Multifamily Housing: Property, Market Segment, and Owner Characteristics' Influence on Hurricane Harvey Exposure and Impacts

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(1) Research overview and key findings

Motivation: Multifamily rental housing (MFRH) is a significant, but understudied, portion of the housing stock (Peacock et al 2018). Findings related to disasters are dated, anecdotal, and not easily generalized. Limited available data for commercial real estate is a challenge. This research examines hazard risk, exposure, shorter-term disaster impacts, and longer-term recovery trajectories across MFRH differentiated by property, market segment, and owner characteristics.

Case study: Hurricane Harvey's (2017) impact in Harris County, Texas, was examined due to its extensive impacts, recency, and adequate time post-event to observe longer-term recovery outcomes.

Approach: We examine occupancy rates and property values for market-rate MFRH adjust to varied flood exposure intensity using proprietary property data linked to flood depth data. The sample consists of ~4,100 properties with ~598,000 housing units built before 2017. The indicators of property condition are examined (1) before disaster impacts, (2) immediately following disaster impacts, and (3) the period tracing out recovery through the 4th quarter of 2023. We explore dynamics across these periods. Event study models provide a broad picture of occupancy rate and property value dynamics across time. Then, using a series of regression models we examine how the characteristics of interest are associated with flood hazard risk, actual flood exposure, and disaster impacts.

Key findings highlight repeat flood impacts leading up to Harvey; properties with subsidized units were less at-risk pre-disaster; a post-disaster crowding toward and need for affordable housing; land use density coupled with building design can be effective mitigation tools; and certain owners locally headquartered with greater internal capacity had less short-term impacts.

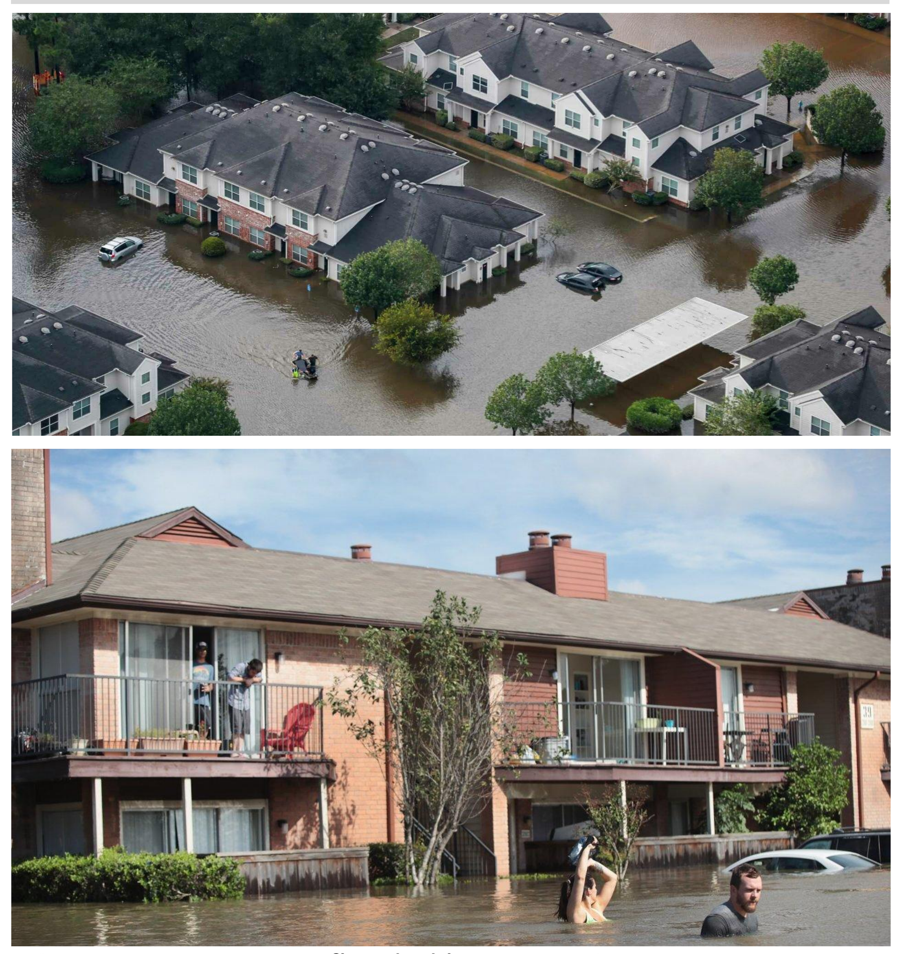


Figure 1. Apartments flooded by Harvey in Houston, TX.

