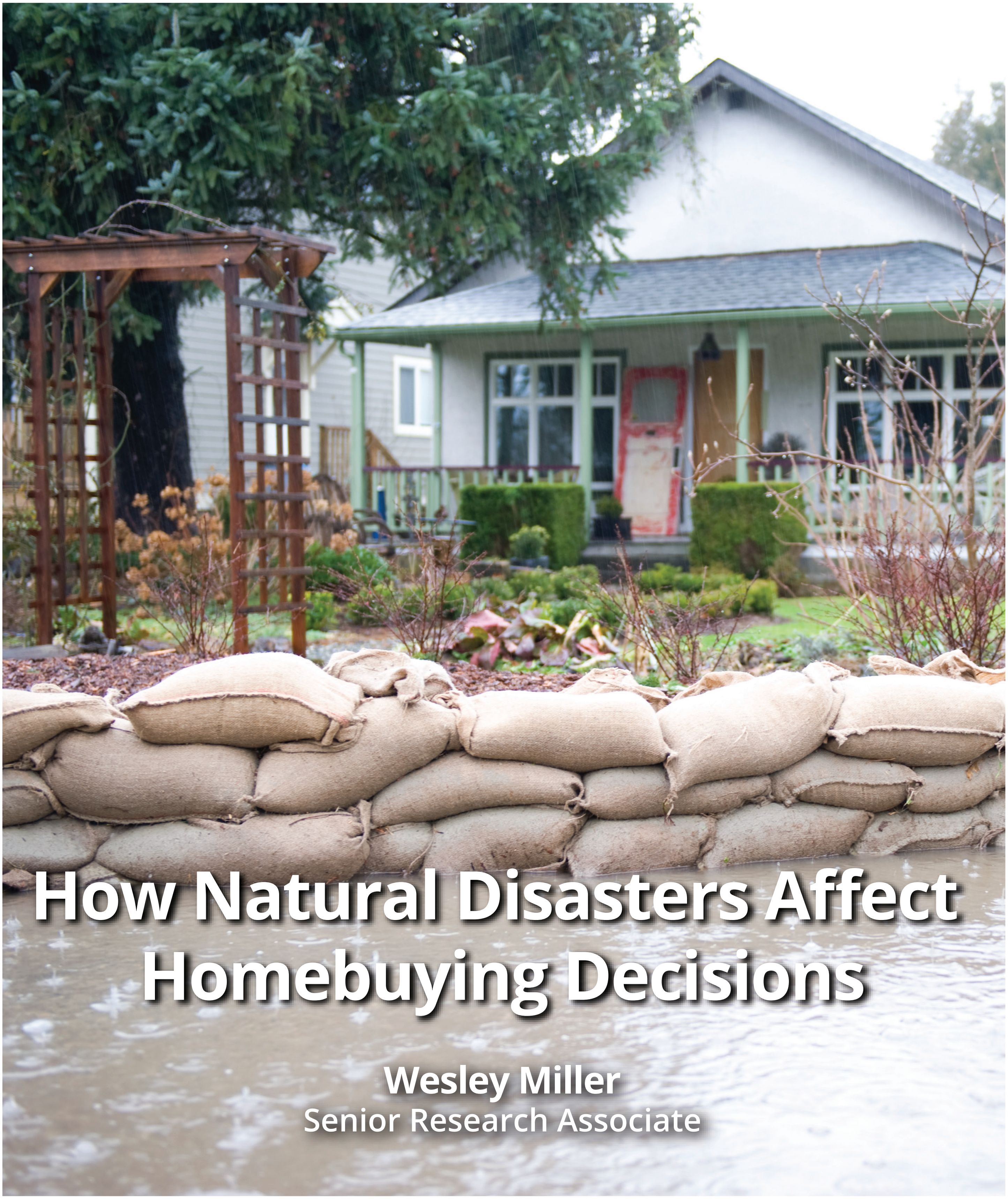

How Natural Disasters Affect Homebuying Decisions

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Texas Real Estate Research Center

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Table of Contents

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Introduction

The combination of climate change and economic growth in disaster-prone regions increasingly exposes Texas' population to extreme weather events (IPCC, 2023). Natural disasters have an immediate impact on economic activity and typically lead to net out-migration, decreased income, and lower real estate values (Boustan et al., 2020).

