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RESEARCH ARTICLE

Homeowner Preference for Household-level Flood Mitigation in US: Analysis of a Discrete Choice Experiment

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Abstract
The Federal Emergency Management Agency (FEMA) offers a portfolio of flood risk mitigation options for high-risk homeowners, hoping to reduce flood damages. Buyout (home acquisition) and home retrofit (e.g., home elevation) are candidates available to homeowners. FEMA has recently amended and increased its buyout efforts. This study examines homeowners' stated preference for buyout and home elevation contracts using survey data. Results indicate multiple factors influence the decision to participate in home acquisition and elevation programs. Importantly, we find that preferences vary with the timing (whether the contract is offered before or after a damage event) of the contract offered.

Keywords: buyout; choice experiment; flood insurance; flood risk and mitigation; home elevation; willingness to accept

JEL classifications: D12; Q54; Q58

1. Introduction

The National Flood Insurance Program (NFIP) is the most subscribed public disaster program tasked with disaster preparedness and recovery in the US. Yet, the program is challenged with solvency issues partly due to program design.[1] The program has accumulated debt exceeding $20 billion (Congressional Research Service, 2019), and efforts to achieve solvency through risk-based premium rate structures have met public resistance, rolling back proposed rates increases (Frimpong et al., 2019). Consequently, this has raised concerns about program performance and sustainability.

In lieu of actuarially fair risk-based premium rate structures, and with recognition that hardened structures like sea walls, levees, and dams should not be used in all cases to reduce risk exposure (Fan and Davlasheridze, 2016), the Federal Emergency Management Agency (FEMA) is increasingly using government buyouts (home acquisition) to address NFIP's solvency challenges. Buyouts are government efforts to buy and retire severely (about 50%) damaged or repetitive-loss properties or relocate structures to areas with lower flood risk. Generally, buyouts are funded through FEMA's Hazard Mitigation Grant Program (HMGP) (Mach et al., 2019), which provides 75% federal minimum cost share. The remaining 25% matching funds are either supported by local government, non-governmental agencies or the homeowners themselves (FEMA, 2015).

[1]NFIP is not actuarially sound for several reasons. The program is not structured to build a capital surplus, cannot deny policies to high-risk applicants, and cannot deny insurance because of frequent losses. It is also subject to statutory limits on rate increases and its premium rates do not reflect actual flood risk (Government Accountability Office (GAO), 2010).

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Other possible federal funding sources include FEMA's Pre-Disaster Mitigation Assistance (PMA), which was recently replaced with the Building Resilient Infrastructure and Communities program; Flood Mitigation Assistance (FMA); Housing and Urban Development's Community Development Block Grant Disaster Recovery (CDBG-DR) Program (BenDor et al., 2020; Peterson et al., 2020); and the Community Development Block Grant Mitigation Program (CDBG-MIT). Buyouts are usually initiated after a presidential disaster declaration and homeowner participation in the program is voluntary. Alternatively, homeowners may benefit from any of the aforementioned mitigation grant or recovery programs to subsidize home elevation. Home elevation involves raising structures on either stilts, mounds, concrete pillars or foundations to an elevation at Base Flood Elevation (BFE) or higher (FEMA, 2015).

To encourage buyout program participation, policy makers are considering several suggested programmatic changes. One of the proposed changes will potentially allow homeowners to retain ownership of the deed-restricted lot and build new structures so long as they meet current local building codes (Flavelle, 2018). Another proposed change would allow buyouts to occur on a continuous basis and not only after a presidential disaster declaration in an area. While these proposed changes could influence buyout participation, there are no empirical studies evaluating the impact of such policy changes.

This paper investigates coastal US residential homeowners' stated preferences for buyout and home elevation contract attributes and estimates average willingness to accept (WTA) values for buyout and home elevation contracts. Given the proposed changes to buyout programs, this study examines attributes including property pricing, retained ownership of the deed-restricted lot, timing of the transaction, and contract options that include future flood insurance pricing, home elevation cost, and subsidies.

Within the flood risk mitigation literature, the relatively few studies examining individuals' decision to participate in buyouts have focused on the effects of demographic and geospatial factors (Fraser et al., 2003; Fraser, Doyle, and Young, 2006; Fraser, De Vries, and Young, 2006; Kick et al., 2011; De Vries and Fraser, 2012; Zavar, Hagelman, and Rugeley, 2012; Bukvic et al., 2015; Robinson et al., 2018; Frimpong et al., 2019). Frimpong et al. (2019) examined the effect of offered price on homeowners' decision to participate in buyouts using a contingent valuation survey of 123 homeowners in Eastern North Carolina. Other studies have also focused on the effect of demographic and geospatial factors on individuals' decisions to buy flood insurance (Baumann and Sims, 1978; Browne and Hoyt, 2000; Michel-Kerjan and Kousky, 2010; Kousky, 2010; Gallagher, 2014; Kriesel and Landry, 2004; Landry and Jahan-Parvar, 2011; Petrolia, Landry, and Coble, 2013) or elevate their homes (Botzen, Aerts, and van den Bergh, 2012). In this paper, we use a much larger national sample of coastal properties and build on past studies by expanding the list of attributes related to buyout and home elevation contracts. We additionally examine the impact of future insurance premium pricing on homeowners' decision to engage in mitigation options. This analysis further allows for the quantification of tradeoffs between different subsidized risk mitigation activities. We also provide WTA estimates as well as a rough benefit-cost analysis based on a simulated buyout contract.

Results indicate that homeowners prefer buyout contracts that offer larger payments, give homeowners more time before they must vacate the property, and reduce the lag time between signing of the contract and payment to the homeowner. Perhaps surprisingly, homeowners do not put a premium on being able to retain the lot. Regarding elevation, homeowners unsurprisingly prefer contracts with lower elevation costs and higher elevation subsidies. We also ask respondents to consider their house as-is (pre-damage) in some choices, while in other choices we ask respondents to imagine their house was recently damaged by a flood event. We find not only that general preferences for buyout contracts vary with the timing of the contract (whether it is offered before or after a flood damage event), but further that preferences for specific attributes also vary with timing of the contract offered. Further, per our analysis, we find that even a payment of a 125%

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pre-damage value of the house, if targeted to high-risk homes, will accrue a benefit-cost ratio of 3 to 1 which is attractive to both parties (homeowner and government).

The next section presents policy background with details on the NFIP, buyouts, and structure elevation. The third section describes the survey and data used for the discrete choice analysis. Section four presents the theoretical foundation and econometric model used in the analysis. Regression results and robustness checks are presented in the fifth section, while section six provides discussion and concludes the paper.

2. Policy Background

2.1 National Flood Insurance Program

To provide access to affordable federally backed flood insurance and to encourage community-level flood risk mitigation, the US congress passed the National Flood Insurance Act of 1968 that created the NFIP (FEMA, 2019a). Community-level participation in NFIP is voluntary, and only residents and businesses of participating communities can buy flood insurance policies. Participating communities adopt floodplain management ordinances and are encouraged to exceed minimum mitigation efforts. Currently, the NFIP is the most widely used flood risk management strategy among residents (Thomas and Leichenko, 2011) with over 22,000 participating communities and over 5 million policies-in-force (Congressional Research Service, 2019). Private insurance companies write policies, but the federal government is responsible for paying damage claims. NFIP's policy coverage is limited to structure and contents, with limits of \$250,000 and \$100,000, respectively, for single-family building and up to \$500,000 for other residential or non-residential buildings (FEMA, 2020). Flood insurance premium rates are determined mainly by Flood Insurance Rate Maps (FIRMs) which are updated periodically. Other factors that affect premiums include whether the structure is elevated above historic flood levels and the extent to which the community participates in the community rating system (Frimpong et al., 2020). As such, the assessed flood risk level for a structure can change when new FIRMs take effect. However, policy holders with continuous coverage whose flood risk levels have increased are not affected by the post-FIRM insurance premium rates. This rule is also referred to as grandfathering (FEMA, 2016). As a result, premiums may not reflect current flood risk.

Since its inception, NFIP has seen several reforms to bolster the effectiveness of the program. The Flood Insurance Protection Act of 1973 and The National Flood Insurance Reform Act of 1994 were enacted to encourage NFIP enrollment, and The Flood Insurance Reform Act of 2004 was intended to encourage flood risk reduction. In 2012, the Biggert-Waters Flood Insurance Reform Act was introduced to bolster the financial health of NFIP by increasing premium rates but was later repealed and replaced with The Homeowner Flood Insurance Affordability Act of 2014 (FEMA, 2019b). To date, the program has borrowed over \$20 billion dollars from the US Treasury to meet its claim payment obligations (Congressional Research Service, 2019), making it a financially "high-risk" public disaster program. To complement community-level flood risk mitigation efforts, FEMA introduced the Hazard Mitigation Assistance (HMA) programs (i.e., HMGP, PMA, and FMA) to assist states and local communities in reducing community-level flood risk by reducing the risk to individual properties.

2.2 Buyouts

Among the host of potential risk mitigation measures that homeowners could pursue for natural disasters, buyout is by far the most effective way of eliminating future flood risk. Under a buyout program, homeowners have the option to sell high-risk property to the government for demolition or relocation of the structure to an area with lower flood risk. The program is generally funded through FEMA's HMGP, a component of the HMA program, and is authorized by Section 404 of the Stafford Act, 42 U. S. C.5170c (FEMA, 2015). However, local governments could also obtain other competitive federal funds including PMA, FMA, CDBG-DR Program, and the Community Development Block Grant Mitigation Program. Local governments (states and territories) and federally recognized tribes may apply for FEMA's HMGP funds to be used for buyouts (FEMA, 2015) after a presidential disaster declaration. Prior to local authorities implementing buyouts, a benefit-cost analysis is used to assess the advantages and disadvantages of the acquisition (FEMA, 2005). Contracts are voluntary, so individual homeowners may choose to accept or reject offers made by local authorities. Once a contract is agreed upon, the at-risk structure is demolished or relocated if possible and the cleared lot is typically left as open space or converted to a recreational area (FEMA, 2005).