Image sources: www.chron.com/news/houston-texas/houston/article/houston-apartments-damaged-hurricane-harvey-12270464.php; https://s.wsj.net/public/resources/images/BN-UY070_3czKT_M_20170902194544.jpg

(2) Harvey's direct impacts were prolonged and devastating

- **Initial landfall** on August 25, 2017, near Port Aransas, TX with maximum sustained winds of 130 mph
- **Harvey tracked back out** to the coast, stalled over the Houston region and released 60 inches of rain
- **Second landfall** on August 30, 2017, in Southeast Texas and Western Louisiana
- 200,000+ homes and businesses were damaged, 30,000+ people displaced, and 89 people died
- Estimated damage of \$160 billion (inflation adjusted), 2nd most costly tropical storm behind Katrina (NOAA)

Figure 2a. Wind speeds were highest with the initial landfall

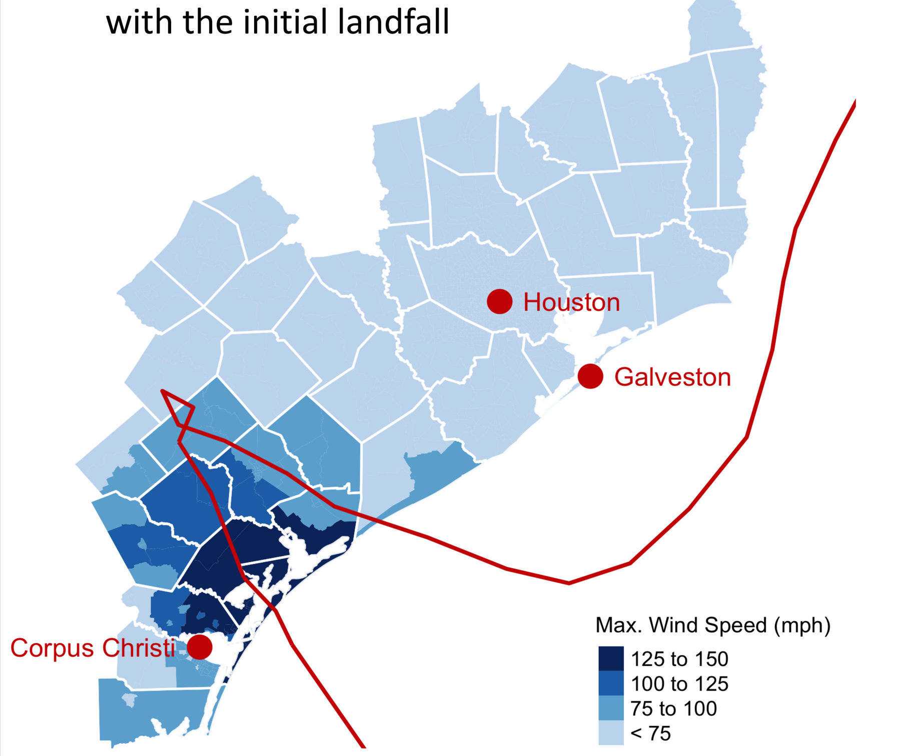
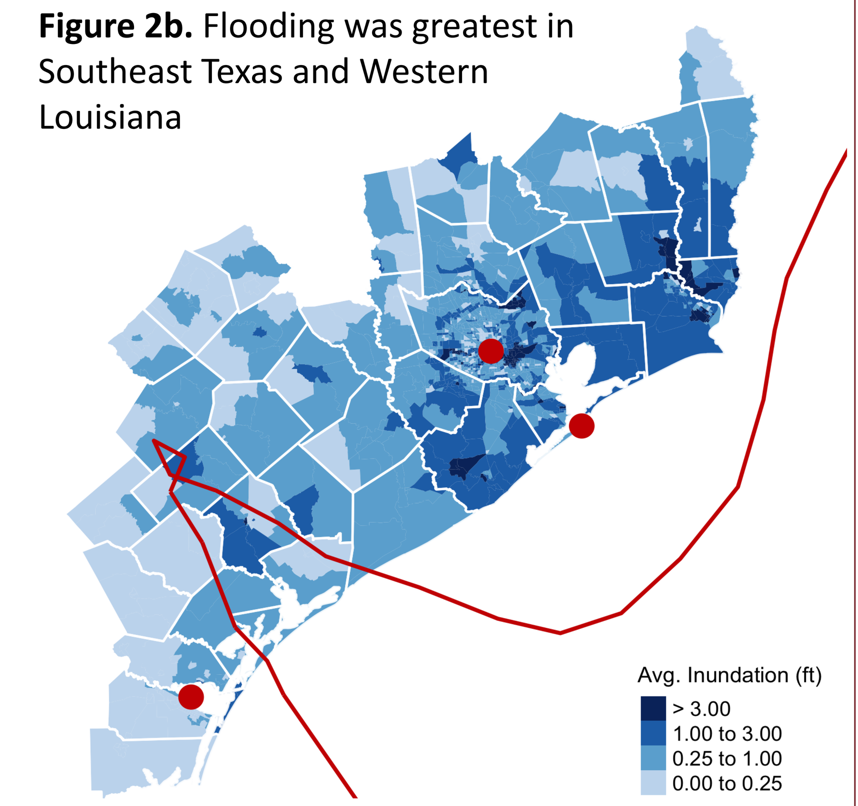
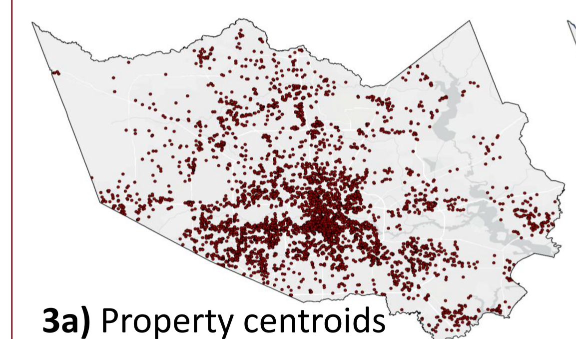