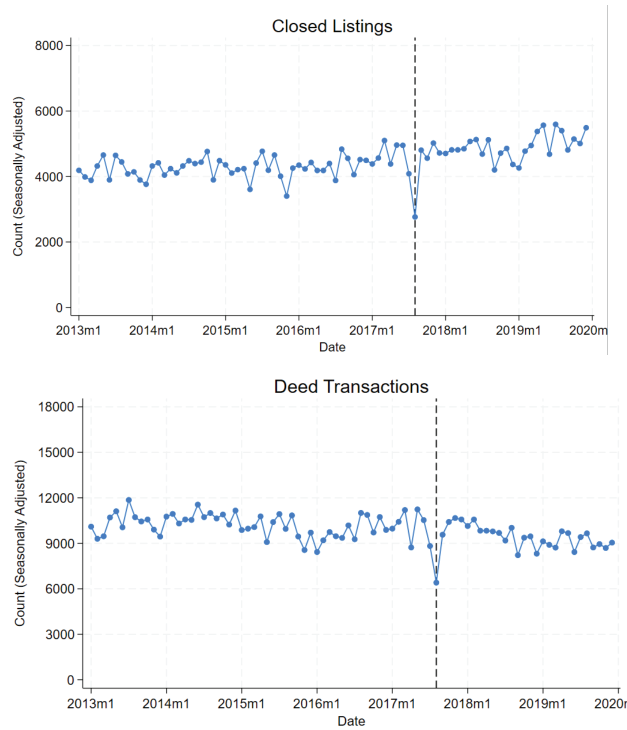
While the regional impacts of disasters are well documented, much less is known about how Texans have responded in terms of their housing and neighborhood choices. Housing market outcomes following disasters reflect the choices of those directly impacted and others whose choices may reflect awareness of the disaster. Households and businesses may change their location and investment decisions based on an area's perceived disaster risks.

These choices drive housing activity during the recovery process, and understanding the circumstances in a post-disaster market can make real estate professionals better equipped to find housing for their clients after these events. Moreover, household responses to natural disasters have important implications for changes to the local tax base and neighborhood composition. All these factors interact with policy decisions surrounding land use and building regulation, insurance markets, and disaster relief.

It's possible to glean some insights from Hurricane Harvey, which wreaked havoc on hundreds of thousands of people in the Houston area when it struck in August 2017.

Harvey produced record-level rainfall that impacted more than 200,000 Houston homes, approximately 10 percent of the MSA's housing stock, and caused $125 billion in direct damage. The shock to local home sales was immediate as the storm disrupted real estate transactions (Figure 1). Housing sales, however, normalized within a few months. A deeper understanding of disaster response is necessary to explain the recovery pattern.

Figure 1. Post-Harvey Drop in Houston Housing Sales



Notes: Monthly counts are seasonally adjusted.

Source: Multiple Listing Service and deed transaction data is obtained from the Texas Real Estate Research Center's Data Relevance Project and CoreLogic, respectively.

Flooding Across Houston

Although flooding from Hurricane Harvey was widespread, the destruction was unevenly distributed socioeconomically (Torres and Miller, 2018). There are several reasons why flood damage correlates with socioeconomic factors. Risk-averse individuals may select away from water sources or implement mitigation measures (e.g., the installation of flood vents). Others may value water as an amenity and prefer to live near the natural resource, increasing their risk of flooding. Sources of correlation extend beyond individuals, as community-level infrastructure investment and maintenance decisions are important determinants of local damage.

Historical development patterns also influence the differences in disaster impact. For instance, older neighborhoods may be near waterways because of the historic importance of water-borne trade.

The Addicks and Barker Reservoirs are Houston's primary flood infrastructure, as their earthen dams prevent runoff from the Katy Prairie from inundating the city center during storms. The Army Corps of Engineers developed the reservoirs in the 1940s by constructing the dams and acquiring 25,000 acres of abutting land. This government-owned land is designed to temporarily detain rainfall and allow for controlled drainage into the Gulf of Mexico (Furrh and Bedient, 2023).

Unlike lake-forming reservoirs, the government-owned land is perennially dry outside of extreme rainfall and is used as wooded parks, athletic fields, and other alternative uses, effectively masking its flood risk to surrounding suburbs. While inland flood exposure typically depends on proximity to flowing water, Panel A of Figure 2 shows how the reservoirs create a pool based on a tub concept, where water rises uniformly with the basin irrespective of the location of water flow. Panel B illustrates how Hurricane Harvey's unprecedented rainfall filled the Addicks and Barker Reservoirs, forcing water above the government-owned land for the first time and flooding thousands of homes. These homes lie outside of the 100-year floodplain, a classification that serves as the primary flood-risk signal in housing markets.

