Valuing Seawall Protection in the Wake of Hurricane Disaster: Difference-in-Difference Approach

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MOTIVATION

- Coastal communities are vulnerable to floods, hurricanes, storm surges and inundation due to Sea Level Rise, and climate change will likely worsen these effects (IPCC, 2012)
- Policy makers devise and strategize coastal adaptation plans (Kousky, 2014)
  - Structural protections: sea walls, groans, levees, dikes
  - Building with water (elevating and retrofitting homes)
  - Gradual coastal retreat
- Large disasters open "windows of opportunities" (Miletti, 2009)
  - E.g. Galveston seawall (17-feet high, 10-mile long) built in early 1900
  - 2008 Hurricane Ike → debates about building a complex coastal spine that will extend existing seawall ("Ike Dike")
- Benefits of seawall →
  - Avoided damage from Hurricane Alicia (1983) ~$100 million (City of Galveston, 2011)
  - Avoided damages from Ike for houses protected by the seawall
- Public and scientific controversy remains:
  - Protective infrastructure costly to build → no full protection
  - Induced development ("false sense of security") (Kousky et al., 2006)
  - Potential adverse affect of coastal armoring on fragile ecosystem

RESEARCH QUESTION

- Is the value of a hard structure for hazard protection such as seawall capitalized into housing prices?
- What is the value of seawall in the wake of a large scale disaster?
- Does the value of "seawall protection" disappear or diminish over time?

Difference-in-Difference-in-Difference Hedonic Method

Non-parametric approach:

$$\ln(P_{it}) = \beta_0 + \beta_1 SW_{it} + \beta_2 \cdot IKE_{2008} + \beta_3 FZ_{it} + SW_{it} \cdot IKE_{2008} + \beta_5 FZ_{it} \cdot IKE_{2008} + \beta_6 SW_{it} \cdot FZ_{it} + \beta_7 SW_{it} \cdot FZ_{it} \cdot IKE_{2008} + \theta_t + \mu_l + \varepsilon_{it}$$

$$\hat{\beta}_7 = (\overline{lnp}_{SW,FZ,t2} - \overline{lnp}_{SW,FZ,t1}) - (\overline{lnp}_{NSW,FZ,t2} - \overline{lnp}_{NSW,FZ,t1}) - (\overline{lnp}_{SW,NFZ,t2} - \overline{lnp}_{SW,NFZ,t1})$$

Semi-parametric Approach → controlling for the effect of covariates (i.e. housing-specific And location-specific characteristics) in D-i-D

P_{it} is value of property *i* in time period *t*;

SW_{it} = 1 for seawall protected area → treatment group (local polynomial regressions are used to determine distance cutoff (Linden & Rockoff, 2008)).

IKE_{2008} =1 if property *i* is sold after Hurricane Ike (after September 1, 2008)

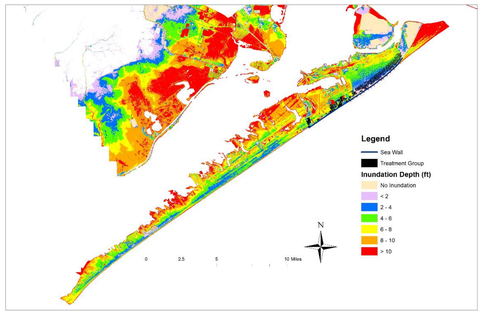
$FZ_{it} = 1$ if property *i* is located in a Special Flood Hazard Area (SFHA): A and V zones

θ_t is year fixed effects

μ_l is location fixed effects (e.g. block group).

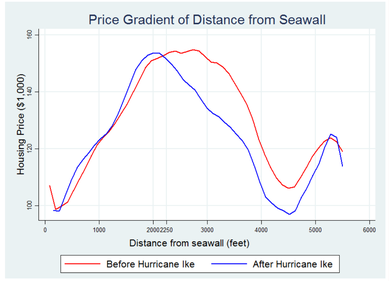
SAMPLE

Figure 1: Galveston Island, Ike Inundation map



Identify Treatment

Figure 2: proximity to seawall



Summary Statistics

Variable*	Description	Mean	Std. Dev.	Min	Max
Price	Inflation adjusted sales prices ($2012)	204,825	226,404	1,574	12,300,000
Flood zone (0,1)	1: located in SFHA (A & V zones)	0.83	0.37	0	1
Seawall (0,1)	1: protected by seawall	0.41	0.49	0	1
Ike (0,1)	1: property sold after Ike	0.56	0.50	0	1
Quality (0,1)	1: good, very good, & excellent	0.37	0.48	0	1
Bathroom	Number of bathrooms	1.88	0.91	0	1
Lot size	Lot size in acres	0.17	0.33	0	12.88
Build. sq. ft	Building square feet	1,729.12	865.94	0	25,495.00
House age	The age of the property	37.22	63.16	0	168.00
Foundation (0,1)	1:concrete, block, pier, pipe & slab	0.19	0.40	0	1
Pool (0,1)	1: property with a pool	0.07	0.25	0	1
Stories	Number of stories	1.33	0.46	1	3
Roof (0,1)	1: concrete, metal, or tile roof	0.01	0.08	0	1
Dist. park	Distance to nearest park (ft)	6,526.58	9,371.77	0	32,739.76
Dist. highway	Distance to nearest highway entry/exit (ft)	24,100.26	24,617.62	87.33	95,841.23
Dist. beach	Distance to nearest beach (ft)	3,327.07	2,319.44	0	13,390.68

