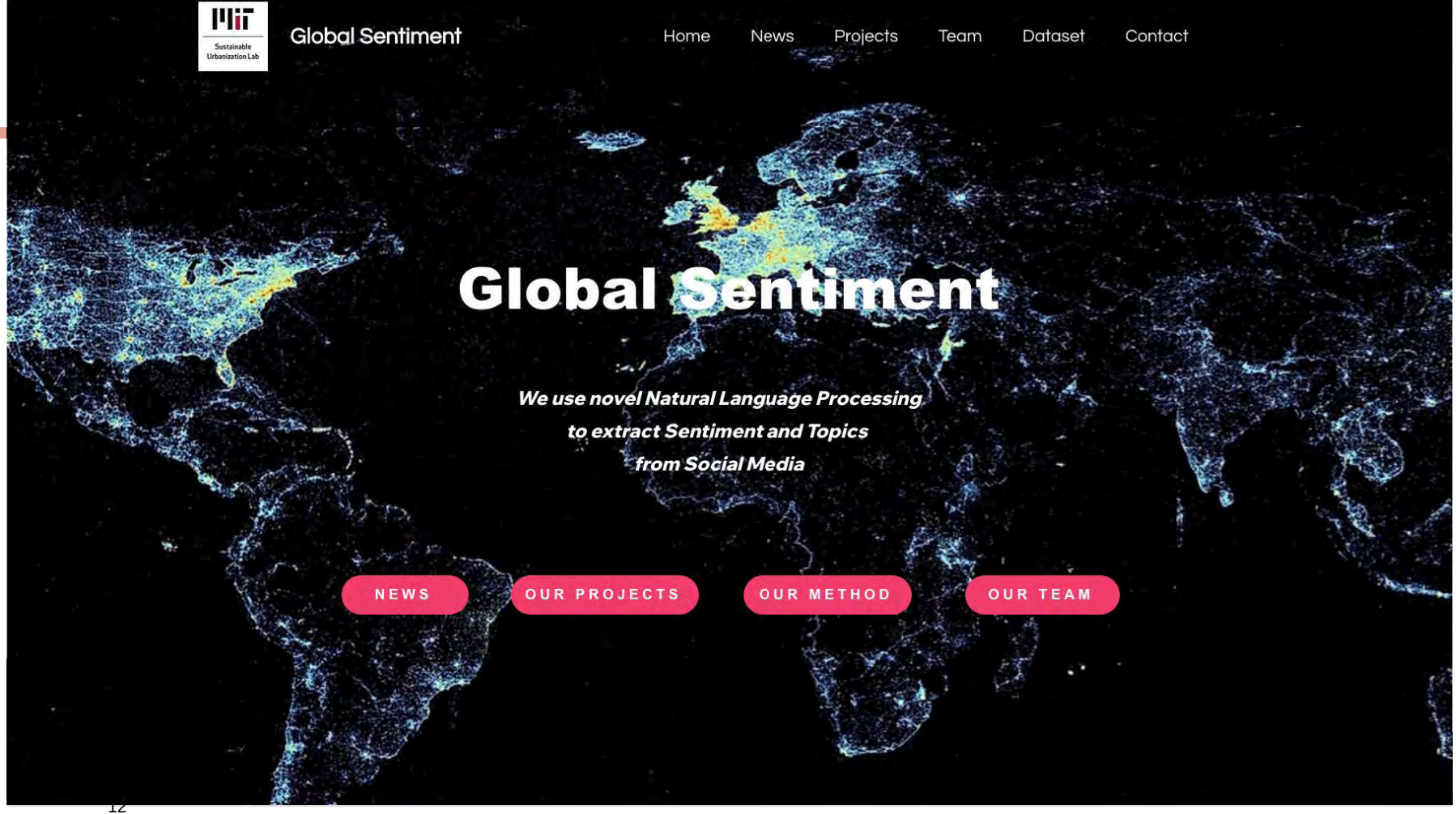
	(1)	(2)
	Lower population + Higher housing vacancy	
SFHA × Post	−.106	1.051
(Special Flood Hazard Area)	(.050)	(.382)
D.V	log(Population)	(%) Vacant
Avg D.V. (Within BW)		11
Year × Stack FE		
Zip code × Stack FE		
Community FE	X	X
Bandwidth	208	175
Num. obs.	305080	236298

Source: Seunghoon Lee. *Adapting to Natural Disasters through Better Information: Evidence from the Home Seller Disclosure Requirement.*. Figure courtesy of Seunghoon Lee. Used with permission.

SUL Project: Climate Change and Global Sentiment

- My SUL Lab's project: **Climate Change and Global Sentiment**
- Nature Language Processing (NLP) + Twitter data: Map how extreme temperatures affect emotional well-being worldwide.
- Sentiment reduction is more universal than belief. (you are unhappy no matter whether you believe in it all not)