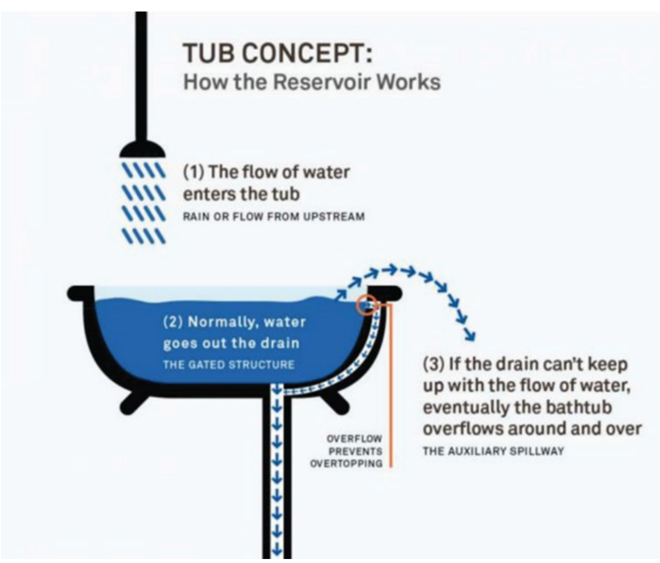
Natural Experiment and Empirical Strategy

The relatively unknown risk and unique flooding mechanism of the Addicks and Barker Reservoirs present a unique setting to estimate the causal effects of disaster damage by comparing outcomes of households in the same subdivision who live just above and just below the peak water level reached during Hurricane Harvey. Property and household characteristics should be identical on both sides of the peak water level, because people could not predict that level when making residential-sorting decisions months or years before the storm. The only difference between homes slightly above and below the peak water level should be flood damage during Hurricane Harvey. This setting approximates a local randomized experiment, where identical homes receive different magnitudes of flood damage.

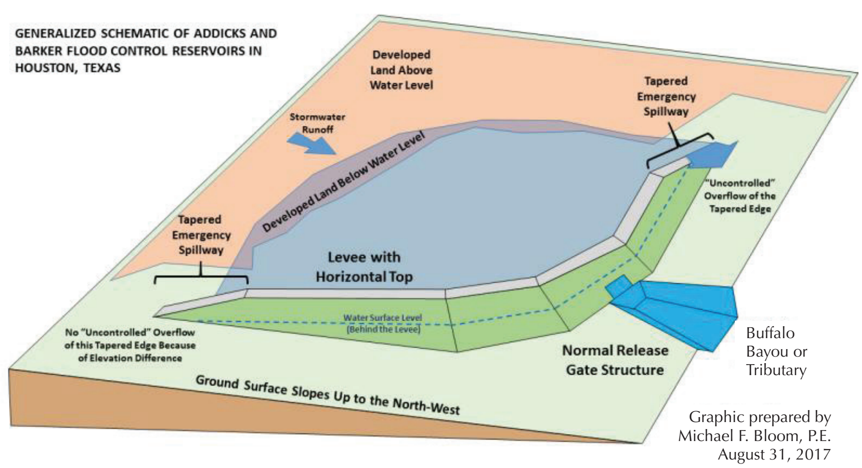
This empirical strategy exploits the fact that the intensity of flood damage decreases with a property's elevation up to the peak water level. For example, National Flood Services LLC estimates approximately $37,000 in structural damage for a 2,500-sf, one-story home that is exposed to six inches of water compared with $24,000 in damage for the same home exposed to a single inch. No damage is expected for homes lying above water (FloodSmart, 2019). This approach is formalized using a fuzzy regression discontinuity design.

Figure 2. Flooding Mechanism

Panel A: General Tub Concept



Panel B: Addicks and Barker Reservoir Overview



Source: O'Neil (2020) and Bloom (2017)

Data

There are roughly 100,000 homes distributed across 2,200 subdivision phases across the Addicks and Barker watersheds. The table summarizes the characteristics of these homes, which were typically constructed in the mid-1990s but vary in size and value. Household-level property damage is estimated as the change in appraised value before and after Hurricane Harvey, and the average damage was $1,333 and $6,681 in the Addicks and Barker Watersheds, respectively. While appraisal changes are imperfect measures of flood damage, they correlate closely with FEMA's estimates of flood depth during Hurricane Harvey.

Properties are exposed to flood damage when water exceeds their first-floor elevation, which is approximated using aerial light detection and ranging (LiDAR) data (TNRIS, 2022). Figure 3 illustrates the distribution of LiDAR points across two residential parcels in the Barker Watershed. For simplicity, it is assumed that residential structures lie at the parcel's maximum elevation point.

Although damage should jump immediately as water enters the home, Figure 4 suggests a smooth relationship between elevation and flooding. The smoothness is caused by measurement error in first floor elevation (i.e., some structures lie above or below the maximum ground elevation observed in the LiDAR data). Statistical bias caused by this measurement error can be addressed by removing certain observations (shaded grey), revealing an average increase of $47,795 in flood damage for homes lying just below the peak water level reached during Hurricane Harvey.