Buyouts gained popularity after the Great Midwest Floods in 1993, where communities in Cherokee and Story County in Iowa acquired 157 and 28 properties, respectively (FEMA, 2011). Since then, several other communities have utilized the HMGP. After floods in 1997, approximately 800 properties were bought out in Grand Forks, North Dakota. A year later, San Antonio, Texas, acquired 400 properties to reduce future flood risk, and after Hurricanes Fran and Floyd in 1999, about 1,150 properties were bought in Greenville and Kinston, North Carolina (De Vries and Fraser, 2012; Frimpong et al., 2019). In addition to eliminating future flood risk to properties and lives, buyouts have several other advantages. Barnhizer (2003) mentions that for every $1 the government invests in the buyout, homeowners who participate save $2 in future flood insurance premia by moving to lower-risk areas. By making offers based on pre-damage assessments of the home, acquisition programs provide an opportunity for homeowners to protect themselves against decreased home values in the wake of a flood event (Frimpong et al., 2019; Greer and Binder, 2017). Federal and local governments, on the other hand, could potentially save on future insurance payouts and other flood-related expenditures when a flood-prone area is cleared of structures (Barnhizer, 2003). Buyout benefits accrue to society when the resulting open space is repurposed as recreational grounds such as fishing, hunting, boating, and hiking (Barnhizer, 2003). Further, open space could potentially help mitigate future floods (Brody and Highfield, 2013) which may in turn increase adjacent property values (Barnhizer, 2003).

2.3 Structure/Home Elevation

For communities participating in NFIP, potential policy holders with structures at risk of flood damage are required to raise their structure above the BFE (100-year flood elevation) (FEMA, 2015). Homeowners are also encouraged to incorporate freeboard requirements into elevation. Freeboard is an additional height (usually 1 foot) above the BFE. There are three basic ways to elevate a house: raising the structure on piers or piles; on a mound; or on a tall foundation (FEMA, 2015). Location, size, quality of materials and construction, complexity of details, site constraints, utility requirements, systems requirements, development and permitting fees, and general market and economic conditions are all factors that influence whether a structure can be elevated. The cost of elevating structures varies based on the size of the structure. For a medium-sized brick or concrete slab house, the cost of elevating the house is estimated at $30,000 (FEMA, 2005). Elevation incentives are available to homeowners through many of the same mitigation grant programs that offer home acquisition contracts, including HMGP, FMA, and CDBG-DR. They are also offered through the Pre-Disaster Mitigation Program (PDM) and CDBG-MIT. As elevation reduces flood risk, homeowners with elevated houses often benefit from lower NFIP flood insurance premiums (FEMA, 2015).

3. Survey and Data

A total of 1,366 residential homeowners recruited by Qualtrics responded to an online survey administered between August 2018 and April 2019. All human subject research related to this

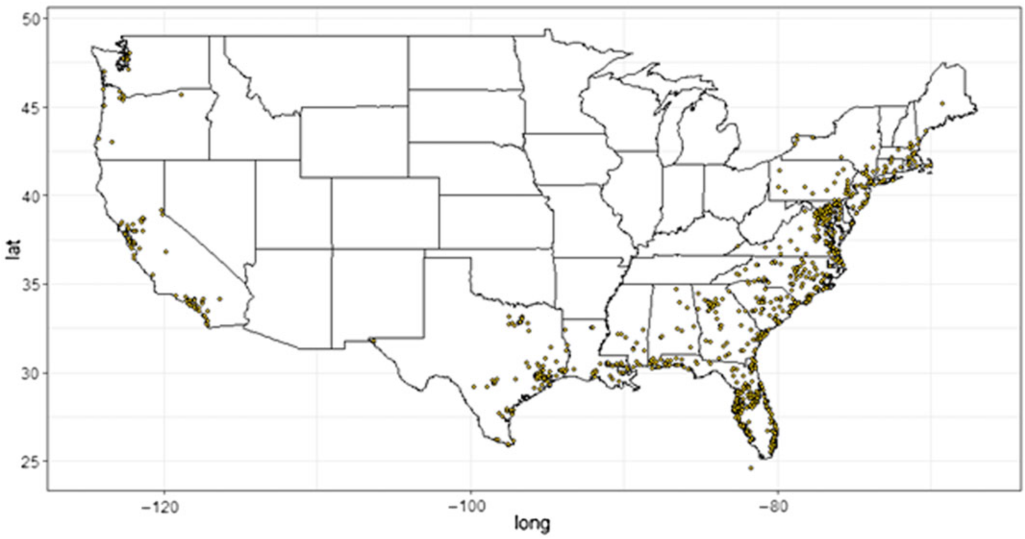

Figure 1. Distribution of survey respondents.

work was approved by East Carolina University's Institutional Review Board. The survey opens with a participation consent form, followed by questions that screened homeowners who are at least 18 years old and have property within 150 kilometers of a shoreline.[2] For our analysis, we focus on only respondents who live in states bordering the Atlantic, Pacific, or Gulf of Mexico, which reduces our sample to 1,283. Respondents answer questions on their history in the community, experience with floods, and perceptions of flood risk as well as a host of demographics. Respondents were also asked to provide the address of their property. Figure 1 shows the distribution of respondents' properties in the study area.

Respondents were presented a series of hypothetical flood risk mitigation scenarios. Each scenario offered three options: a buyout contract, a home elevation contract, and a status quo option of choosing neither contract. The attributes related to buyout and elevation contracts, as well as the levels they take in the experimental design, are detailed in Table 1. The choice of attributes and the levels they take are guided by literature review and through discussions with experts. For buyout contracts, attributes include what is being sold (either the structure and the lot or just the structure), the price the homeowner will receive (as a percentage of the pre-damage fair market value of the property being sold[3]), how long it will take for the homeowner to receive their payment, and how long the homeowner has before they must vacate the property. The price attribute levels chosen are consistent with the literature that indicates that these prices range from 75% to 125% of the pre-damage value of the property (Frimpong et al., 2019). We specify the acquisition contract time to have 15, 45, 75, and 120 days. While it could take up to about 45 days, on average, to close buyout transaction after the homeowner accepts offer (Missouri State Emergency Management Agency, 2016), it is not unusual for buyouts transactions to take up to 18 months, from disaster to closing transactions (Robinson et al., 2018). The number of days a homeowner can have access to property after buyout depends on the condition of the property. We specify the levels as 30, 60, 90, and 120. For home elevation contracts, attributes include the cost of elevating the

[2]For the vast majority of the sample, this proximity to a shoreline refers to a coast (Atlantic, Pacific, or Gulf). A small minority of our sample live near rivers that experience flooding, but we have included these responses in our model as they are relevant to the topic as well as coastline flooding.

[3]If the homeowner is selling only the house, this is measured as the value of only the house. If homeowner is selling both the house and the lot, this is measured as the value of the house and the lot combined.

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Table 1. Program attributes and levels

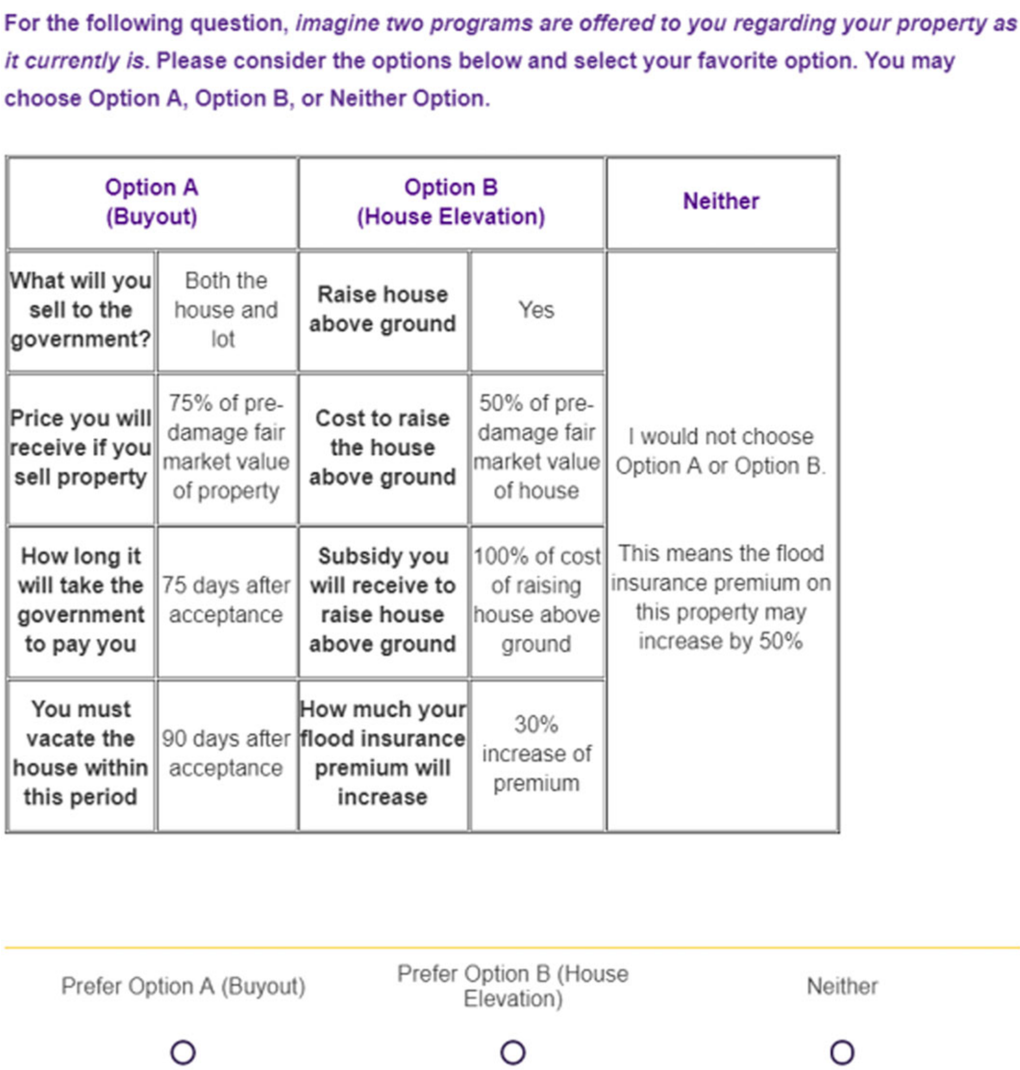
Attribute	Level
Buyout	
What will you sell to the government	1 = house and lot, 0 = house only
Price you will receive if you sell property	75%, 90%, 100%, 110%, and 125%
How long it will take the government to pay	15 days, 45 days, 75 days, and 120 days
You must vacate the house within this period	30 days, 60 days, 90 days, and 120 days
Home elevation	
Cost to raise the house above ground	20%, 30%, 40%, and 50%
Subsidy you will receive to raise house above ground	25%, 50%, 75%, and 100%
How much your flood insurance premium will increase	20%, 30%, 40%, and 50%