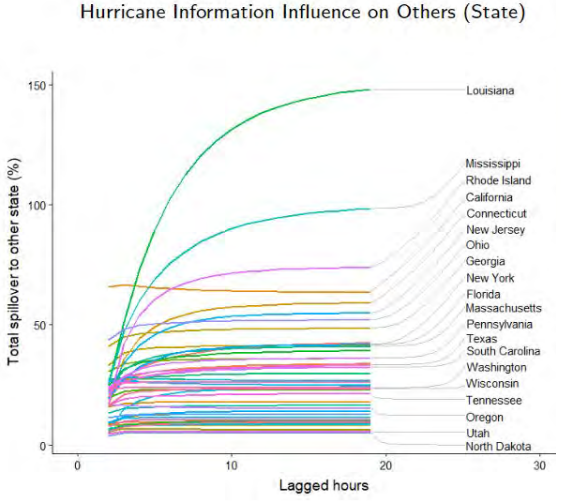


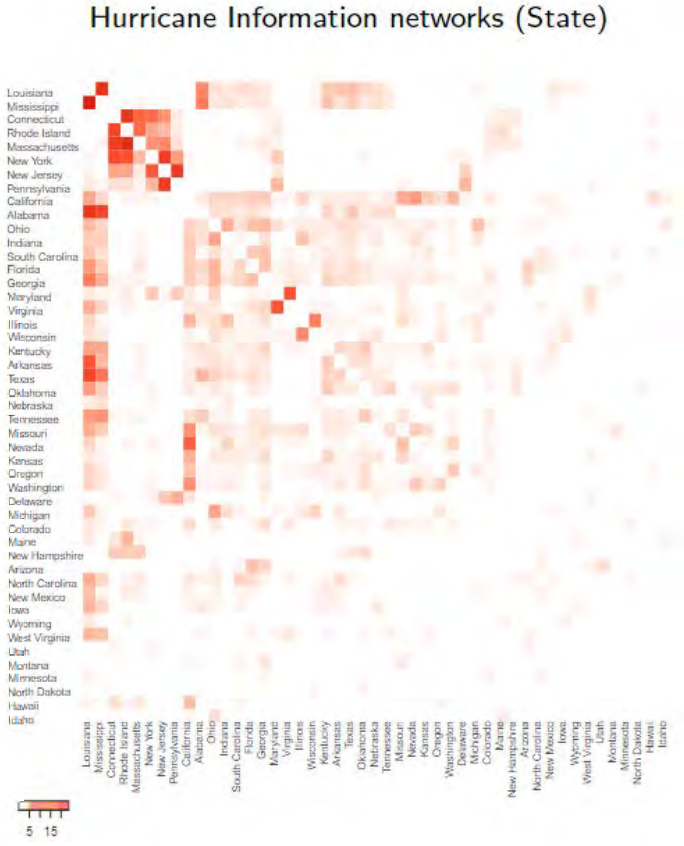


https://www.globalsentiment.mit.edu/

Information/belief Travels

- Another ongoing project of SUL.
- Information/belief travels across space after climate disasters.
  Social media data + Econometrics to measure the information network.



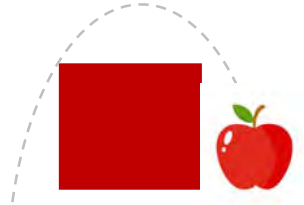


CLIMATE RISKS IN HOUSING MARKETS

Ortega, Francesc, and Süleyman Taşpınar. "Rising sea levels and sinking property values: Hurricane Sandy and New York's housing market." *Journal of Urban Economics* 106 (2018): 81-100.

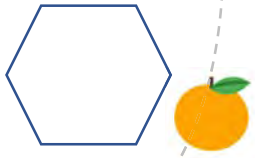
Hedonic Model on Climate Risks

Treated
(inside flood zone)



After Hurricane Sandy

Control
(outside flood zone)



Use the difference in price to measure the impacts of flood risk?

Hedonic Model on Climate Risks

P = 3 Rooms + 2 Subway Stops + Inside Flood Zone + A Nice Park + Residual

$ 1M = $0.6M + $0.2M + -$0.1M + $0.1M + $0.2M

$ 1M = $0.2M × 3 + $0.1M × 2 + -$0.1M × 1 + $0.1M × 1 + $0.2M

$P = \alpha_1 \times X_1 + \alpha_2 \times X_2 + \alpha_3 \times X_3 + \alpha_4 \times X_4 + \varepsilon$

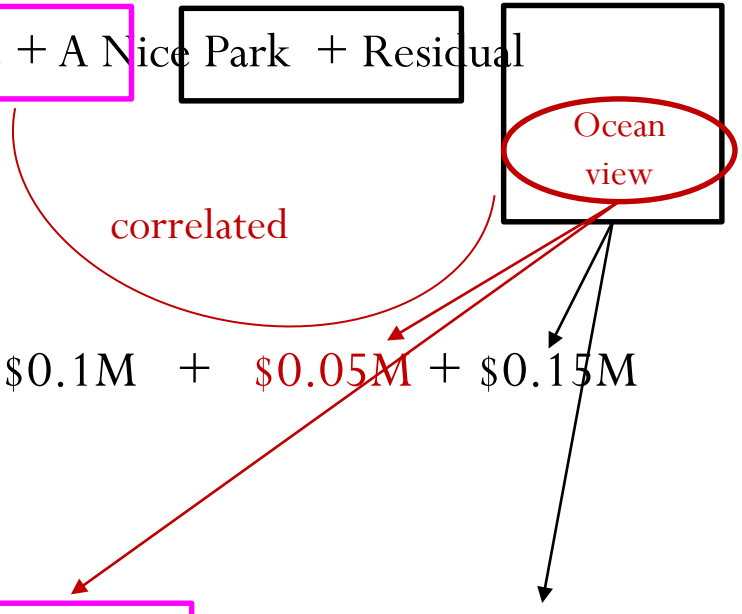
Input

Output

(R^2= 83%)

Hedonic Model on Climate Risks

P = 3 Rooms + 2 Subway Stops + Inside Flood Zone + A Nice Park + Residual



If we can observe and measure "Ocean view":

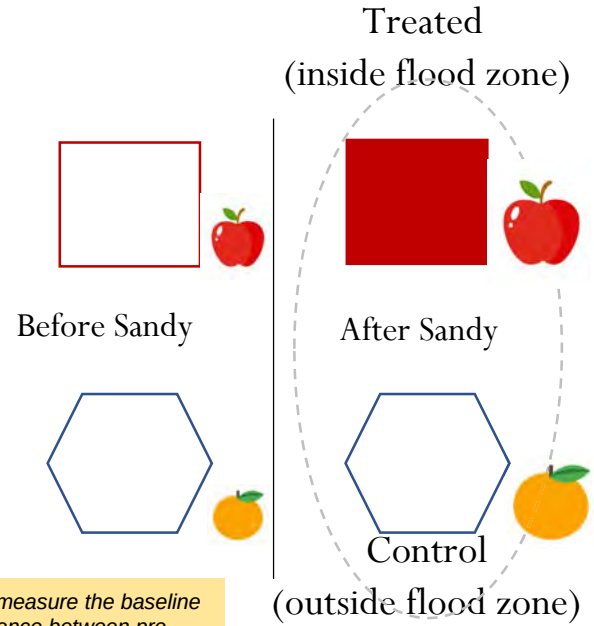
$ 1M = $0.6M + $0.2M + -$0.1M + $0.1M + $0.05M + $0.15M