Figure 2b. Flooding was greatest in Southeast Texas and Western Louisiana

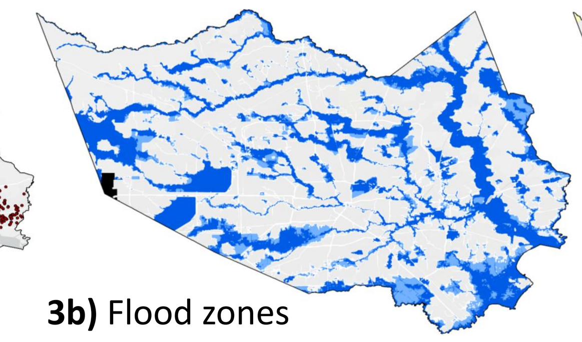


(3) Linking property, owner, flood risk and exposure data

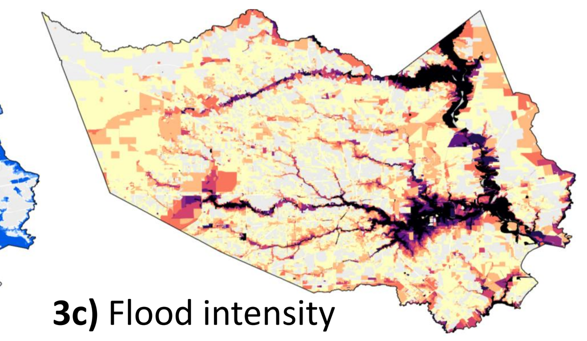
- Property coordinates with FEMA maps identify whether in or out of the 100-year flood zone.
- Average flood intensity per Census Block is determined using 30-meter resolution raster data and assigned to properties.
- Other property and owner characteristics, Census demographic data, quarterly occupancy rates, and assessed property values are also combined.