While flood damage distinctly depends on the peak water level, Figure 5 reveals no such relationship between pre-Harvey property characteristics and elevation. In particular, the distribution of home size is essentially identical above and below the peak water level. A similar pattern holds for other property characteristics (e.g., year of construction, lot size, etc.). This is unsurprising as Harvey's precise magnitude was unpredictable when households moved into these neighborhoods. Since households above and below the peak water level are essentially the same before the storm, any post-storm differences that appear are attributed to the impact of flood damage.

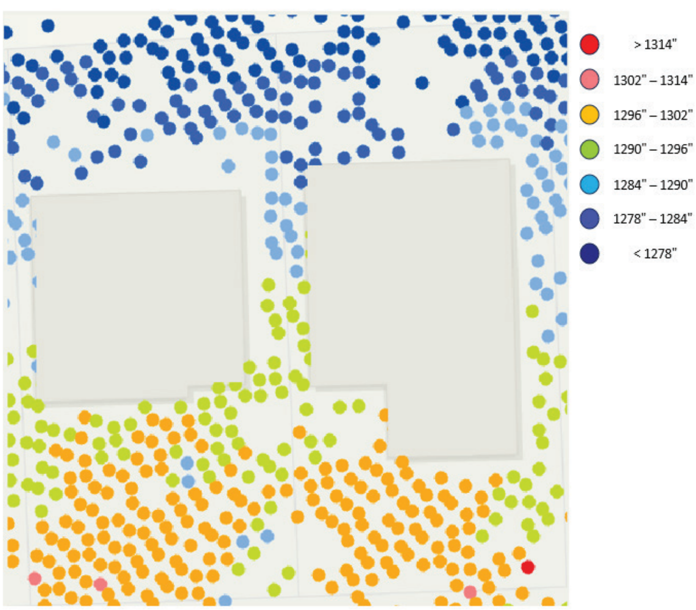
Summary Statistics

Mean	Addicks Watershed	Barker Watershed
Year of Construction	1995	1994
Square Feet	2230	2707
2017 Appraised Value	$183,538	$288,806
Estimated Damage	$1,333	$6,681
Number of Subdivision Phases	1,637	852
Number of Owner-Occupied Homes	65,735	35,022

Notes: Summary statistics of owner occupied single-family residential properties located in the Fort Bend and Harris County portions of the Addicks and Barker Watersheds. Appraisal district data are obtained from CoreLogic.

Sources: CoreLogic, Harris Central Appraisal District, and Fort Bend Central Appraisal District

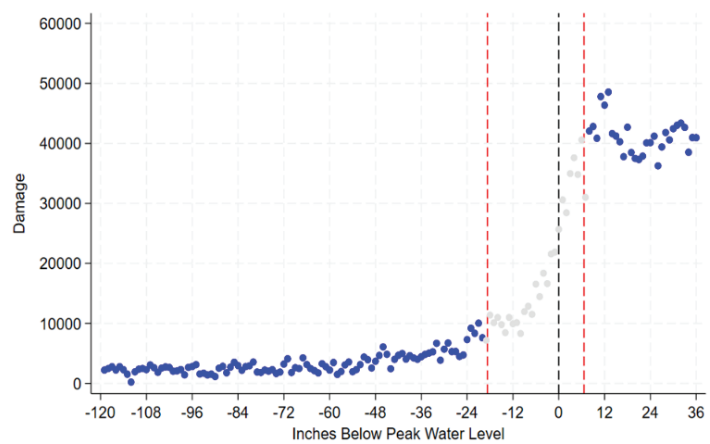
Figure 3. Property-Level Ground Elevation



Notes: Aerial LiDAR ground elevation points (measured in inches) for two residential properties in Oak Park Trails Subdivision in the Barker Reservoir. Property parcel shapefiles are available at the Harris and Fort Bend Central Appraisal Districts.

Source: Aerial LiDAR data accessed from TNRIS (2022)

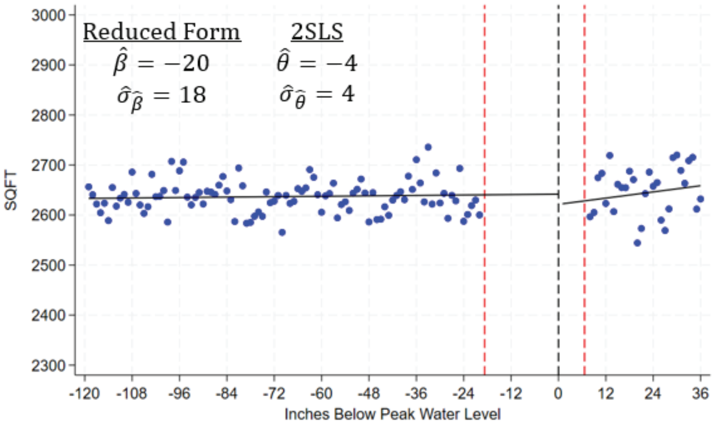
Figure 4. Damage-Elevation Relationship



Notes: The coefficient plot is generated by rounding elevation to the nearest inch and estimating a subdivision fixed effects model saturated in 1-inch elevation dummy variables. The sample mean of the outcome variable is added back to the coefficient estimates for illustrative purposes. The red lines correspond to the preferred sample trimming at -18.7 and 6.6 inches below the peak water level.