If we cannot observe and measure "Ocean view" and "Inside Flood Zone = Ocean view" (extreme case):

$ 1M = $0.6M + $0.2M + -$0.1M + $0.05M + $0.1M + $0.15M

Underestimate price penalty → - $0.05M

Another Difference-in-Differences (DID)



Then, subtract the baseline trend from the time trend of pre-apple to post-apple:

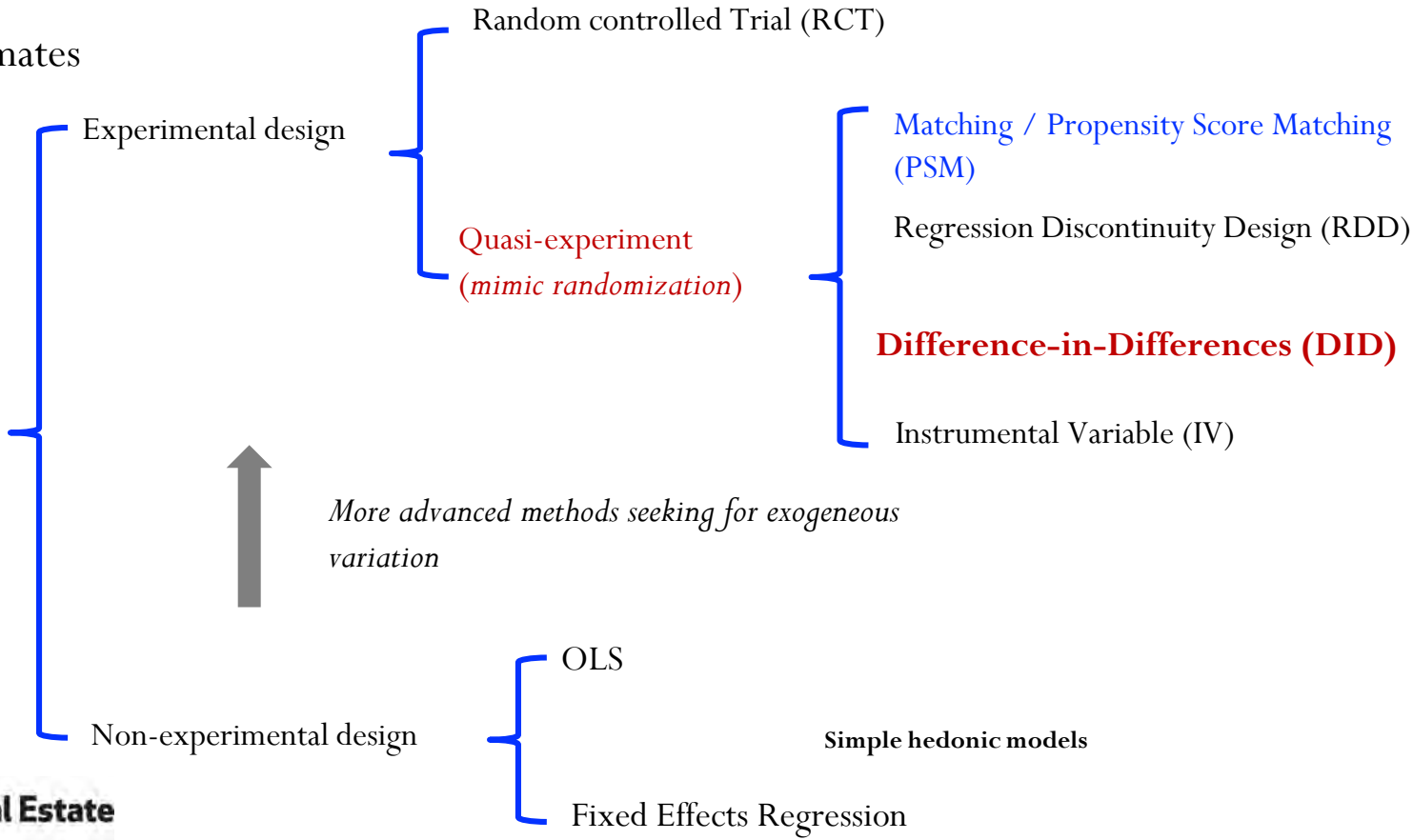
First measure the baseline time trend from pre-orange to post-orange:

First measure the baseline difference between pre-apple and pre-orange:

Then, subtract the baseline difference from the endline difference between post-apple and post-orange to get the real treatment effect