3a) Property centroids



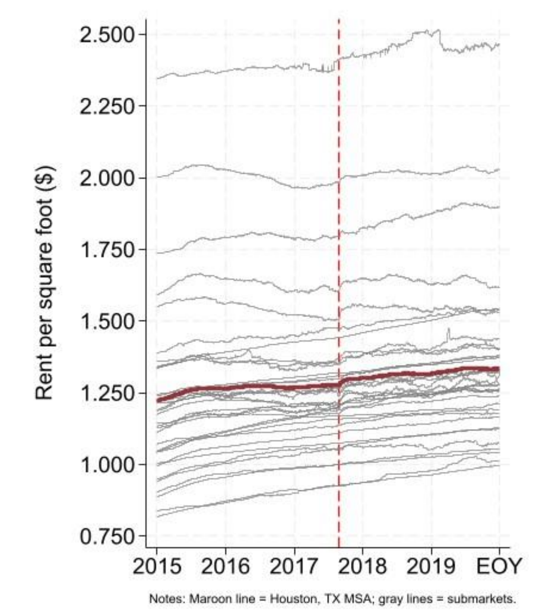
3b) Flood zones



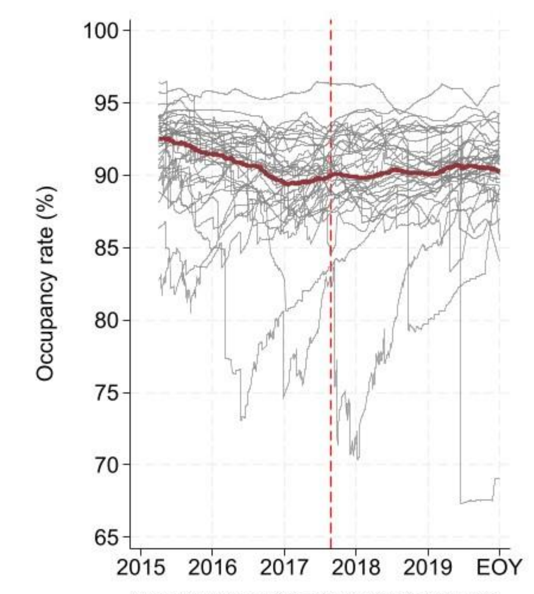
3c) Flood intensity

(4) Analysis of geographies can mask lower-level trends

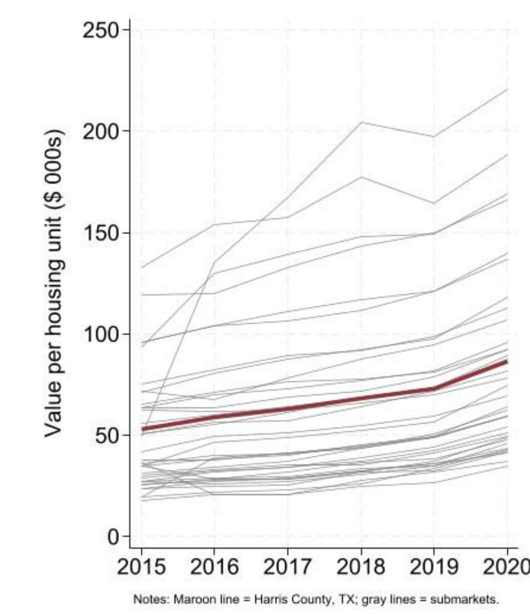
- Despite extensive flooding, negative effects are not observable for submarket geographies.
- Property-level analysis examines impacts more thoroughly, presented in the following sections.



4a) Average daily asking rents



4b) Total daily occupancy rates



4c) Average property values

(5) Occupancy rates and values fell for flooded properties

- Figures 5a and 5b plot **event study model** coefficients for the marginal difference in occupancy rates between properties that were flood exposed (treatment) and those that were not (control), controlling for property-specific characteristics and submarket-level trends (Miller, 2023).
- Results for **occupancy rates** (figure 5a) indicate no initial differences between treatment and control groups, an early decline from 2015 and 2016 flooding, a sharp decline into 3Q17 following Harvey, bottoming in 4Q17, and a return to market levels during 3Q19 (2 years post-Harvey).
- Results for **property values** (figure 5b) also indicate an early decline prior to Harvey, trough following Harvey in 2018, and recovery trend through 2020 consistent with the patterns observed for occupancy rates.