house and the subsidy they will receive. The cost of elevating the structure is measured as a percentage of the home's value, while the size of the subsidy is measured as the percentage of the total cost of elevating the house. As pointed out in the previous section, cost of elevating a house depends on several factors, including the size of the house, type of elevation, and type of material used in the building-brick or concrete (FEMA, 2005). Since we are unable to assess the values of the respondents' houses, using percentage for the levels of elevation cost and elevation subsidy attributes is convenient. Lastly, we also specify a value for how much the homeowner can expect their flood insurance premiums to rise. This attribute is expressed as a percentage increase relative to their current premium and is given different levels for the elevation contract and the status quo[4] option of neither contract. FEMA is constantly reforming NFIP to accurately capture flood risk and ensure program sustainability. Recently, FEMA implemented the Risk Rating 2.0 which has increased some policy premiums (FEMA, 2021). As many of these attributes are presented as percentages and may be confusing for some respondents, in the section of the survey that outlines the attributes respondents were presented with numeric examples to illustrate how different percentages would translate to dollar amounts. Respondents were also shown an image of a property bought and torn down by local government (Buyout) and an image of a property being elevated above ground.

The choice experiment design was determined using SAS 9.3 experimental design macros (Kuhfeld, 2010).[5] The resulting design of 30 choice sets was selected to maximize D-efficiency (Scarpa and Rose, 2008). Due to the complex nature of the choice design, we group the 30 choice sets into 15 blocks in a randomized fashion, each block containing two choice sets to limit cognitive strain on respondents. Additionally, there is evidence that hypothetical bias mitigation techniques can show reduced effectiveness after 4–5 choices (Howard et al., 2017). Homeowners are shown four choice sets in a randomized fashion (i.e., 2 of the 15 blocks). In this way, the order of choice sets is not confounded with specific attribute levels in our analysis. In two choice sets, respondents are prompted to consider their house as it currently is, without damage from a flood event. In the other two choice sets, homeowners are asked to assume a recent flood event has damaged their property when making their choice. The order of damaged scenarios is randomized. Figure 2 shows an example of the choice set.

[4]Subjects were given the same status quo premium increase in all choices, while premium increases varied for different elevation policies. There was between-subject variation in status quo premium increases, meaning different subjects were given different expected premium increases in the status quo. We use the term "status quo" here as it is the common terminology in the literature, but note that it is not literally a status quo outcome as respondents are told that they will experience premium increases in coming years. Further, this option was not described in the survey as a "status quo," but was instead labeled the "neither program" option.

[5]They include *%mktruns, %mktex, %mktroll, %choiceff, %mktdups,* and *%mktblock.*



For the following question, *imagine two programs are offered to you regarding your property as it currently is*. Please consider the options below and select your favorite option. You may choose Option A, Option B, or Neither Option.

Option A (Buyout)		**Option B (House Elevation)**		**Neither**
What will you sell to the government?	Both the house and lot	**Raise house above ground**	Yes	I would not choose Option A or Option B. This means the flood insurance premium on this property may increase by 50%
Price you will receive if you sell property	75% of pre-damage fair market value of property	**Cost to raise the house above ground**	50% of pre-damage fair market value of house	
How long it will take the government to pay you	75 days after acceptance	**Subsidy you will receive to raise house above ground**	100% of cost of raising house above ground	
You must vacate the house within this period	90 days after acceptance	**How much your flood insurance premium will increase**	30% increase of premium	

Prefer Option A (Buyout) ○   Prefer Option B (House Elevation) ○   Neither ○

Figure 2. Sample choice exercise.

4. Empirical Model

The theoretical foundation of our analysis is a random utility model where utility is a function of a vector of contract attributes X_{ijk}:

$$U_{ij} = \beta X_{ijk} + e_{ij} \tag{1}$$

where U_{ij} is utility individual i derives for jth alternative, β is vector of preference parameters associated with k contract attributes, X_{ijk} and e_{ij} are the error term. With the assumption that the errors are independent and identically distributed and follow an extreme value type 1 distribution, we utilize the standard conditional logit model.

Of particular interest is evaluating whether preferences are substantially different when considering houses that are not currently damaged from a flood event. To explore any potential differences between damaged and undamaged houses, an indicator variable for whether a choice is made assuming the house is not damaged by a flood event (*Before*) or damaged by flood event (*After*) is interacted with the attributes and alternative-specific constants (ASC) for *Buyout* and *Elevation*:

$$U_{ij} = \left[\sum_{k=1}^{K} \beta_k X_{ijk} + \eta Buyout_{ij} + \varphi Elevation_{ij}\right] \times Before + \left[\sum_{k=1}^{K} \delta_k X_{ijk} + \alpha Buyout_{ij} + \gamma Elevation_{ij}\right] \times After + e_{ij} \quad (2)$$

where X is a vector of k attributes. β_k, η, φ, δ_k, α, and γ are parameters to be estimated. Table 2 presents a description of the variables used in the regression analysis.

We estimate two main models of interest: a conditional logit model (Mcfadden, 1974) and a random parameters logit (RPL) model (Revelt and Train, 1998; Train, 2009). Conditional logit models assume between-respondent homogeneity of preferences, while RPL models assume preferences for an attribute are heterogeneous and follow a specified distribution. In our case, we assume normal preference distributions for each attribute with the exception of our payment attributes (buyout payment and elevation subsidy), which are assumed to have a lognormal distribution. For all attributes, we estimate the mean and standard deviation of the preference distribution. All RPL models are estimated using maximum simulated likelihood and use 1,000 Halton draws in each simulation.

4.1 Policy Simulation: Estimating Willingness to Accept

Next, we adopt Hanemann's (1984) average compensating variation (CV) framework to estimate the minimum WTA for a buyout and home elevation contract for the average homeowner in our sample. For each contract type, we generate two WTA estimates: one for a contract offered prior to damage and one for a contract offered after damage. This framework requires specifying all attribute levels for each contract except for price. The buyout contract requires the homeowner to sell both the house and lot, pays the homeowner in 365 days,[6] and requires the homeowner to vacate the property after 60 days. The proposed home elevation contract would cost 30% of the property's value to elevate the structure. In all cases, the respondent has the option of choosing the status quo option, which carries with it an insurance premium rate increase of 50%. Conversely, choosing the elevation contract leads to a smaller premium increase of 30%. The CV framework is defined as follows:

$$\mathrm{CV} = -\frac{1}{\beta_{\mathrm{price}}}(V_1 - V_0), \quad (3)$$

where V_1 is the estimated utility of the contract, V_0 is the estimated utility of the status quo option, and β_{price} is the coefficient associated with the buyout transaction price. If a contract is offered after a house is damaged, we use δ_{price} instead of β_{price}. When estimating the CV for buyout contract, we replace *Elevation* in equation (2) with status quo ASC to measure the estimated utility for the status quo.

[6]The highest value we used in the choice experiment for acquisition pay period was 120 days, but after the data were collected it became clear to us that payments to homeowners regularly take 1 year or more to be made. Indeed, as of the fall of 2021, there are homeowners in Lumberton, NC who are still waiting for buyout payments from damage that occurred during Hurricane Florence in 2018. As a result, we selected a level (365 days) that lies outside of the range of attribute levels presented to respondents. Estimating the marginal utility effects beyond the range of presented values is problematic if these marginal utilities are nonlinear, so we tested for nonlinear effects of acquisition pay period using three different models: including a squared term for acquisition pay period, including both squared and cubic terms, and a model that included a series of dummy variables for acquisition pay period. In all models, we fail to reject the null hypothesis of linear marginal disutility of increases in pay period. Results from these models and P values for hypothesis tests are presented in the online Appendix.