Causal Framework

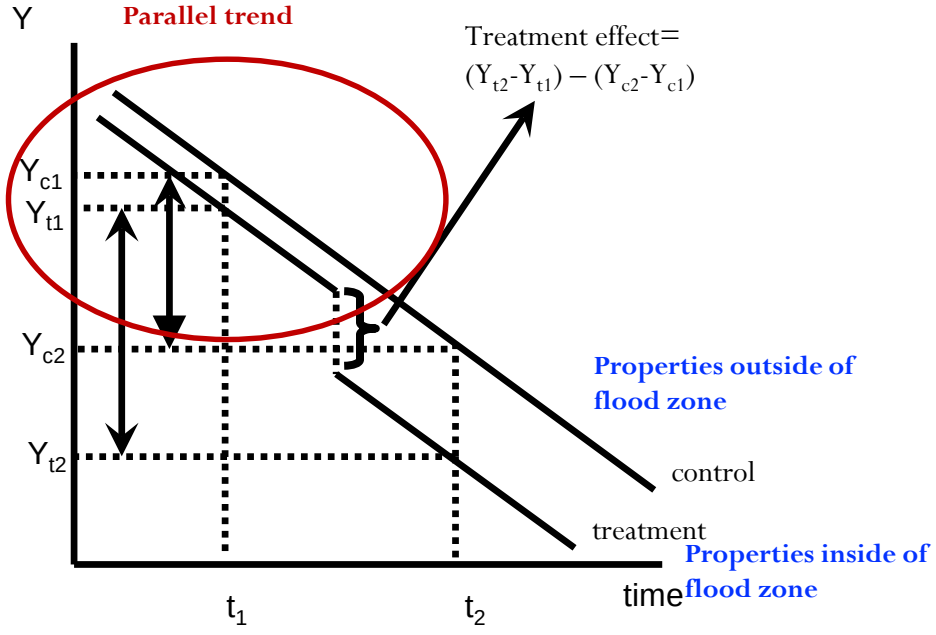
- Make the estimates **CAUSAL**



Difference-in-differences (DID)

- Control group identifies the time path of outcomes that would have happened in the absence of the treatment
- In this example, Y falls by Y_{c2}-Y_{c1} even without the intervention

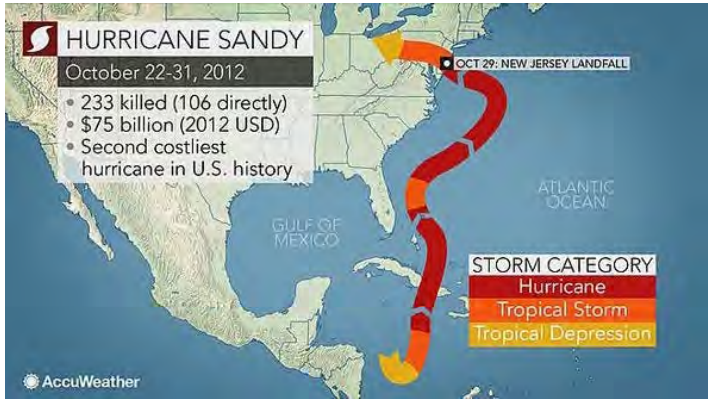
	Before Change	After Change	Difference
Group 1 (Treated)	Y_{t1}	Y_{t2}	$\Delta Y_t = Y_{t2}-Y_{t1}$
Group 2 (Control)	Y_{c1}	Y_{c2}	$\Delta Y_c = Y_{c2}-Y_{c1}$
Double Differences			$\Delta\Delta Y$ $\Delta Y_t - \Delta Y_c$



Rising Sea Level and Sinking Property Value

- Research Question:
  What is the impact of hurricane Sandy on the New York City housing market?

- Data
  All housing sales 2003-2017 (Sandy's shock in Fall 2012);
  Geocoded FEMA data on building structure damage.



- Findings:
  [1] Properties in the flood zone had **8%** persistent price penalty after Sandy.
  [2] Some heterogeneity results.

Source: Ortega, F., & Taşpınar, S. (2018). Rising sea levels and sinking property values: Hurricane Sandy and New York's housing market. Journal of Urban Economics, 106, 81–100.

Rising Sea Level and Sinking Property Value

- Empirical specification:

Time: Post-hurricane indicator

(Standardized DID setting)

$$\ln p_{it} = \alpha_i + \alpha_t + \beta HEZAB_i \times Post_t + \varepsilon_{it}$$

Treatment: Sales in the flood zone
(Control: properties out of the flood zone.)

(DID setting with differential treatment intensity)

$$\ln p_{it} = \alpha_i + \alpha_t + \left(\beta_0 Dam0_i + \beta_1 Dam1_i + \beta_2 Dam2_i\right) \times Post_t + \varepsilon_{it},$$

From Dam0 to Dam2: increasing damages.
(Control: properties out of the flood zone.)

Controls: property FE; quarter-year FE.

Rising Sea Level and Sinking Property Value

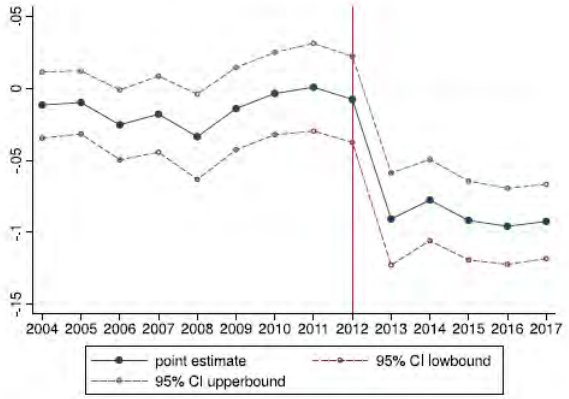
Hurricane Sandy has persistently reduced housing prices by 9% in the city's flood zone, relative to similar properties in the rest of the city.

Dep. var. ln*p*	1	2	3
Post × HEZAB	−0.09***	−0.06***	
	[0.01]	[0.01]	
Post × Dam0			−0.04***
			[0.01]
Post × Dam1			−0.09***
			[0.02]
Post × Dam2			−0.15***
			[0.05]
Obs.	310,335	158,502	158,502
Properties	131,037	66,364	66,364
R-squared	0.19	0.158	0.158
FE	BBL-Apt	BBL	BBL

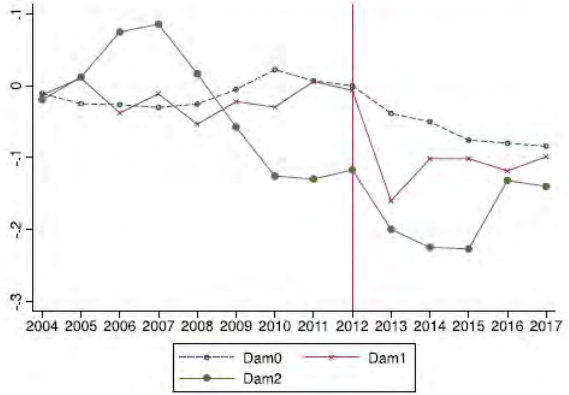
Rising Sea Level and Sinking Property Value

Time-varying coefficients by year.