Sources: TNRIS and CoreLogic

Figure 5. Home Size and Elevation



Notes: The regression estimates and lines are based on a local linear regression with rectangular kernels and a preferred bandwidth of [-120.0,-18.7] and [6.6,36.0]. Standard errors are clustered at the subdivision-phase level. The coefficient plots are generated by rounding elevation to the nearest inch and estimating a subdivision fixed effects model saturated in 1-inch elevation dummy variables. The sample mean of the outcome variable is added back to the coefficient estimates for illustrative purposes. The red lines correspond to the preferred sample trimming at -18.7 and 6.6 inches below the peak water level.

Sources: TNRIS and CoreLogic

Results

Natural disasters are associated with increased residential mobility (Boustan et al., 2020). Billings et al. (2022) and Gallagher et al. (2023) indicate a similar pattern after Hurricane Harvey, when out-of-Houston migration spiked immediately after the storm. Migration rates, however, were roughly the same in flooded and non-flooded census blocks, suggesting neighborhood-level damage played little role in individuals' mobility decisions.

While individuals may not differentiate relocation decisions based on *neighborhood* damage intensity, Panel A of Figure 6 indicates the importance of *property*-level damage in influencing behavior. Households exposed to $10,000 of flood damage are 2 percentage points (40 percent) more likely to move out of their pre-Harvey residence within six months of the storm compared to their non-flooded neighbors who lived above the peak water level. Panel B illustrates the estimated cumulative impact on residential mobility through

Figure 6. Residential Mobility

Notes: Residential mobility is measured using data from Infutor, a proprietary data source used to construct residential address histories. The point estimate is the estimated causal effect of $10,000 of damage, reflecting the ratio of the reduced-form and first stage effects. Panel A is based on an indicator for Infutor observing at least one individual in household j moving between September 2017 and March 2018. The regression estimates and lines are based on a local linear regression with rectangular kernels and a preferred bandwidth of [-120.0,-18.7] and [6.6,36.0]. Standard errors are clustered at the neighborhood level. The coefficient plots are generated by rounding elevation to the nearest inch and estimating a subdivision fixed effects model saturated in 1-inch elevation dummy variables. The sample mean of the outcome variable is added back to the coefficient estimates for illustrative purposes. The red lines correspond to the preferred sample trimming at -18.7 and 6.6 inches below the peak water level. Panel B plots the point estimates and 95 percent confidence intervals using a cumulative outcome variable for each post-storm quarter. For example, the estimates for 1Q2018 are based on whether at least one individual in a household moved between September 2017 and March 2018. Standard errors are clustered at the neighborhood level.

Sources: TNRIS, CoreLogic, and Infutor

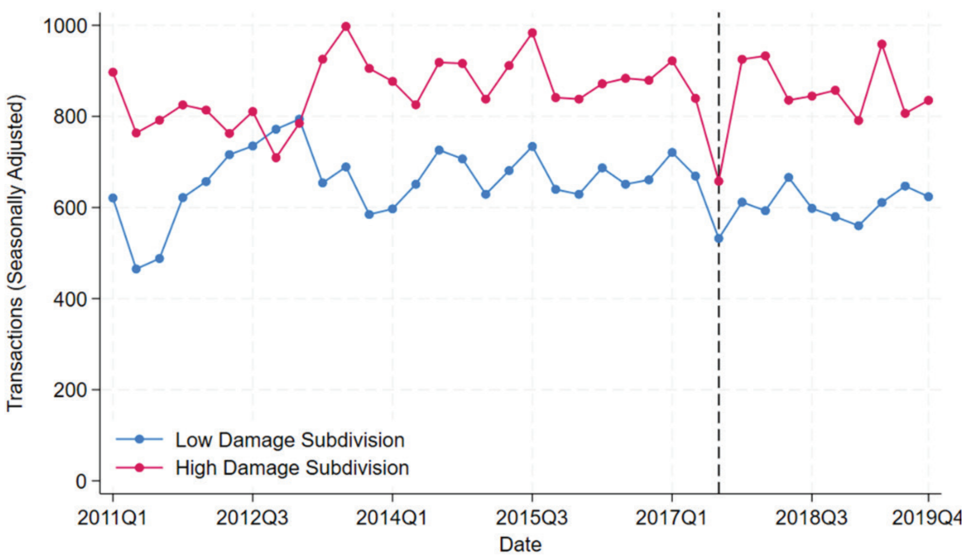
ten quarters. The initial wave of moves occurs in 4Q2017 and 1Q2018 before attenuating through 2019. Panels C and D reveal differential dynamics across move types. Damage causes an immediate increase for within-county moves that persists for nearly two years. On the other hand, there is a delayed impact on out-of-county moves that lasts several quarters before dissipating. Longer distance moves may require more planning and carry higher transaction costs that prevent an instantaneous response during disaster events.