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Table 2. Variable definition

Variable	Definition
	Buyout
Price × Before	Price (% of pre-damage value of property) for buyout contracts offered before a flood event
Price × After	Price (% of pre-damage value of property) for buyout contracts offered before a flood event
Sell both house and lot × Before	Dummy equal to 1 if contract offered before flood event requires selling both house and lot
Sell both house and lot × After	Dummy equal to 1 if contract offered after flood event requires selling both house and lot
Acquisition pay period × Before	Number of days to pay buyout participant for contract offered before flood event
Acquisition pay period × After	Number of days to pay buyout participant for contract offered after flood event
Vacate × Before	Number of days to vacate property after contract offered before flood event is agreed upon
Vacate × After	Number of days to vacate property after contract offered before flood event is agreed upon
	Home elevation
Elevation cost × Before	Cost (% of pre-damage value of property) to elevate a home for elevation contract offered before flood event
Elevation cost × After	Cost (% of pre-damage value of property) to elevate a home for elevation contract offered after flood event
Elevation subsidy × Before	Subsidy (% of cost of elevation) to elevate home for elevation contract offered before flood event
Elevation subsidy × After	Subsidy (% of cost of elevation) to elevate home for elevation contract offered after flood event
Insurance appreciation × Before	% increase in insurance premium for elevation contract offered before flood event
Insurance appreciation × After	% increase in insurance premium for elevation contract offered after flood event
	Alternative-Specific Constants (ASC)
Buyout × Before	Dummy equal 1 if alternative is buyout and contract is offered before flood event
Buyout × After	Dummy equal 1 if alternative is buyout and contract is offered after flood event
Elevation × Before	Dummy equal 1 if alternative is elevation and contract is offered before flood event
Elevation × After	Dummy equal 1 if alternative is elevation and contract is offered after flood event

Likewise, we replace *Buyout* in equation (2) with status quo ASC when estimating CV for elevation contract.[7]

[7]Buyout contract offered before flood damage, $V = \left[\sum_{k=1}^{K} \beta_k X_{ijk} + \eta Buyout_{ij} + \lambda Status-quo_{ij}\right] \times Before$. Elevation contract offered before flood damage, $V = \left[\sum_{k=1}^{K} \beta_k X_{ijk} + \varphi Elevation_{ij} + \lambda Status-quo_{ij}\right] \times Before$

For contracts offered after flood damage, we interact with *After* instead of *Before*. Buyout contracts offered before flood damage indicate that the property will be sold as-is, not sold when (if ever) damage occurs.

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Table 3. Demographics of sample (N = 1,283 unless noted otherwise)

Variable	N	Freq.	%	Mean	Std. Dev.	Min	Max
Age	1,280			49.138	17.128	18	92
Education							
Non-formal		5	0.390				
High school		353	27.510				
Associate		273	21.200				
Bachelors		438	34.140				
Post-graduate		215	16.760				
Income							
Lower (<$50,000)		459	35.780				
Middle ($50,000–$99,999)		562	43.800				
Upper (>$99,999)		261	20.340				
Male		587	45.750				
White		961	74.900				
Residence type							
Permanent		1,147	89.400				
Seasonal		89	6.940				
Other (own rental property)		47	3.660				
House type							
Manufactured		97	7.560				
Single family		10,005	78.330				
Duplex/townhouse		83	6.470				
Apartment/condominium		88	6.860				
House Condition	1,282						
Poor		10	0.780				
Fair		93	7.250				
Good		383	29.880				
Very good		523	40.800				
Excellent		273	21.290				
Attachment to place (%)							
Personal	1,281			74.148	23.100	0	100
Family	1,278			75.380	24.560	0	100
Tenure (years)	1,277			12.857	10.913	0	69
Mortgage		740	57.680				
Flood Insurance	1230	630	51.220				
Property damage experience		403	31.410				
Percent damage	403						

(*Continued*)

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Table 3. (*Continued*)

Variable	N	Freq.	%	Mean	Std. Dev.	Min	Max
Less than 20%		96	23.820				
20–39%		140	34.740				
40–59%		105	26.050				
60–79%		38	9.430				
80–100%		24	5.960				
Expected % future damage	403						
Less than 20%		85	21.090				
20–39%		123	30.520				
40–59%		103	25.560				
60–79%		65	16.130				
80–100%		27	6.700				
Next flooding within the next							
5 years or less		458	35.700				
10 years or less		239	18.630				
25 years or less		101	7.870				
100 years or more		110	8.570				
I don't know		375	29.230				
100-year floodplain	1,201	171	14.240				

5. Results

5.1 Descriptive Statistics

Based on respondents' address information, a plurality (577 (44.97%)) have properties in East Coast states (excluding Florida samples), 206 (16.06%) have properties in the Gulf Coast states (excluding Florida samples), 401 (31.25%) are in Florida, and 99 (7.72%) are in West Coast states. Table 3 describes the demographics of our sample. The mean age of respondents is 49.14. A plurality have a bachelor's degree, are in the \$50,000–\$99,999 income bracket, and report their home to be in very good condition, while a majority are white, are permanent residents, live in a single-family house, have mortgage, and have home flood insurance. About 31% of the sample have experienced various degrees of property damage due to floods, 54% expect flooding in the next 10 years, and 14% are in 100-year floodplain.

Regardless of the timing of the contracts (i.e., contracts offered before damage and after damage), buyout is the most selected option, being selected 51% of the time before damage and 53% of the time after damage. Home elevation is selected between 27–28% of the time, regardless of timing. Although not reported, this is fairly consistent across all demographics.

5.2 Estimated Coefficients of Conditional Logit and RPL Models

Results from our estimated conditional logit and RPL models are presented in Table 4. The results are consistent across models. As one would expect, homeowners prefer buyout contracts that offer more money in exchange for the property, pay the homeowner more quickly, and allow more time for the homeowner to vacate the property. Further, there is no premium homeowners give to being able to retain the lot; indeed, we find that they would prefer to sell the lot with the house.

Table 4. Logit regression results

Variable	Conditional Logit	Random Parameter Logit	
	Coefficient	Mean	Std. deviation
Price × Before	0.018***	0.032***	0.138
	(0.002)	(0.005)	(0.092)
Price × After	0.011***	0.019***	0.064
	(0.002)	(0.004)	(0.144)
Sell both house and lot ×	0.195**	0.280**	0.367
Before	(0.079)	(0.134)	(1.064)
Sell both house and lot ×	0.224***	0.389***	0.292
After	(0.078)	(0.126)	(0.646)
Acquisition pay period ×	−0.003***	−0.004**	0.007
Before	(0.001)	(0.002)	(0.007)
Acquisition pay period ×	−0.003***	−0.006***	0.001
After	(0.001)	(0.002)	(0.011)
Vacate × Before	0.004***	0.007***	0.003
	(0.001)	(0.002)	(0.005)
Vacate × After	0.004***	0.008***	0.005
	(0.001)	(0.002)	(0.006)
Elevation cost × Before	−0.015***	−0.025***	0.013
	(0.004)	(0.009)	(0.030)
Elevation cost × After	−0.004	−0.009	0.032*
	(0.004)	(0.009)	(0.018)
Elevation subsidy × Before	0.011***	0.016***	0.475*
	(0.002)	(0.004)	(0.270)
Elevation subsidy × After	0.007***	0.011***	0.213
	(0.002)	(0.003)	(0.213)
Insurance appreciation ×	−0.003	−0.020***	0.032***
Before	(0.002)	(0.004)	(0.004)
Insurance appreciation ×	−0.001	−0.016***	0.028***
After	(0.002)	(0.004)	(0.003)
Buyout × Before	−1.567***	−3.886***	−0.131
	(0.318)	(0.663)	(0.182)
Buyout × After	−0.462	−1.978***	−0.093
	(0.313)	(0.494)	(0.540)
Elevation × Before	−0.086	−0.635*	2.039***
	(0.187)	(0.330)	(0.278)

(*Continued*)

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Table 4. (*Continued*)

	Conditional Logit	Random Parameter Logit	
Variable	Coefficient	Mean	Std. deviation
Elevation × After	0.075	−0.432	1.720***
	(0.185)	(0.357)	(0.349)
Log pseudolikelihood	−5,140.285	−4,820.041	−4,820.041
Observations (Cluster id)	15,384 (1,283)	15,384 (1,283)	

Notes: Robust standard errors in parentheses. Errors are clustered by the respondent. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. Price and subsidy attributes are lognormally distributed, so presented values are the exponent of estimated coefficients. Standard deviation estimates are in proportion to estimated coefficients rather than the exponent of estimated coefficients.

These findings hold for both pre-damage and post-damage offers, though a test for difference in magnitude of the coefficients finds that *Price* × *Before* and *Price* × *After* are statistically different at 1% significance level (P-value is <0.01). Specifically, we find that homeowners are more sensitive to price changes before damage occurs compared with after damage occurs. This finding is consistent with Frimpong et al.'s (2019) findings from a separate survey that offered hypothetical buyouts to respondents. We find no other differences in contract timing for buyout contracts, except for the alternative-specific constant for buyout.

These findings yield interesting policy implications. It is clear from model coefficients that homeowners are more likely to accept buyouts that pay them faster and let them stay in their home longer (presumably allowing more time and flexibility in finding a new home); the advantage of our modeling approach is it allows us to understand the tangible value of altering these contract characteristics. As an example, we can identify changes in contract characteristics (increases in time before one must vacate the property and decreases in time to pay the property owner) that are equivalent to a one percentage point increase in buyout payment and further evaluate whether these values differ before vs. after damage has occurred. As an example, our models estimate that a one percentage point increase in payment is equivalent to increasing the speed of payment by about 3.5 days if the home is damaged and 6.5–8.5 days if the home is not damaged. This illustrates that prompt payments are more crucial after damage occurs than when the property is undamaged.