Model Treatment	Model 1 HEZAB	Model 2 Dam0	Model 2 Dam1	Model 2 Dam2
T × 2012	−0.01	0	−0.01	−0.12
	[0.02]	[0.02]	[0.02]	[0.08]
T × 2013	−0.09***	−0.04**	−0.16***	−0.20**
	[0.02]	[0.02]	[0.03]	[0.10]
T × 2014	−0.08***	−0.05***	−0.10***	−0.22***
	[0.01]	[0.02]	[0.02]	[0.07]
T × 2015	−0.09***	−0.08***	−0.10***	−0.23***
	[0.01]	[0.02]	[0.02]	[0.07]
T × 2016	−0.10***	−0.08***	−0.12***	−0.13**
	[0.01]	[0.02]	[0.02]	[0.06]
T × 2017	−0.09***	−0.08***	−0.10***	−0.14**
	[0.01]	[0.02]	[0.02]	[0.06]
Observations	354,310		354,310	
R-squared	0.143		0.143	
Number of BB	22,062		22,062	
Fixed-effects	Block		Block	



Overall:
Stabilizes at 8%.



High damages properties:
Large drop right after the storm and converge to the neighborhood loss.

Changes in Flood Risk Premium

- Prior to Hurricane Fran in 1996: No market risk premium for the presence in a flood zone

- After Hurricanes: Significant **price differentials** between houses **inside and outside floodplain**.

- Study area: North Carolina. A 5.7% decrease of floodplain houses after Hurricane Fran and 8.8% decrease after Hurricane Floyd.

Variables	Model A		
	Coeff.	Std. error	*p*-values
Floodplain (=1)	0.011	0.022	0.6040
Floodplain (=1) × sold btw Fran and Floyd	−0.057	0.028	0.0437
Floodplain (=1) × sold after Floyd	−0.088	0.028	0.0018

Source: Bin, O., & Landry, C. E. (2013). Changes in implicit flood risk premiums: Empirical evidence from the housing market. Journal of Environmental Economics and management, 65(3), 361-376.

CLIMATE RISKS IN COMMERCIAL REAL ESTATE MARKETS

Commercial Real Estate vs. Residential

Commercial Real Estate

Commercial

Common ground

- Physical damage
- Increased insurance costs
- Reduced demand

……

Residential

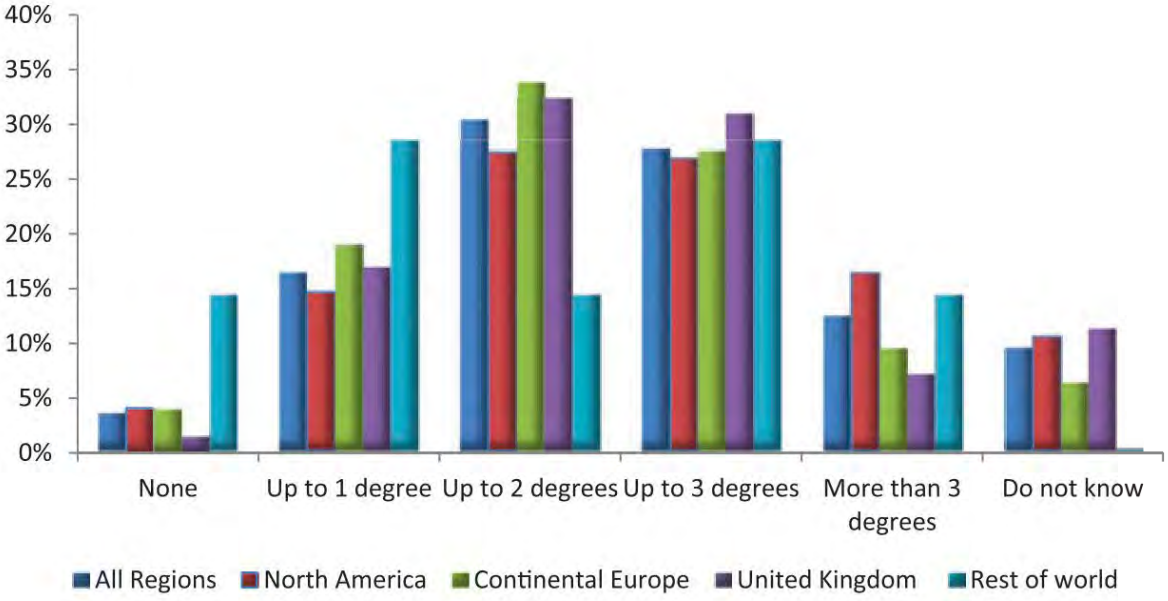
Residential Real Estate

What are the differences?

1. CRE: more sophisticated investors

Survey of 439 executive about about the role of climate risks for their institutions

Expectations of Institutional Investors for the global temperature rise by the end of this century