*Data Sources: CoreLogic Inc.; Galveston Central Appraisal District; Distances calculated by Authors using ArcGIS software

Hedonic Regression (DDD) Results

Variables	Non-Parametric	Semi-Parametric
	(1)	(2)
seawall	0.167**	0.067
	(0.071)	(0.060)
flood_zone	0.030	-0.064
	(0.078)	(0.052)
ike	0.124**	0.059
	(0.059)	(0.039)
Seawall*ike	-0.033	-0.043
	(0.041)	(0.035)
Flood_zone*Ike	-0.178***	-0.161***
	(0.041)	(0.031)
Seawall*flood_zone	0.122	-0.010
	(0.099)	(0.071)
Seawall*ike*flood_zone	**0.129****	**0.101****
	(0.057)	**(0.046)**
Block Group Fixed Effects	Y	Y
Year Fixed Effects	Y	Y
Structural Characteristics	N	Y
Observations	8,000	7,956
Number of block_group	273	272
R-squared	0.095	0.479

*** p<0.01, ** p<0.05, * p<0.1; clustered robust standard errors in parenthesis; clustering unit – block group.

The effect over time

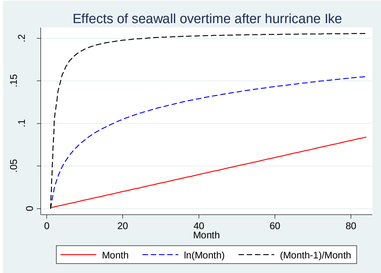
Following approach by Bin and Landry (2013):

$$\ln(P_{it}) = \beta_0 + \sum_k \beta_k X_{kit} + \beta_F \cdot FZ_{it} + \beta_S SW_{it} + \gamma_1 t + \beta_4 SW_{it} \cdot f(t) + \theta_t + \mu_l + \varepsilon_{it}$$

t – number of months after Ike

- $f(t) = t$
- $f(t) = \ln(t)$
- $f(t) = (t-1)/t$

Figure 3: Seawall Effect Overtime



VARIABLES	T	ln(t)	(t-1)/t
Quality	0.190***	0.189***	0.189***
	(0.016)	(0.016)	(0.016)
totalbaths	0.203***	0.201***	0.200***
	(0.026)	(0.026)	(0.026)
Baths^2	-0.020***	-0.020***	-0.019***
	(0.005)	(0.005)	(0.005)
acres	3.076***	3.080***	3.080***
	(0.300)	(0.299)	(0.298)
Acres^2	-1.894***	-1.899***	-1.894***
	(0.512)	(0.512)	(0.510)
Build. Sq. feet	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
Build. Sq. feet^2	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Dummy for pool	0.082***	0.082***	0.081***
	(0.023)	(0.024)	(0.024)
ln(dist. to highway)	0.136**	0.138**	0.138**
	(0.069)	(0.069)	(0.069)
ln(dist. to beach)	0.023	0.024	0.025
	(0.055)	(0.055)	(0.055)
Flood zone	-0.164***	-0.163***	-0.164***
	(0.051)	(0.050)	(0.050)
month after Ike	0.025	0.017	-0.021
	(0.042)	(0.024)	(0.097)
seawall	0.004**	-0.048	-0.127
	(0.002)	(0.051)	(0.088)
seawall-x-month	**0.001***	**0.035*****	**0.208****
	(0.001)	**(0.012)**	**(0.089)**
Observations	4,297	4,297	4,297
Number	266	266	266
R-squared	0.567	0.567	0.567

*** p<0.01, ** p<0.05, * p<0.1; clustered robust standard errors in parenthesis; clustering unit – block group; Reported selected variables

MAJOR FINDINGS & FUTURE DIRECTIONS

- Significant price premium for seawall protection after major hurricane disaster
  - Price premium was estimated to be 11-14%* after hurricane Ike.
  - Price premium for seawall protection does not disappear and slightly increases over time (Fig. 3) → significant benefits for coastal protection as revealed by housing prices.

Future Directions:

- Correct for spatial dependence in the errors
- Apply propensity score matching to identify appropriate controls
- Explore the effects of public protection and private mitigation (e.g. housing attributes that capture retrofits)

* Given the log term of the house price, price premium for seawall protected properties is calculated as: exp(0.129)-1 =14%, exp(0.101) -1=11%, respectively for non-parametric and semi-parametric approach (Campbell et al., 2011, pp.2117).

SELECTEED REFERENCES

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.
Campbell, J. Y., Giglio, S., & Pathak, P. (2011). Forced sales and house prices. *American Economic Review*, *101*(August), 2108–2131.
City of Galveston. (2011). *City of Galveston Hazard Mitigation Plan* (pp. 1–34). Retrieved from http://www.cityofgalveston.org/DocumentCenter/Home/View/79
IPCC. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. Field CB, Barros V, Stocker TF, Dahe Q, editors. Cambridge: Cambridge University Press; 2012.
Kousky, C., Luttmer, E. F., & Zeckhauser, R. J. (2006). Private investment and government protection. *Journal of Risk and Uncertainty*, *33*(1-2), 73-100.
Kousky, C. (2014). Managing shoreline retreat: a US perspective. *Climatic change*, *124*(1-2), 9-20.
Linden, L., & Rockoff, J. E. (2008). Estimates of the Impact of Crime Risk on Property Values from Megan's Laws. *American Economic Review*, *98*(3), 1103–1127.