Turning to elevation subsidies, we find the expected outcome that homeowners prefer contracts with larger subsidies. The model suggests that respondents also prefer elevation contracts with a lower cost of elevation, though this attribute is not statistically significant when contracts are offered after damage is suffered. Homeowners prefer options that deliver lower levels of insurance premium appreciation. While this effect is not statistically significant in the conditional logit model, it is highly significant in the RPL. One possible explanation for this weaker-than-expected insurance premium preference relates to the sample. Almost half of respondents report that they do not carry flood insurance on their property; therefore insurance premium increases may be viewed as having no consequence for many in our sample. This is supported by our RPL results, where we find a statistically significant standard deviation estimate for insurance appreciation, suggesting that there is evidence of a spread in preferences. This lends credence to the theory that while some homeowners dislike premium hikes, others (likely those who don't insure their home against flood events) are indifferent to these changes, leading to a spread of preferences in the sample. Further support for this theory is provided by conditional logit models that estimate preference heterogeneity in premium appreciation by current insurance status (whether the homeowner currently has a flood insurance policy). These results, provided in the online appendix, show that for choices before damage, homeowners with insurance are sensitive to insurance appreciation while homeowners without insurance policies are not.

Table 5. Results from the estimated compensation variation framework

	Buyout Contract		Elevation Contract	
	Min. WTA, Cond. Logit	Min. WTA, Mixed Logit	Min. WTA, Cond. Logit	Min. WTA, Mixed Logit
Before	111.786%***	111.583%***	43.694%***	63.154%***
	(18.203)	(15.634)	(8.712)	(11.613)
After	106.385%***	124.198%***	2.179%	34.810%**
	(29.032)	(24.011)	(30.168)	(16.361)
Test for difference	5.401	12.614	41.515	28.344*
	(31.673)	(27.07)	(29.231)	(16.452)

Notes: Bootstrap standard errors in parentheses. *** $P < 0.01$. Buyout contract (for Before and After timing) comprises the following attributes (levels): Sell both house and lot (1); Acquisition pay period (365 days); Vacate (60 days). Home elevation contract: Elevation cost (30%); Insurance appreciation (30%). Replication based on 1,283 clusters in id.

Coefficients on the interaction terms *Buyout* × *Before, Buyout* × *After, Elevation* × *Before,* and *Elevation* × *After* (the ASCs) should be interpreted relative to the base alternative (the status quo). Only the coefficient on *Buyout* × *Before* is significant and negative in the conditional logit model, indicating buyout contracts offered prior to a flood damage event is significantly less preferred to the current policy that comes with potential increase in future insurance premium rate (after controlling for other attributes of the alternative). The RPL model additionally finds statistically significant mean effects for after-damage buyout and before-damage elevation ASCs. Further, there is evidence of greater preference heterogeneity for elevation programs than for buyout programs. While buyout programs have much larger (in absolute value) mean preference coefficients for their ASCs (−3.886 and −1.978 for buyouts compared with −0.635 and 0.432 for elevation), the ASCs for elevation have much larger estimated standard deviations, implying a greater spread of preferences.[8]

5.3 Estimated Average Compensating Variation for Buyout and Elevation Contract Scenario

Table 5 presents point estimates and standard errors for our CV calculations. These values can be interpreted as the minimum WTA compensation or the minimum cost to officials for offering the specified buyout or elevation contract to the average respondent. Officials would have to pay the average homeowner 111.583–111.786% of the value of the property to incentivize the homeowner to accept the outlined buyout contract for an undamaged property. For a buyout contract offered after damage has occurred, WTA varies by model, giving a range of 106.385–124.198% of the pre-damage value of the property. While the difference in WTA estimates prior to and after damage is fairly large (for a \$200,000 property, the premium for offering a contract prior to damage in our models ranges from −\$25,000 to almost \$11,000), we find that the standard errors around these estimates are large enough for us to be unable to reject the null hypothesis of equal WTA values at standard confidence levels[9] (*P*-value = 0.865 and 0.690 for the conditional logit and RPL models, respectively).

[8]We attempt to further account for variability in preferences across homeowners with interaction of (1) homeowner-specific variables and (2) flood risk variables with alternative-specific constants and report the results of conditional and random parameter logit models side-by-side in the online appendix. Our expectation that the results are consistent with what we report in the main paper is met. Individual-specific and flood risk variables included in the models are race, education, income, attachment to place, whether homeowner has flood insurance, has property is in a 100-year floodplain, and has experienced flood damage to property.

[9]We test for differences by estimating the difference between these CV values and bootstrapping a standard error for this difference using the conditional logit model. For RPL models, we use the Delta Method to estimate standard errors on the difference. Testing for differences between the two estimates, where the null hypothesis is $CV_{Before} = CV_{After}$ is equivalent to testing for whether their difference is equal to zero, or the null hypothesis $CV_{Difference} = 0$ where $CV_{Difference} = CV_{Before} - CV_{After}$.

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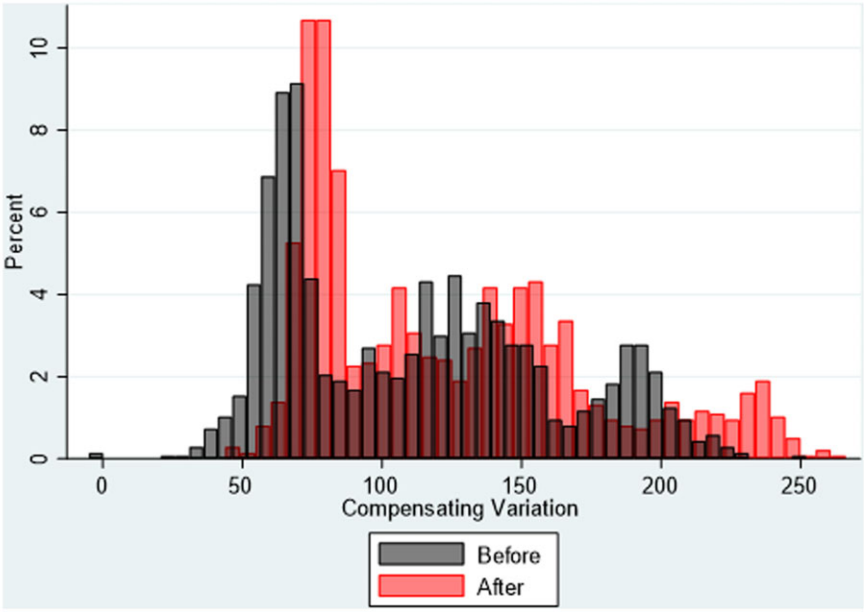

Figure 3. Histogram of buyout compensating variation estimates.

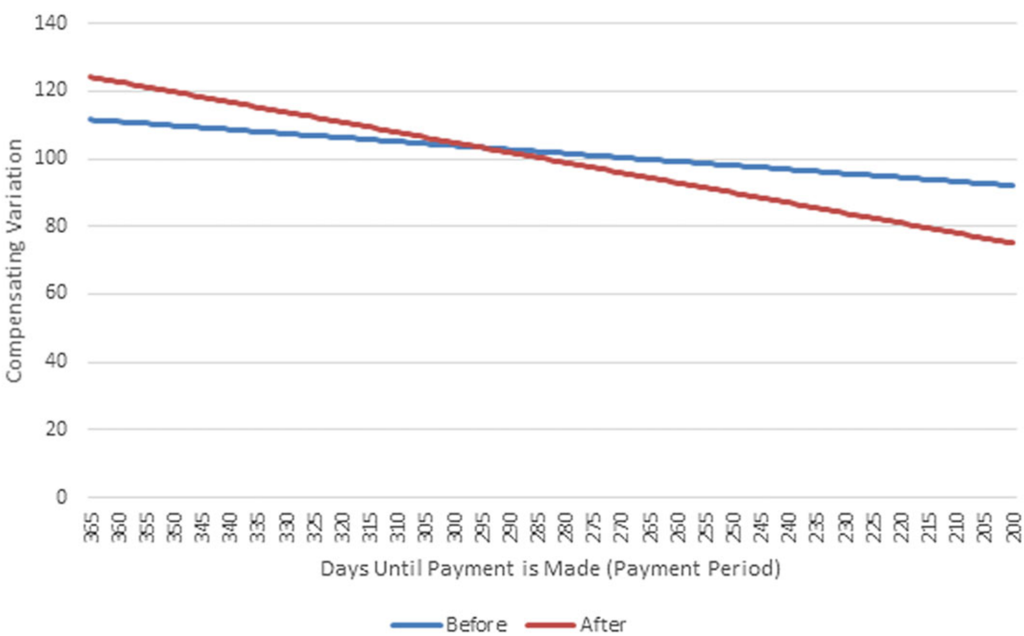

Figure 4. Sensitivity of compensating variation estimates to payment period.