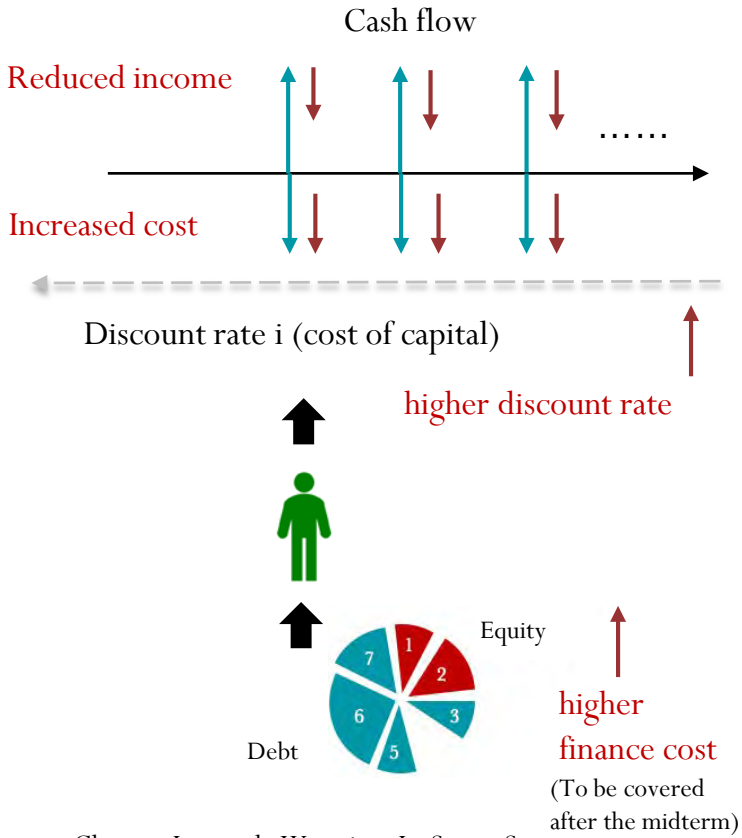
Source: Krueger, P., Sautner, Z. and Starks, L.T., 2020. The importance of climate risks for institutional investors. *The Review of Financial Studies*, *33*(3), pp.1067-1111. © Oxford University Press. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/.

2. CRE: Corporation Image and Fiduciary Responsibility

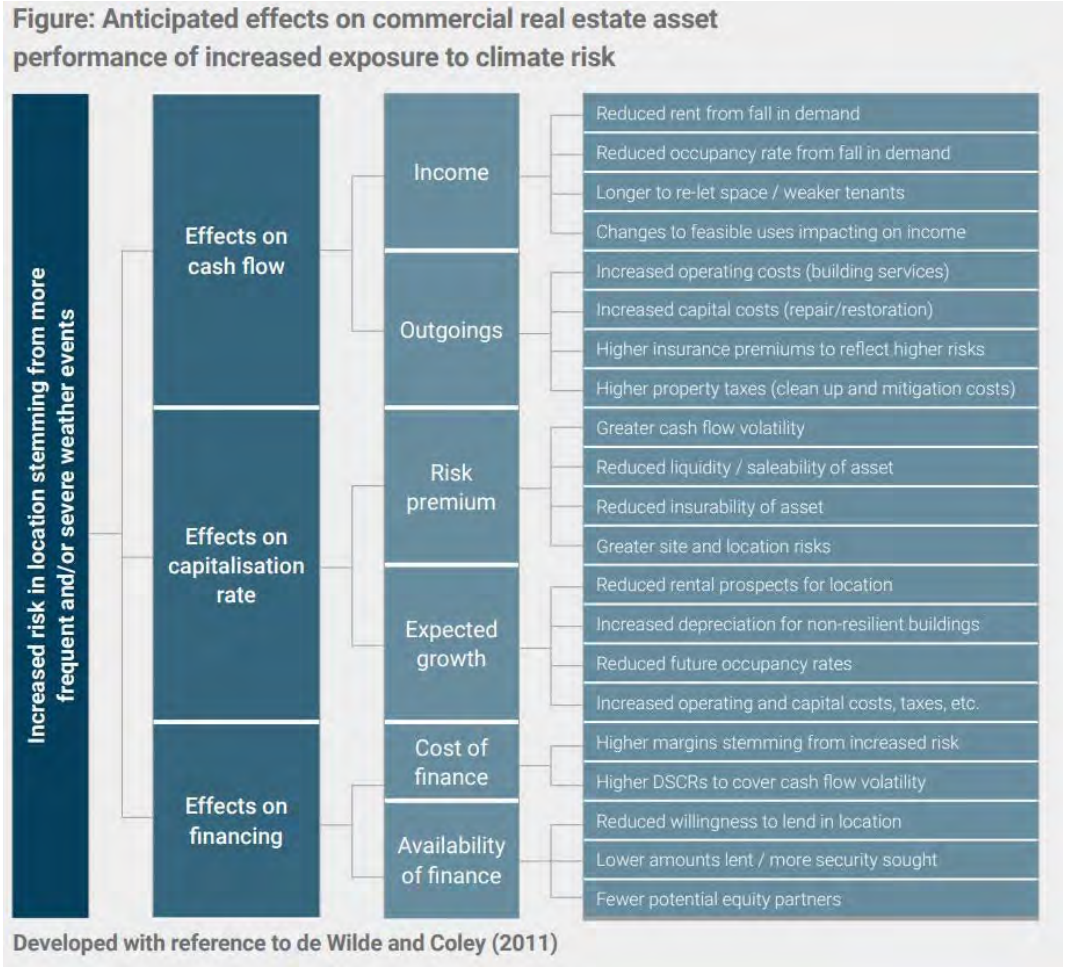
3.CRE: Higher Regulatory and Industry Standard Bars

GRESB
REAL ESTATE

Center for Real Estate

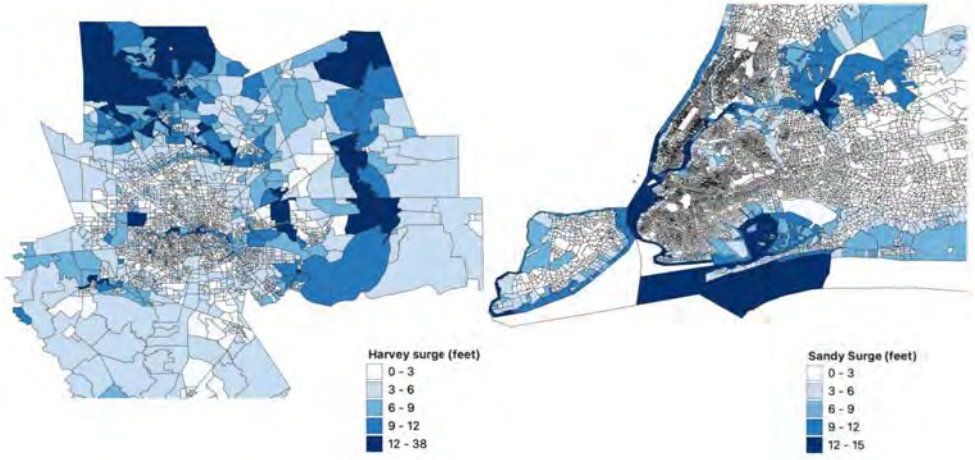


Source: Clayton, J., van de Wetering, J., Sayce, S., & Devaney, S. (2021). Climate Risk and commercial property values: a review and analysis of the literature.