Economic theory predicts an aggregate decrease in housing market transactions after natural disasters that results from a combination of decreased housing stock and demand. Similar to trends in residential mobility, Figure 7 displays the lack of relationship between local-level damage and home sales. The number of home sales in high- and low-damage subdivisions track similarly before and after Hurricane Harvey. If anything, high-damage subdivisions suffer a stronger shock on impact and then rebound higher for longer.

The results in Figure 8, however, confirm that property-level damage causes a decrease in housing sales in the short run. Suffering \$10,000 of damage decreases homeowners' propensity to sell within six months by 0.3 percentage points (21 percent) relative to their non-flooded neighbors who lived just above the peak water level. The cumulative impact grows for about a year and appears to persist through 2019. Homeowners on the margin of moving may choose to repair their property before selling, and many flooded households were forced to wait months after Hurricane Harvey for full disbursement of disaster aid or insurance payments to help fund this investment.

While the effects on homeowners' relocation decisions attenuate over

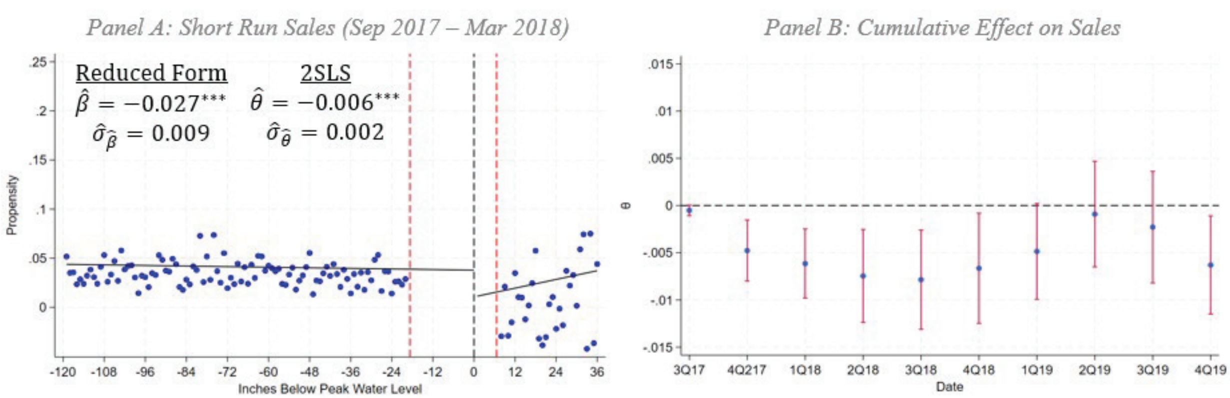
Figure 7. Home Sales in Houston's Addicks, Barker Reservoirs' Subdivisions



Notes: The count of CoreLogic deed transactions are collapsed at the subdivision-phase level. Subdivision-phases with above zero average property damage are classified as "high damage." The two series are residualized by quarter and rescaled by the constant term.

Source: CoreLogic

Figure 8. Housing Sales



Notes: The point estimate is the estimated causal effect of \$10,000 of damage, reflecting the ratio of the reduced-form and first stage effects. Panel A is based on an indicator for property *j* having a deed recorded between September 2017 and March 2018. The regression estimates and lines are based on a local linear regression with rectangular kernels and a preferred bandwidth of [-120.0,-18.7] and [6.6,36.0]. Standard errors are clustered at the neighborhood level. The coefficient plots are generated by rounding elevation to the nearest inch and estimating a subdivision-phase fixed effects model saturated in 1-inch elevation dummy variables. The sample mean of the outcome variable is added back to the coefficient estimates for illustrative purposes. The red lines correspond to the preferred sample trimming at -18.7 and 6.6 inches below the peak water level. Panel B plots the point estimates and 95 percent confidence intervals using a cumulative outcome variable for each post-storm quarter. For example, the estimates for 1Q2018 are based on whether a property had a deed recorded between September 2017 and March 2018. Standard errors are clustered at the neighborhood level.