WTA for home elevation contracts is also displayed in Table 5. For elevation contracts offered prior to a home damaged by flood, officials will have to provide the average homeowner 43.694–63.154% of the total cost of elevating the home as a subsidy to motivate the homeowner to engage in home elevation. On the other hand, for elevation contracts offered after the home is damaged by flood, WTA ranges from essentially zero in the conditional logit model to 34.810% of

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Table 6. Heteroscedastic logit results

Variable	(1) Heteroscedastic Logit
Price × Before	0.021***
	(0.003)
Price × After	0.012***
	(0.003)
Sell both house and lot × Before	0.210**
	(0.085)
Sell both house and lot × After	0.240***
	(0.083)
Acquisition pay period × Before	−0.003***
	(0.001)
Acquisition pay period × After	−0.004***
	(0.001)
Vacate × Before	0.004***
	(0.001)
Vacate × After	0.004***
	(0.001)
Elevation cost × Before	−0.016***
	(0.005)
Elevation cost × After	−0.005
	(0.005)
Elevation subsidy × Before	0.012***
	(0.002)
Elevation subsidy × After	0.007***
	(0.002)
Insurance appreciation × Before	−0.003
	(0.002)
Insurance appreciation × After	−0.001
	(0.002)
Buyout × Before	−1.822***
	(0.380)
Buyout × After	−0.524
	(0.341)
Elevation × Before	−0.211
	(0.226)
Elevation × After	0.024
	(0.203)

(*Continued*)

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Table 6. (*Continued*)

Variable	(1) Heteroscedastic Logit
Scale Parameter Covariates	
Previous Damage Experience	−0.285*
	(0.166)
Log Pseudolikelihood	−5135.322
Observations	15,384 (5,128)

Notes: Robust standard errors in parentheses. Errors are clustered by the respondent. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

the cost of elevating the home in the RPL model. The reader must keep in mind that this contract includes the assumption that elevation will carry with it premium increases of 30% instead of 50%, so in this scenario elevation yields tangible financial rewards to the homeowner even without a subsidy.

Digging deeper into our CV numbers for buyout contracts, the RPL model allows for estimating individual-specific preference parameters for all random attributes in our model (Hole, 2007). This capability enables us to estimate before- and after-damage CV estimates for each respondent in our sample. The distribution of these estimates is presented in Figure 3. Both CV estimates follow a similar pattern, with large densities in the range of 50–100% of property value and a fat right tail. This suggests that, while a sizeable portion of communities may be willing to accept buyout contracts at traditional offers of 75–100% of property value, there are likely to be non-negligible portions of communities who would refuse such offers. This has been seen in practice. What has not been demonstrated in the past, however, is the observation from our histogram that a sizeable portion of communities who reject an offer at fair market value may be induced to accept an offer at 10–30% above market value. This is true not just after damage has occurred, but also prior to the onset of damages.

As a final exercise related to our CV estimates, we explore the sensitivity of CV estimates in our RPL model to changes in pay period. Figure 4 Displays CV estimates for before- and after-damage contracts for various payment period values. The far-left portion of the figure represents CV estimates from Table 5, which assumes 365 days elapse before payment. Both before and after CV estimates diminish as payment period is shortened, as one would expect. Also as one might expect, respondents care more about prompt payments when their property has sustained damage, so the slope of the after-damage line in Figure 4 is steeper than its before-damage counterpart. As a result, after-damage CV estimates equalize with before-damage estimates at payment periods around 300 days. This is further evidence supporting the general finding in our data that prompt payments, while effective at inducing participation in all instances, are especially powerful after damage has occurred.

5.4 Robustness Check 1: Controlling for Differences in Error Variance

Many discrete choice models assume uniform variance in the error term between respondents and choices. Assuming homoscedasticity in this way can go beyond inconsistent estimates of standard errors and can bias parameter estimates in discrete choice modeling, since it is difficult to separate preferences from scale parameters (Deshazo and Fermo, 2002; Louviere et al., 2002). The heteroscedastic logit model allows for the scale parameter to be a function of respondent- and choice-specific observables. Because we allow all inputs in the utility function to vary by before-/after-damage framing, we are not able to separately estimate the effect of before-/after-damage framing

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Table 7. Conditional logit regression results with high-risk subsample

Variable	Full Sample	Subsample
	Coefficient	Coefficient
Price × Before	0.018***	0.015***
	(0.002)	(0.004)
Price × After	0.011***	0.019***
	(0.002)	(0.004)
Sell both house and lot × Before	0.195**	0.337**
	(0.079)	(0.135)
Sell both house and lot × After	0.224***	0.262*
	(0.078)	(0.138)
Acquisition pay period × Before	−0.003***	−0.002
	(0.001)	(0.002)
Acquisition pay period × After	−0.003***	−0.003*
	(0.001)	(0.002)
Vacate × Before	0.004***	0.005**
	(0.001)	(0.002)
Vacate × After	0.004***	0.004*
	(0.001)	(0.002)
Elevation cost × Before	−0.015***	−0.003
	(0.004)	(0.007)
Elevation cost × After	−0.004	−0.002
	(0.004)	(0.007)
Elevation subsidy × Before	0.011***	0.008**
	(0.002)	(0.003)
Elevation subsidy × After	0.007***	0.007**
	(0.002)	(0.003)
Insurance appreciation × Before	−0.003	−0.005
	(0.002)	(0.003)
Insurance appreciation × After	−0.001	−0.005
	(0.002)	(0.004)
Buyout × Before	−1.567***	−1.804***
	(0.318)	(0.559)
Buyout × After	−0.462	−1.826***
	(0.313)	(0.535)
Elevation × Before	−0.086	−0.578*
	(0.187)	(0.326)
Elevation × After	0.075	−0.440
	(0.185)	(0.326)

(*Continued*)

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Table 7. (*Continued*)

Variable	Full Sample	Subsample
	Coefficient	Coefficient
Log pseudolikelihood	−5,140.285	−1,695.562
Observations (Cluster id)	15,384 (1,283)	5,001 (417)

Notes: Robust standard errors in parentheses. Errors are clustered by the respondent. ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

on scale.[10] Instead, we allow for scale to vary by experience with flood damage. Specifically, we use a dummy variable equal to one if respondents report ever experiencing flood damage at the property in question.

The results of this model are presented in Table 6. We do find mild evidence that scale differs between respondents who have and have not experienced flood damage (P-value = 0.086) but controlling for this difference does not substantially alter our results. Indeed, when controlling for this we do find that any before-/after-damage gaps in buyout CV estimates are reduced even further than in our previous models. Using this model, estimated CV is 114.60% of the value of the home before damage and 114.50% of the value of the home after damage.

5.5 Robustness Check 2: High-Risk Subsample

We further probe the robustness of our sample by estimating the model in equation (2) focusing on respondents who potentially face high risk of flooding. Specifically, we consider respondents whose properties are either in the NFIP's special flood hazard area (SFHA, also known as the 100-year floodplain) or have at least one foot of predicted flood depth in the National Hurricane Center's hydrodynamic Sea, Lake and Overland Surges from Hurricanes (SLOSH) model (Jelesnianski et al., 1992; Zachry et al., 2015).[11] SLOSH models simulate storm surge inundation estimates for category 1 to category 5 hurricanes based on the Saffir-Simpson Hurricane Wind Scale. This "high-risk" subsample is comprised of 417 respondents and represents properties that would be more likely to be targeted for home acquisition. We present conditional logit results and WTA estimates for the high-risk subsample in Tables 7 and 8.

The main findings are notably similar in the full sample and the high-risk subsample. Signs are identical for all coefficients with the exception of the elevation ASC after damage has occurred, and for this variable, the coefficient is not statistically significant in both samples. One important note, however, is that we find greater resistance to buyouts after flood damage has occurred (measured in the *Buyout* × *After* ASC) in the high-risk subsample. Also, WTA results differ significantly from those reported in the main paper. As with the full sample, our model generates CV estimates for our buyout offer in the range of 100–120% of the value of the home in the high-risk sample, suggesting that our findings in the general sample of coastal homes mirror those in a more targeted group of high-risk homes. Somewhat counterintuitively, our CV estimate is higher after damage (118%) than before damage (103%), but this difference is not statistically significant (P-value for difference = 0.758). Compared with the full sample, CV estimates of WTA for home

[10] A reviewer correctly noted that a common fix to this issue is to estimate a single coefficient for the price attribute, as the marginal utility of income is unlikely to vary under most treatments (Czajkowski et al., 2016). While this is an excellent solution in most applications, the financial implications of our before/after damage treatment are such that respondents' net assets (and corresponding marginal utility of income) could substantially differ between treatments. Indeed, we find that buyout price yields one of the greatest coefficient disparities between treatments.

[11] We base SLOSH estimates and SFHA designation by overlaying data layers for each metric with property addresses obtained in survey responses.

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Table 8. Results from the estimated compensation variation framework, high-risk subsample

	Buyout Contract		Elevation Contract	
	Min. WTA	95% Confidence Interval	Min. WTA	95% Confidence Interval
Before	103.497%**	23.090, 183.904	74.847%	−49.573, 199.267
	(41.020)		(63.480)	
After	118.316%***	59.875, 176.760	55.885%	−94.197, 205.967
	(29.810)		(76.574)	
Test for difference	−14.820		18.962	
	(48.140)		(96.720)	

Notes: Bootstrap standard errors in parentheses. ***$P < 0.01$, **$P < 0.05$. Buyout contract (for Before and After timing) comprises the following attributes (levels): Sell both house and lot (1); Acquisition pay period (365 days); Vacate (60 days). Home elevation contract: Elevation cost (30%); Insurance appreciation (30%). Replication based on 913 clusters in id.

elevation are higher in the high-risk sample (55–75% of the cost of elevation, compared with 2–43% in the full sample), though standard errors for these estimates are relatively large.

6. Discussion and Conclusion

For the past few decades, there has been a marked increase in the use of buyouts to address and mitigate growing flood damages in the U.S, although the program faces participation challenges (Bukvic and Owen, 2017; deVries, 2017; Fraser et al., 2003). This paper presents the first empirical analysis of homeowners' stated preference for household-level flood risk mitigation utilizing discrete choice data from a national survey of predominantly coastal homeowners. We provide information on the attributes of buyout contracts that are of utmost interest to homeowners and use this information to construct WTA estimates that would guide policy makers in designing buyout contracts.