Siqi's Research: Hurricane and CRE

- Quantifying the Impacts of Climate Shocks in Commercial Real Estate Markets (Hurricane Sandy, 2012; Hurricane Harvey, 2017)
- Authors: Rogier Holtermans, University of Guelph; Dongxiao Niu, Maastricht University; Siqi Zheng, MIT



Notes: This Figure shows the surge level of inundation area by Census block group in Texas and New York, with a focus on Houston and New York City. The blue shades indicate surge level (feet).

- Commercial real estate transactions (Real Capital Analytics)
  New York 2007-2017 and Texas, 2012-2021
  Transaction date, price, location, property type, quality, buyer and seller characteristics, etc.
- Hurricanes (3-meter surge map from FEMA Modeling Task Force)

Final sample: 10,359 transactions in New York and 15,312 in Texas State

Siqi's Research: Hurricane and CRE

- DID model using hurricanes as a climate shock (Ortega and Taşpınar, 2018; Gibson and Mullins, 2020, Meltzer et al., 2021)

Property damage measure (i) surge dummy; (ii) average surge level (feet) at census block level; (iii) high surge (>3 feet) and low surge dummies

$$Price_{it} = \alpha_0 + \alpha_1 * Post_t + \alpha_2 * Surge_i + \alpha_3 * Surge_i * post + \beta * Hedonics_{it} + T_t + \sigma_c + \mu_{ict}$$

Property transaction price per sq. ft. for property i at time t

=1 if the transaction happened after the specific hurricane (Aug 2017 for TX and Oct 2012 for NY)

- Hedonics: property types, building attributes, such as age, size, number of stories, building quality, etc.
- Year-quarter time trends, Census tract fixed effects

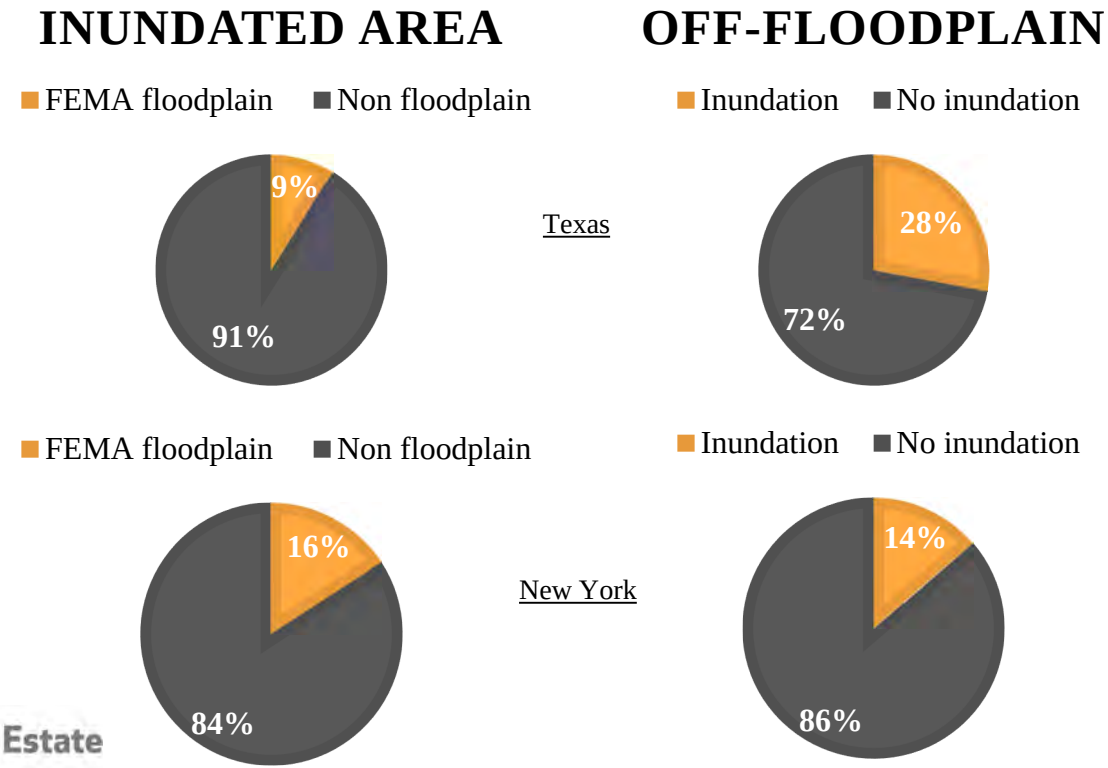
Baseline results – decrease in transaction price

	Dependent Variable: Log (Price/sq. ft.)					
	Texas			New York		
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.028	-0.040	-0.029	0.595***	0.594***	0.595***
	(0.049)	(0.048)	(0.048)	(0.033)	(0.033)	(0.033)
Surge dummy	-0.093**			0.043*		
	(0.040)			(0.025)		
Post × Surge dummy	-0.033*			-0.009		
	(0.017)			(0.021)		
Mean surge		0.026**			0.004	
		(0.010)			(0.010)	
Post × Mean surge		-0.035***	**$4.41/sq. ft**		-0.015*	**$5.49/sq. ft**
		(0.008)	**$311,500/building**		(0.008)	**$100,335/building**
High Surge			-0.052			0.010
			(0.042)			(0.033)
Low Surge			-0.143***			0.057*
			(0.043)			(0.031)
Post × High Surge			-0.088***			-0.033
			(0.022)			(0.029)
Post × Low Surge			0.028			0.013
			(0.023)			(0.028)
Observations	15,312	15,312	15,312	10,359	10,359	10,359
R^2	0.703	0.703	0.703	0.912	0.912	0.912

Notes: Standard errors are reported in brackets. Significance at the 0.10, 0.05, and 0.01 level is indicated by *, **, and ***.