Figure 5a. Effect of flooding on occupancy rates

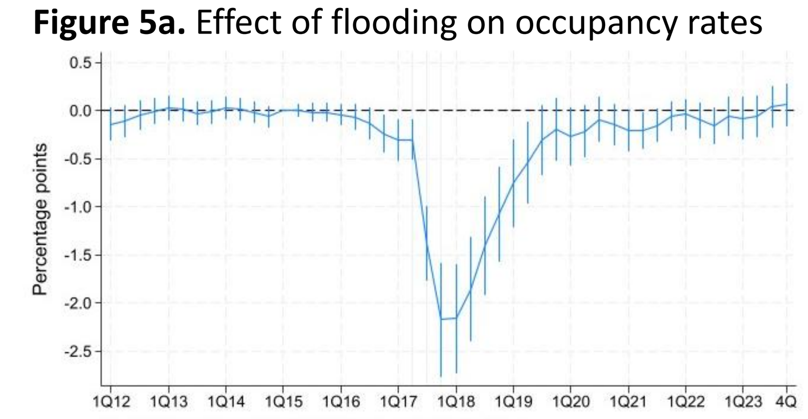
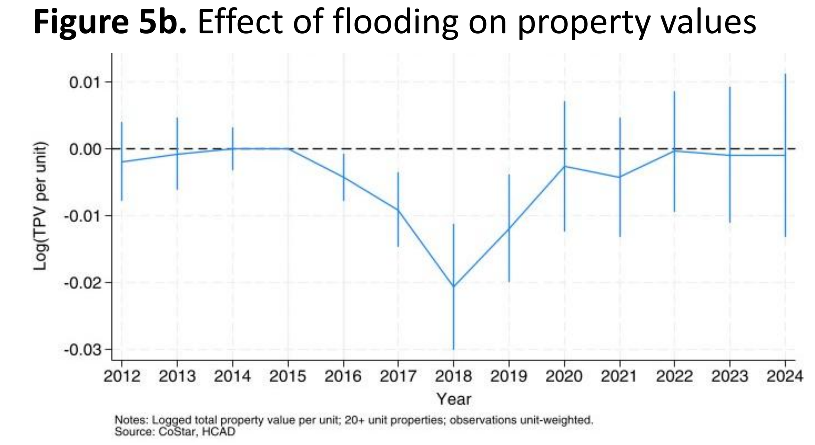


Figure 5b. Effect of flooding on property values



(6) Flood risk tied to renovation, affordability, & ownership

Table 1 provides output for the flood risk and flood exposure models.

- The **flood risk models** examine how property characteristics, market segments, and owner types and characteristics are associated with a property being in the 100-year flood zone.
- The **flood exposure models** examine how the same set of characteristics are associated with actual Harvey flooding.

Select highlights from the results:

- Significant flooding in and out of the 100-year flood zone → some say flooding was indiscriminate
- Recently renovated properties were more likely to be in the 100-year flood zone and flooded → indicates repeat flooding and flood-induced renovation
- Locally-based owners and owners with more properties in the Houston MSA more likely to own properties in the flood zone → local knowledge, willing to accept hazard risks
- Properties with subsidized units and those that are user-owned were less likely to in flood zone; Properties with subsidized units less flooded → affordable housing development policy and practice