The choice experiment design used to elicit homeowner preference for risk mitigation contracts is unique in several ways. First, the survey tests homeowner preferences for several proposed changes to government acquisition programs: allowing for the lot to be retained and offering buyouts before damage occurs. Second, it is the first discrete choice design in which respondents make decisions between buyout offers and other risk mitigation options like home elevation. Understanding how homeowners perceive these potential changes to buyout programs, and how homeowners trade-off buyout offers with other risk mitigation tools, is of paramount importance to policy makers as the need to reduce coastal risk to the housing stock grows.

Our analysis reveals important insights concerning homeowner preference for flood risk mitigation. Descriptively, most homeowners prefer buyouts to home elevation and prefer home elevation to the status quo. This is true regardless of whether buyouts are offered prior to a flood damage event or after an event. This suggests that under the right contract conditions, many homeowners are likely to accept buyouts. Results indicate that price offered for buyouts is a key factor that positively influences the decision to participate. This finding is consistent with that of findings by Frimpong et al. (2019) and Kick et al. (2011). Interestingly, the results show that homeowners prefer not to retain the right to rebuild on the same lot after accepting a buyout, should such an option be available. This finding is important, especially now that officials are considering allowing homeowners to rebuild to higher standards on the same lot to address considerations of attachment to place where the location of property has personal or historical significance for the individual (Binder et al., 2019). The choice to increase proceeds by selling both the lot and the house seems to dominate. Possible reasons may come from complications

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untangling mortgage requirements, need to finance a new home purchase, or seizing the opportunity to relocate to a less vulnerable home site. Results further indicate that the shorter the payment period and the longer time homeowners can stay in the acquired home before vacating, the more likely homeowner will accept a buyout offer. These findings are unique in that variations in contract characteristics of this type were not examined in previous buyout studies. As expected, the higher the elevation cost, the less likely homeowners are to elevate a structure, while increasing elevation subsidies will motivate homeowners to elevate their homes. Regarding the home elevation program, as expected, we find that factors that influence the elevation decision include the cost of elevating the home, the size of elevation subsidies, and future insurance premium rate appreciation.

Another key finding of this study relates to the premium that must be paid to induce buyouts before a flood event occurs. We use average CV and bootstrapping to test whether there are differences between WTA for undamaged homes and damaged homes. While we find that WTA is higher for offers made before damage, we cannot reject the null hypothesis of equal WTA values. While it is unlikely that entire communities will willingly accept buyout offers for their undamaged homes without being offered a substantial price premium, this work suggests that offering buyouts on a rolling basis and before a storm hits is worth exploring further, especially if offers are coupled with the potential for homeowners to stay in their homes for a substantial period before vacating, an idea that has gathered support in recent years (Rott, 2021).

In addition to low buyout participation, officials are concerned about the high cost associated with buyouts (Barnhizer, 2003). However, several studies show that the benefits of buyouts outweigh the cost (Rose et al., 2007; Godschalk et al., 2009; Salvesen et al., 2018). Rose et al. (2007), for example, indicate that the average benefit-cost ratio for FEMA floodplain buyout grants for the period 1993 and 2003 is 5 to 1. Other analysis of buyouts shows that the program has accrued avoided losses of several millions of dollars (Salvesen et al., 2018). Currently, the federal government funds 75% of the acquisition process while additional funds (25%) are sourced from the local government, non-governmental agencies, and the homeowner. Our WTA estimates show that the average respondent in our sample is willing to accept a minimum of 111% of the pre-damage value of their property to relinquish property at its current condition to authorities (106–124% if the buyout contract is offered post-flood damage event). Using the Rose et al. benefit-cost ratio estimate of 5 to 1 (5 to 1 suggests benefits of $375 for every $75 spent), it appears likely that a program that increased its offer from 75% to 125% of the value of the home (i.e., increasing cost to $125) in order to remove at-risk homes from the housing stock before they are damaged would, assuming they keep the same benefits, reduce the benefit-cost ratio to 3 to 1 (i.e., $375/$125), which is still attractive. While this broad-strokes analysis is useful, a fruitful avenue of future work would be to compare premiums to claims at a disaggregated level to determine the property-specific benefits that could be compared with program costs of buyouts derived from this paper.

Between the years 2000 and 2016, the federal government, through FEMA's HMGP, spent $648,421,227 in buyouts of 10,265 damaged properties (median payout is $50,314; average is $63,168 per home) (Patterson, 2018). Meanwhile, NFIP policy covers up to $250,000 per structure and $100,000 for contents (for single-family dwelling) and about 500,000 for other residential and commercial structures that are damaged by floods. Many of these properties are likely to be repeat-loss properties moving forward, indicating that FEMA could pay claims on the damaged property for years. Buyout contracts are mostly offered post-disaster but based on our WTA estimate (111.786% pre-damaged value of property) and the available statistics on the benefits of buyouts discussed, we posit that even offering buyouts pre-disaster will accrue large benefits. Findings from Salvesen et al. (2018) indicate that for every 1.5 miles of road removed from a flood-prone neighborhood, local governments could save about $30 per year from avoided infrastructure cost. Other costs that could be avoided include emergency and response costs. The National Institute of Building Sciences also finds that the impact of federal mitigation grants, including grants for

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property acquisition, resulted in an economic impact of $6 for every $1 invested (Multihazard Mitigation Council, 2017; Salvesen et al., 2018).

Future extensions of this work could examine whether homeowner preferences for buyout and home elevation offers vary in predictable ways by homeowner demographics, homeowner attitudes, and attributes of the home. Ideally, another future step would be to move from the realm of stated preference to one of revealed preference by seeing how variation in the details of offers impacts real-world decisions. Lastly, all of the preference parameters and corresponding welfare measures used in this research focused on percentage changes in the value of the home. While this is a useful prism through which to examine the issue, a valuable extension would be to see if the same qualitative results hold when estimating (dis)utilities denominated in dollars. This could be done by either denominating attributes in the choice experiment in dollar terms or by combining a choice experiment denominated in percentage values with data on assessed value of the home.

Supplementary material. For supplementary material accompanying this paper visit https://doi.org/10.1017/aae.2022.5

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References

BenDor, T. K., Salvesen, D., Kamrath, C., & Ganser, B. "Floodplain Buyouts and Municipal Finance." *Natural Hazards Review* **21**,3(2020), 04020020.

Bukvic, A. & Owen, G. "Attitudes Towards Relocation Following Hurricane Sandy: Should We Stay or Should We Go?" *Disasters* **41**(2017):101–23.

Binder, S.B., Barile, J.P.,Baker, C.K. and Kulp, B. "Home Buyouts and Household Recovery: Neighborhood Differences Three Years After Hurricane Sandy." *Environmental Hazards* **18**,2(2019):127–45.

Binder, S.B. & Greer, A. "The Devil is in the Details: Linking Home Buyout Policy, Practice, and Experience after Hurricane Sandy." *Politics and Governance* **4**,4(2016):97–106.

Bukvic, A., Smith, A., & Zhang, A. "Evaluating Drivers of Coastal Relocation in Hurricane Sandy Affected Communities." *International Journal of Disaster Risk Reduction* **13**(2015):215–28.

Brody, S. D. & Highfield, W. E. "Open Space Protection and Flood Mitigation: A National Study." *Land Use Policy* **32**(2013):89–95.

Barnhizer, D. D. "Givings Recapture: Funding Public Acquisition of Private Property Interests on the Coasts." *Harvard Environmental Law Review* **27**(2003):295–375.

Botzen, W. J. W., Aerts, J. C. J. H., & Van den Bergh, J. C. J.M. "Individual Preferences for Reducing Flood Risk to Near Zero Through Elevation." *Mitigation and Adaptation Strategies for Global Change* **18**,2(2013):229–44.

Baumann, D. D., & Sims, J. H. "Flood Insurance: Some Determinants of Adoption." *Economic Geography* **54**,3(1978): 189–96.

Browne, M. J., & Hoyt, R. E. "The Demand for Flood Insurance: Empirical Evidence." *Journal of Risk and Uncertainty* **20**,3(2000):291–306.

Congressional Research Service. Introduction to the National Flood Insurance Program (NFIP). 2019. Internet site: https://fas.org/sgp/crs/homesec/R44593.pdf

https://doi.org/10.1017/aae.2022.5 Published online by Cambridge University Press

Czajkowski, M., Hanley, N., & LaRiviere, J. "Controlling for the Effects of Information in a Public Goods Discrete Choice Model." *Environmental and Resource Economics* **63**,3(2016), 523–44.

De Vries, D. H., & Fraser, J. C. "Citizenship Rights and Voluntary Decision Making in Post-disaster US Floodplain Buyout Mitigation Programs." *International Journal of Mass Emergencies and Disasters* **30**,1(2012):1–33.

DeShazo, J. R., and Fermo, G. "Designing Choice Sets for Stated Preference Methods: The Effects of Complexity on Choice Consistency." *Journal of Environmental Economics and Management*, **44**,1(2002), 123–43. https://doi.org/10.1006/jeem.2001.1199

Frimpong, E., Kruse, J., Howard, G., Davidson, R., Trainor, J., & Nozick, L. "Measuring Heterogeneous Price Effects for Home Acquisition Programs in At-risk Regions." *Southern Economic Journal* **85**,4(2019):1108–31.

Frimpong, E., Petrolia, D., Harri A., and Cartwright, J. "Flood Insurance and Claims: The Impact of the Community Rating System." *Applied Economic Perspectives and Policy* **42**,2(2020):245–62.