Heterogeneity: Place – Price of *New news*

Inconsistency between ex ante information on underlying climate risk and ex post damage from actual events



Heterogeneity: Place – Price of *New news*

- Hurricane discount mainly observed outside of flood zones (New news can be costly).
- Investors already capitalize flood risks into their asset value based on the flood zone designation.

	Dependent Variable: Log (Price/sq. ft.)							
	Texas				New York			
	Inside-zone	Outside-zone	<500m	<1000m	Inside-zone	Outside-zone	<500m	<1000m
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	0.064	-0.020	-0.058	-0.062	0.853***	0.608***	0.698***	0.628***
	(0.202)	(0.054)	(0.080)	(0.062)	(0.228)	(0.033)	(0.054)	(0.040)
Mean Surge	0.290**	0.033*	0.040*	0.039**	-0.127	0.010	0.018	0.013
	(0.117)	(0.018)	(0.024)	(0.020)	(0.083)	(0.010)	(0.012)	(0.010)
Post × Mean Surge	-0.019	-0.042***	-0.041***	-0.039***	-0.020	-0.011	-0.023**	-0.018**
	(0.029)	(0.010)	(0.013)	(0.011)	(0.044)	(0.008)	(0.010)	(0.009)
Hedonic attributes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Census Tract FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,313	6,582	10,184	11,575	312	10,809	3,448	6,518
R^2	0.811	0.741	0.731	0.724	0.937	0.915	0.905	0.910

Notes: Standard errors are reported in brackets. Significance at the 0.10, 0.05, and 0.01 level is indicated by *, **, and ***.

Hurricane and CRE

- Proximity (to coast, elevation) lowers commercial real estate price after Hurricane Sandy
  - New York directly hit by Sandy and damaged
  - Boston spared by Sandy but at risk
  - Chicago unaffected due to in-land waterfront location

	Main Effect		
	New York	Boston	Chicago
	(1)	(2)	(3)
Proximity	-0.216***	-0.095***	-0.004
	(-2.579)	(-3.346)	(-0.082)
Flood Zone	-0.434***	0.175*	-0.687**
	(-2.697)	(1.730)	(-2.448)
Local Establishments	-0.157	1.739	0.781
	(-0.149)	(1.362)	(0.762)
Year–Fixed Effects	Yes	Yes	Yes
Zip Code–Fixed Effects	Yes	Yes	Yes
Observations	2,216	1,394	951
Adj. R-squared	0.190	0.200	0.286

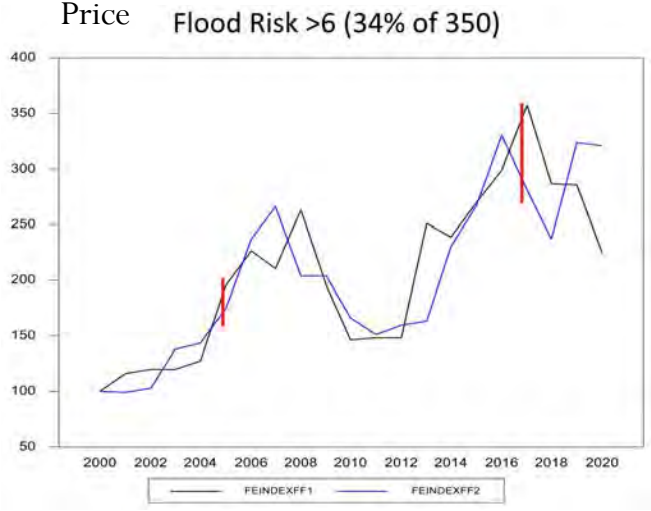
Source: Addoum, J. M., Eichholtz, P. M. A., Steiner, E., & Yönder, E. (2021). Climate Change and Commercial Real Estate: Evidence from Hurricane Sandy. Working paper.

Climate Risk is a Future Risk

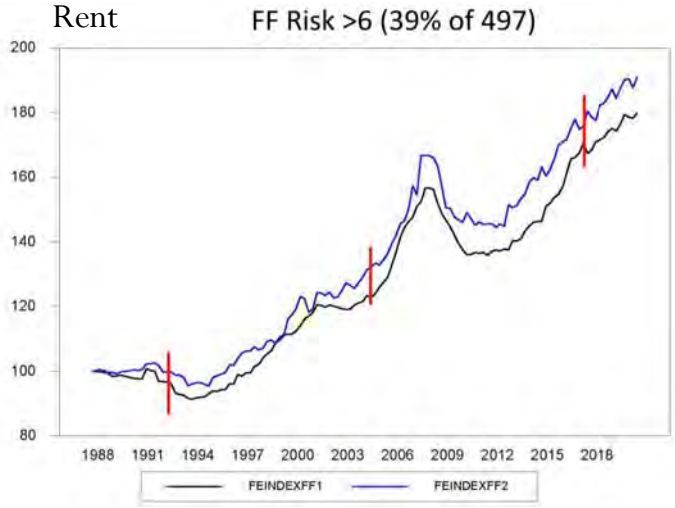
- Price: Buildings in riskiest locations show price decline after 2017.
- Rent: Buildings in riskiest locations have equal rent growth to the 61% least risky. No difference in movements around hurricanes.
- Different between price and rent: Future expectations.

Blue: lower risk;
Black: higher risk.

Price



Rent



Source: William Wheaton, Anne Kinsella Thompson, Katherine Salvatori (2022). Impact of Flooding on Miami (Dade) office market properties. Figures courtesy of William Wheaton, Anne Kinsella Thompson, and Katherine Salvatori. Used with permission.