Sources: TNRIS and CoreLogic

time, there is a persistent impact on housing consumption. For example, Figure 9 illustrates the effect of flood damage on the probability of households owning their post-Harvey residence. Suffering $10,000 of damage decreases homeownership by 0.8 percentage points (1 percent) through 2019. This estimate is statistically significant at the 95 percent confidence level despite flooded and non-flooded households changing their residences at roughly the same rate by the end of this period. The estimated decrease in homeownership is particularly stark given that only 15 percent of the sample relocated from their pre-storm residence during the 30-month post period. Conditioning on the set of movers in Panel B reveals a large transition out of owner occupancy. In particular, households exposed to $10,000 of damage are 5.5 percentage points (or 8 percent) less likely to own their next residence compared to their non-flooded peers. In other words, Harvey-related damage prevented roughly 1,100 home sales through 2019, resulting in around $300 million in lost dollar volume.

The transition out of homeownership occurred during a period of substantial home-price appreciation in Houston, where the average sale price increased 42 percent between 2017 and 2022. The average pre-storm home value for households who were located below the peak water level and who transitioned out of homeownership was roughly $245,000. Applying the average increase in sale price, these homes would have surpassed an average of $347,000 by 2022. This appreciation combined with an average of $73,000 of damage incurred by these households suggests approximately $175,000 of potential lost wealth for households who transitioned into renter occupancy because of flooding.

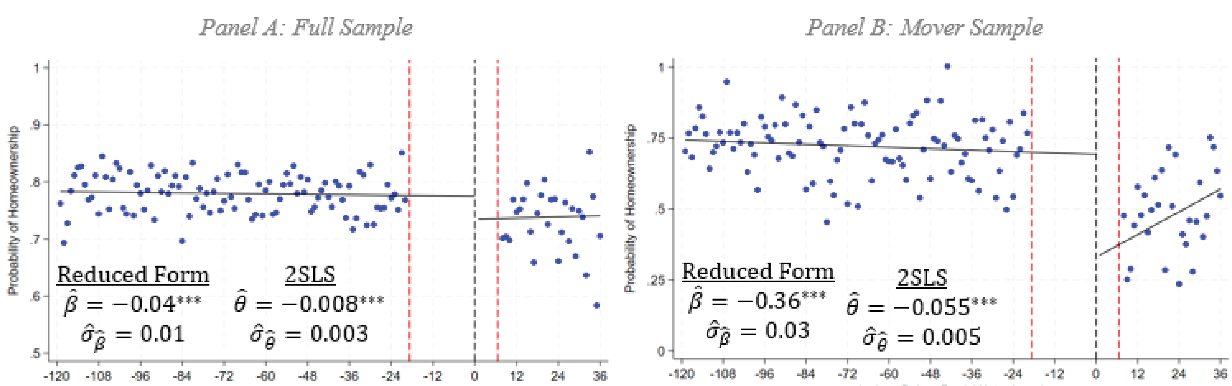
The impact of flood damage extends to the types of neighborhoods and homes where individuals choose to live. Results in Figure 10 indicate that impacted households tend to sort into higher-valued homes and higher-income neighborhoods. These changes in socioeconomic environment, combined with the estimated decrease in homeownership, highlight the potential tradeoffs in a post-disaster environment.

Conclusion

Housing choices are central to individual well-being. The decision to remain in a home or move to a new location could impact access to certain labor markets, health care systems, school districts, and other amenities. Movers must decide where to relocate, and the characteristics of their neighborhood may affect themselves or other members of their household through environmental or peer effects (Chyn and Katz, 2021). They must also decide whether to rent or purchase their new residence, an investment decision that may impact wealth creation and intergenerational mobility.

Property-level damage increases residential mobility in the short run, particularly for shorter-distance moves. In contrast, disaster damage delays and prevents home sales