Fan, Q and Davlasheridze, M. "Flood Risk, Flood Mitigation, and Location Choice: Evaluating the National Flood Insurance Program's Community Rating System." *Risk Analysis* **36**,6(2016):1125–47.

FEMA. Risk Rating 2.0 State Profiles. 2021. Internet site: https://www.fema.gov/flood-insurance/risk-rating/profiles.

FEMA. NFIP Coverage Limits. 2020. Internet site: https://emilms.fema.gov/is_1101b/groups/74.html

Federal Emergency Management Agency (FEMA). A Chronology of Major Events Affecting the National Flood Insurance Program. 2019a. Internet site: https://www.fema.gov/sites/default/files/2020-07/fema_nfip_eval_chronology.pdf

Federal Emergency Management Agency (FEMA). Laws and Regulations. 2019b. Internet site: https://www.fema.gov/flood-insurance/rules-legislation/laws

Federal Emergency Management Agency (FEMA). Grandfathering. 2016. Internet site: https://www.fema.gov/node/404682

Federal Emergency Management Agency (FEMA). Hazard Mitigation Assistance Guidance. 2015. Internet site: https://www.fema.gov/sites/default/files/2020-07/fy15_HMA_Guidance.pdf

Federal Emergency Management Agency (FEMA). The Risk is Real: Mitigation Works: Mitigation Best Practices. 2011. Internet site: http://nhma.info/uploads/bestpractices/2011%20-%20Best%20Practices%20-%20Acquisitions%20Buyouts.pdf

Federal Emergency Management Agency (FEMA). Procedures for Developing Scopes of Work for the Acquisition of Flood Prone Properties. 2005. Internet site: https://www.fema.gov/media-library-data/20130726-1516-20490-8060/acquisition_sow.pdf

Flavelle, C. "FEMA Proposes Allowing Owners to Rebuild Homes After Taxpayer Buyout." *Insurance Journal*. 2018. Internet site: https://www.insurancejournal.com/news/national/2018/04/26/487448.htm#

Fraser, J., Elmore, R., Godshalk, D., and Rohe, W. *Implementing Floodplain Land Acquisition Programs in Urban Localities*. Washington, DC: Federal Emergency Management Agency, 2003.

Fraser, J. C., Doyle, M. W., and Young, H. "Creating Effective Flood Mitigation Policies." *Eos, Transactions, American Geophysical Union* **87**,27(2006):265–70.

Fraser, D. J., De Vries, D., and Young, H. Mitigating Repetitive Loss Properties. Final Report Prepared for the URS and FEMA. The Center for Urban and Regional Studies, Chapel Hill, North Carolina, 2006.

Greer, A and Binder, S. B. "A Historical Assessment of Home Buyout Policy: Are We Learning or Just Failing." *Housing Policy Debate* **27**,3(2017):372–92.

Gallagher, J. "Learning About an Infrequent Event: Evidence from Flood Insurance Take-up in the United States." *American Economic Journal: Applied Economics* **6**,3(2014):206–33.

Government Accountability Office (GAO). The National Flood Insurance Program: Continued Actions Needed to Address Financial and Operational Issues. 2010. Internet site: https://www.banking.senate.gov/imo/media/doc/BrownStatement92210pm2.pdf

Godschalk, D. R., Rose, A., Mittler, E., Porter, K., & West, C. T. "Estimating the Value of Foresight: Aggregate Analysis of Natural Hazard Mitigation Benefits and Costs." *Journal of Environmental Planning and Management* **52**,6(2009):739–56.

Howard, G., Roe, B. E., Nisbet, E. C., & Martin, J. F. "Hypothetical Bias Mitigation Techniques in Choice Experiments: Do Cheap Talk and Honesty Priming Effects Fade with Repeated Choices?" *Journal of the Association of Environmental and Resource Economists* **4**,2(2017):543–73.

Hanemann, W. M. "Discrete/Continuous Models of Consumer Demand." *Econometrica: Journal of the Econometric Society* **52**,3(1984):541–61.

Hole, A. R. "Fitting Mixed Logit Models by Using Maximum Simulated Likelihood." *The Stata Journal*, **7**,3(2007), 388–401.

Jelesnianski, C. P. SLOSH: Sea, Lake, and Overland Surges from Hurricanes (Vol. 48). US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, 1992.

Kunreuther, H. "Disaster Mitigation and Insurance: Learning from Katrina." *The Annals of the American Academy of Political and Social Science* **604**,1(2006):208–27.

Kick, E. L., Fraser, J. C., Fulkerson, G. M., McKinney, L. A., & De Vries, D. H. "Repetitive Flood Victims and Acceptance of FEMA Mitigation Offers: An Analysis with Community–System Policy Implications." *Disasters*, **35**,3(2011), 510–39.

Kriesel, W., & Landry, C. "Participation in the National Flood Insurance Program: An Empirical Analysis for Coastal Properties." *Journal of Risk and Insurance* **71**,3(2004):405–20.

Kousky, C. "Understanding the Demand for Flood Insurance." *Natural Hazards Review* **12**,2(2010):96–110.

Kuhfeld, W. F. "Marketing Research Methods in SAS." *Experimental Design, Choice, Conjoint, and Graphical Techniques.* Cary, NC, SAS-Institute TS-722, 2010.

Landry, C. E., & Jahan-Parvar, M. R. "Flood Insurance Coverage in the Coastal Zone." *Journal of Risk and Insurance* **78**,2(2011):361–88.

Louviere, J., Street, D., Carson, R., Ainslie, A., Deshazo, J. R., Cameron, T., Hensher, D., Kohn, R., and Marley, T. "Dissecting the Random Component of Utility." *Marketing Letters* **13**,3(2002), 177–93. https://doi.org/10.1023/A:1020258402210

Mach, K. J., Kraan, C. M., Hino, M., Siders, A. R., Johnston, E. M., & Field, C. B. "Managed Retreat Through Voluntary Buyouts of Flood-prone Properties." *Science Advances* **5**,10(2019):eaax8995.

Missouri State Emergency Management Agency. Frequently Asked Questions for FEMA-funded Residential Property Voluntary Flood Buyouts. 2016. Internet site: https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/FAQ2016.pdf

Michel-Kerjan, E. O., & Kousky, C. "Come Rain or Shine: Evidence on Flood Insurance Purchases in Florida." *Journal of Risk and Insurance* **77**,2(2010):369–97.

Multihazard Mitigation Council. Natural Hazard Mitigation Saves. 2017 Interim Report: An Independent Study. Washington, D.C.: National Institute of Building Sciences, 2017.

National Centers for Environmental Information, NOAA. Calculating the Cost of Weather and Climate Disasters. 2019. Internet site: https://www.ncei.noaa.gov/news/calculating-cost-weather-and-climate-disasters

Peterson, K., Apadula, E., Salvesen, D., Hino, M., Kihslinger, R., & BenDor, T. K. "A Review of Funding Mechanisms for US Floodplain Buyouts." *Sustainability* **12**,23(2020):10112.

Patterson, G. Case Studies in Floodplain Buyouts: Looking to Best Practices to Drive the Conversation in Harris County, 2018. Internet site: https://kinder.rice.edu/sites/g/files/bxs1676/f/documents/KI%202018%20Buyout%20Report%20.pdf

Petrolia, R. D., Landry, E. C., & Coble, H. K. "Risk Preferences, Risk Perceptions, and Flood Insurance." *Land Economics* **89**(2013):227–45.

Revelt, D. & K. Train. "Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level." *Review of Economics and Statistics* **80**,4(1998):647–57.

Rose, A., Porter, K., Dash, N., Bouabid, J., Huyck, C., Whitehead, J., … **& Tobin, L. T.** "Benefit-cost Analysis of FEMA Hazard Mitigation Grants." *Natural Hazards Review* **8**,4(2007):97–111.

Robinson C. S., Davidson R. A., Trainor J. E., Kruse, J. L., & Nozick, L. K. "Homeowner Acceptance of Voluntary Property Acquisition Offers." *International Journal of Disaster Risk Reduction* **31**(2018):234–42.

Rott, N. California has a New Idea for Homes at Risk from Rising Seas: Buy, Rent, Retreat. National Public Radio Broadcast. 2021. Internet site: https://www.npr.org/2021/03/21/978416929/california-has-a-new-idea-for-homes-at-risk-from-rising-seas-buy-rent-retreat

Scarpa, R. & J. Rose. "Design Efficiency for Non-market Valuation with Choice Modelling: How to Measure it, What to Report and Why. *The Australian Journal of Agricultural and Resource Economics* **52**(2008):253–82.

Salvesen, D., BenDor, T. K., Kamrath, C., & Ganser, B. Are Floodplain Buyouts a Smart Investment for Local Governments? 2018. Internet site: https://ie.unc.edu/files/2018/11/Buyout-Final-Report.pdf

Thomas, A., & R. Leichenko. "Through Insurance: Lessons from the NFIP." *International Journal of Climate Change Strategies and Management* **3**(2011):250–63.

Train, K. E. *Discrete Choice Methods with Simulation*. Cambridge University Press, 2009.

Zachry, B. C., Booth, W. J., Rhome, J. R., & Sharon, T. M. "A National View of Storm Surge Risk and Inundation." *Weather, Climate, and Society* **7**,2(2015):109–17.

Zavier, E. M., Hagelman III, R. R., & Rugeley II, W. M. "Site, Situation, and Property Owner Decision Making after the 2002 Guadalupe River Flood." *Papers of the Applied Geography Conferences* **35**(2012):249–25.

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