Table 1. Flood risk and exposure models

	(1) 1=in100yr	(2) flood intensity	(3) flood intensity out of 100-yr	(4) 1=in100yr	(5) flood intensity	(6) flood intensity out of 100-yr
CONSTANT	**-2.1519*** **	**0.4711***	**0.5045***	**-2.8432*** **	0.3341	0.4359
UNIT CONFIG (ref=studio)						
1-Bed				-0.1621	0.1480	0.1416
2-Beds				-0.1191	**0.1765+**	**0.1782+**
3-Beds				-0.1943	0.1801	**0.2211+**
HAZARD						
1=in 100 year		**1.0114*** **			**1.1153*** **	
PROPERTY SIZE (ref=[5,19] units)						
[20,49]	**0.7726***	**0.2655***	**0.3498***	**0.9609** **	**0.2721***	**0.3582***
[50,149]	**1.2621** **	0.2302	0.2475	**1.5073*** **	0.0945	0.1042
[150,299]	**1.4246*** **	0.2228	**0.2645+**	**1.8885*** **	0.0581	0.1150
[300,+]	**1.2667** **	0.1383	0.1344	**1.7584*** **	-0.0328	-0.0244
PROPERTY CHARACTERISTICS						
age in 2017 (years÷10)	**-0.1116***	0.0350	0.0352	0.0519	0.0167	0.0205
1=mid- or hi-rise	-0.1211	**0.6615***	0.4966	-0.3828	0.2324	0.1033
1=has amenities	-0.1979	**-0.2355***	**-0.2831***	-0.1947	**-0.2633** **	**-0.3176** **
1=renovated in past 2 years	**0.5964*** **	**0.4156** **	**0.3242***	**0.6410*** **	**0.4970*** **	**0.3846*** **
1=onsite property management	-0.2397	-0.0497	-0.0272	**-0.3618***	-0.0988	-0.1200
1=has affordable units	**-1.1116***	-0.1636	**-0.2433***	**-0.7581***	**-0.2850** **	**-0.3991*** **
RENT TIER (ref=lower)						
lower-middle	**-0.3759+**	0.0913	0.1187			
middle	**-0.5756** **	0.0475	0.0201	**-0.6472*** **	0.0931	0.0149
middle-upper	**-0.6525***	0.1551	0.0107			
upper	**-0.8576** **	0.0953	0.0225	-0.2406	**0.4210*** **	**0.2749***
no rent data for property	0.1064	0.1539	0.1112	0.0694	0.1970	0.0675
OWNER TYPE (ref=individual)						
institutional	-0.3429	0.1395	0.1357	-0.2519	**0.2457***	**0.3106** **
publicly-traded	-0.7937	-0.2406	-0.2086	-0.6421	-0.0258	0.0054
developer/owner	-0.0328	0.0088	0.0395	-0.1707	**0.1899***	**0.2339** **
other private	-0.0146	-0.1808	-0.1626	**-0.5327+**	-0.0062	0.0111
user	0.0444	-0.1572	-0.0836	**-1.3782** **	-0.1234	-0.0862
.uncategorized	-0.1900	-0.0447	-0.0539	-0.2220	-0.0552	-0.1086
OWNER LOCATION (ref=MSA)						
Texas	-0.2495	0.0628	0.0168	**-0.5906***	0.1407	0.0667
USA	-0.1469	0.1022	0.1134	**-0.3415+**	**0.1646***	**0.1528***
International	0.4730	-0.0364	-0.1519	**0.5941+**	0.0411	-0.1435
.uncategorized	0.0538	-0.0659	-0.2382	0.7125	**-0.2123***	**-0.2044***
OWNER SCALE						
Number of properties in portfolio	-0.0005	0.0006	0.0010	-0.0008	0.0002	0.0006
Number of properties in MSA	**0.0186***	-0.0018	-0.0031	**0.0135+**	0.0004	-0.0015
Number of observations	2,235	2,235	1,973	4,960	4,960	4,336
P-value	0.0000	0.0000	0.0199	0.0000	0.0000	0.0000
(Pseudo) R-squared	0.0540	0.0615	0.0239	0.0609	0.0899	0.0379
Adjusted R-squared	--	0.0496	0.0104	--	0.0845	0.0316
Model type	logit	OLS	OLS	logit	OLS	OLS
Robust standard errors	✓	✓	✓	✓	✓	✓
Unit-weighted	--	--	--	✓	✓	✓

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Observations are properties for columns (1) to (3) and unit configurations nested within properties for columns (4) to (6). Columns (4) to (6) are weighted by number of units. Robust standard errors. Untransformed coefficients reported for logit regression models. The owner type "institutional" includes owners such as banks, insurance companies, pension funds, and private equity; "user" includes owners such as housing agencies and non-profits.

(7) Building height, rent level, & owner type moderated impacts

Disaster impact model output is provided in table 2 examining the changes between two periods for occupancy rates and property values. The general estimating equations are:

- $Y_2 = Y_1 + X\beta + \underline{flood + X\beta * flood} + error$
- $Y_2 - Y_1 = X\beta + \underline{flood + X\beta * flood} + error$
- Y_2 is a property's occupancy rate or property value after Harvey, Y_1 is before;
- $X\beta$ is same set of variables as above;
- flood is the flood intensity measure, and
- flood*Xβ is the interaction with select variables in Xβ.