Figure 9. Estimated Average Treatment Effect on Homeownership

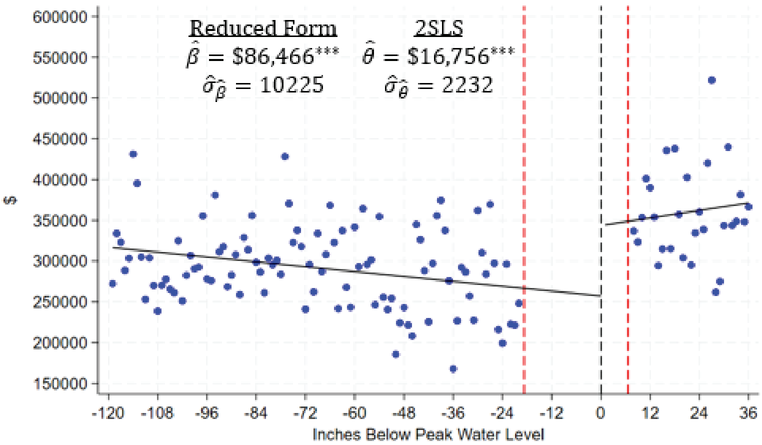


Notes: An individual is considered a post-storm renter if they sold their home after Hurricane Harvey and did not appear in Texas appraisal-district data at their new address before 2022. The American Community Survey indicates that a majority of interstate movers rent their new residence, and due to data constraints, people who leave Texas are assumed to be post-storm renters. The left side of Panel A uses the full sample including homeowners who do not sell after Hurricane Harvey. The right side of Panel B restricts the sample to movers. The point estimate is the estimated causal effect of $10,000 of damage, reflecting the ratio of the reduced-form and first stage effects. The regression estimates and lines are based on a local linear regression with rectangular kernels and a preferred bandwidth of [-120.0,-18.7] and [6.6,36.0]. Standard errors are clustered at the neighborhood level. The coefficient plots are generated by rounding elevation to the nearest inch and estimating a subdivision-phase fixed effects model saturated in 1-inch elevation dummy variables. The sample mean of the outcome variable is added back to the coefficient estimates for illustrative purposes. The red lines correspond to the preferred sample trimming at -18.7 and 6.6 inches below the peak water level.

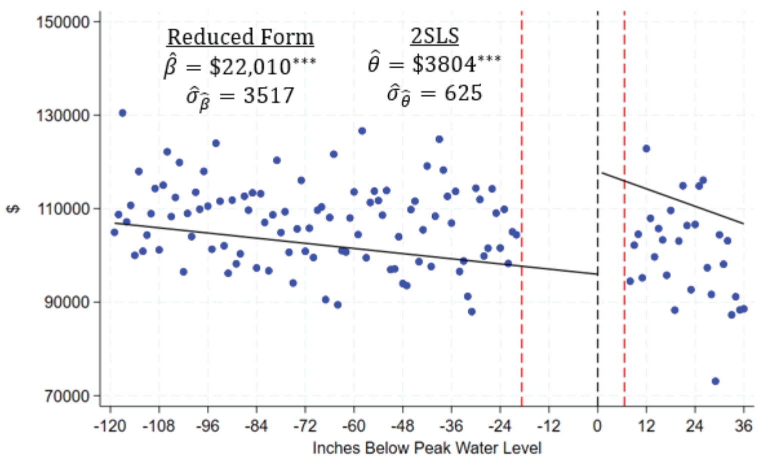
Sources: TNRIS, CoreLogic, and Infutor

Figure 10. Neighborhood and Home Choice for Movers

Panel A: Post-Storm Home Values (2020)



Panel B: Post-Storm Census Tract Average Income (2020)



Notes: Figure 10 restricts the sample to individuals who sold their home after Hurricane Harvey and who have a post-storm address in the Infutor data. Panel A considers only those who relocated within Texas, as matching post-storm movers to appraisal district data is only possible within the state, while Panel B includes movers who relocated across the United States. The point estimate is the estimated causal effect of $10,000 of damage, reflecting the ratio of the reduced-form and first stage effects. The regression estimates and lines are based on a local linear regression with rectangular kernels and a preferred bandwidth of [-120.0,-18.7] and [6.6,36.0]. Standard errors are clustered at the neighborhood level. The coefficient plots are generated by rounding elevation to the nearest inch and estimating a subdivision-phase fixed effects model saturated in one-inch elevation dummy variables. The sample mean of the outcome variable is added back to the coefficient estimates for illustrative purposes. The red lines correspond to the preferred sample trimming at -18.7 and 6.6 inches below the peak water level.

Sources: TNRIS, CoreLogic, Infutor, and U.S. Census Bureau

for multiple years. These opposite effects align with theoretical predictions of disaster damage making a portion of the housing stock uninhabitable. In addition to impacting locational choices, household-level damage pushes people out of homeownership. Despite the combined shock to shelter and wealth, flooded households are more likely to sort into higher-income census tracts. This relative improvement in physical and socioeconomic environments mirrors the long-run recovery patterns documented in the disaster literature (Sacerdote, 2012; Deryugina et al., 2018; Deryugina and Molitor, 2020). Since disaster damage pushes people out of their neighborhoods and into new economic environments, the impacts of extreme weather may extend into other aspects of life. These neighborhood effects may augment or offset the transition into different types of housing or housing tenure.

The combination of results raises important questions about the effectiveness of disaster aid. For example, the delayed effect on housing transactions may indicate that SBA loans are protecting people from losing their homes after catastrophic events. On the other hand, disaster damage net of relief efforts led to a substantial transition out of homeownership and into renter occupancy. The normative implications of this transition are unclear, especially as flooded households tend to relocate into higher income neighborhoods that may offer improved economic opportunities.

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