Select highlights from the results:

- Columns (1), (3) and (5) indicate decline in occupancy rates, level and percent change in values associated with increased flooding
- Mid- and hi-rise properties fared better than lower-rise (e.g., garden style, townhome) → supportive of vertical development
- Lower occupancy rates for higher-rent properties relative to lower-rent → suggests affordable housing demand/needs
- Less short-term impacts for properties with subsidized units → faster recovery, why?
- Publicly-traded owners (e.g., Camden) recovered more quickly because locally headquartered, internal capacity and scale, and likely, pre-established relationships

Table 2. Disaster impact models

	(1) Occupancy rate (4Q17)	(2) Occupancy rate (4Q17)	(3) Value (2018)	(4) Value (2018)	(5) log(val 2018) -log(val 2015)	(6) log(val 2018) -log(val 2015)
Lagged dependent variable	✓	✓	✓	✓	--	--
HAZARD						
flood intensity	**-0.1496*** **	0.0425	**-1,036.23*** **	368.72	**-0.0204*** **	-0.0070
UNIT CONFIG (ref=studio)						
1-Bed		-0.1190				
2-Beds		-0.1188				
3-Beds		-0.1321				
PROPERTY SIZE (ref=[5,19] units)						
[20,49]		0.0400		ref.		ref.
[50,149]		0.0353		493.15		0.0144
[150,299]		-0.0913		-793.37		-0.0215
[300,+]		-0.0371		-485.24		-0.0143
PROPERTY CHARACTERISTICS						
age in 2017 (years÷10)		-0.0036		-110.93		-0.0019
1=mid- or hi-rise		**0.2200*** **		-302.39		0.0134
1=onsite property management		0.0186		-371.79		-0.0149
1=has affordable units		0.0952		**2,195.17***		**0.0654+**
RENT TIER (ref=lower)						
lower-middle				950.06		**0.0400+**
middle		**-0.0740***		-132.81		0.0173
middle-upper				107.36		0.0111
upper		**-0.1114***		721.37		0.0272
no rent data for property				-848.43		-0.0180
OWNER TYPE (ref=individual)						
institutional		-0.0472		-881.21		-0.0102
publicly-traded		**0.3766*** **		**3,455.98+**		**0.0557+**
developer/owner		0.0545		395.76		0.0051
other private		-0.0693		1,272.97		-0.0124
user		0.0768		1,491.13		0.0136
.uncategorized		**0.1726***		979.77		0.0515
OWNER LOCATION (ref=MSA)						
Texas		0.0869		-450.52		-0.0187
USA		0.0439		-1,373.84+		-0.0020
International		0.0209		-1,351.82		-0.0182
.uncategorized		**0.5751***		11,274.33		0.2485
OWNER SCALE						
Number of properties in portfolio		-0.0005		8.97		-0.0000
Number of properties in MSA		-0.0013		-48.22		-0.0006
Base effects and controls	✓	✓	✓	✓	✓	✓
Submarket fixed effects	✓	✓	✓	✓	✓	✓
Number of observations	4,415	4,415	1,537	1,537	1,537	1,537
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(Pseudo) R-squared	0.0666	0.0729	0.9117	0.9134	0.1715	0.1900
Adjusted R-squared	--	--	0.9079	0.9082	0.1367	0.1420
Model type	fractional logit	fractional logit	OLS	OLS	OLS	OLS
Robust standard errors	✓	✓	✓	✓	✓	✓
Unit-weighted	✓	✓	✓	✓	✓	✓

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Observations are unit configurations nested within properties and are weighted by number of units for columns (1) and (2) and properties also unit-weighted for columns (3) to (6). Columns (3) to (6) exclude properties with less than 20 units. Robust standard errors. Untransformed coefficients reported for fractional logit regression models. Lagged dependent variable for columns (1) and (2) are occupancy rates for 1Q15; for columns (3) and (4), 2015 property values. The dependent variable for columns (5) and (6) is the difference of the logged 2018 value and logged 2015 value. All values are standardized by the number of units in the property. Base effects are omitted from the table for brevity. All effects presented are the interaction between the variable and flood intensity measure.

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