**Chapter 2. Distributional Consequences of Flood Buyout and Acquisition Programs**

1. **Background**
   1. **Managed retreat programs**

Flooding is a particularly economically damaging effect of climate change as it damages infrastructure and homes. Climate change exacerbates flooding, and one way that the government has responded to increasing damages is through managed retreat. Managed retreat involves physically moving people away from risk. Government agencies will pay people to demolish homes in high-risk areas and relocate. Interest in buyouts and managed retreat has in part grown because of the recognition that mitigation strategies involving infrastructural improvements may create a false sense of safety, a phenomenon that has been termed the levee paradox (Gissing et al., 2018). Buyouts are a promising alternative, because they involve leaving the purchased property as open or greenspace, stopping future damage costs at the point of purchase and providing ecosystem services.

Managed retreat programs have existed in the US since the 1970s (Miao & Davlasheridze, 2021). The Federal Emergency Management Agency’s (FEMA) Hazard Mitigation Grant Program (HMGP) has funded most of homeowner’s relocation through buyout programs. Through a buyout, FEMA pays the pre-disaster fair market value of the house, and the house is demolished and left as open or green space. Acquisitions are similar, although the land is auctioned and can still be developed (Elliott et al., 2023). The 1988 Stafford Act authorizes HMGP funding for disaster relief after presidential disaster declaration (PDD) (FEMA, n.d.). Funding for buyouts may also come from the Department of Housing and Urban Development’s (HUD) Community Development Block Grant-Disaster Recovery (CDBG-DR) program. Federal agencies like FEMA and HUD typically cover 75% of buyout costs, with a 25% non-federal cost match accounting for the rest (Curran-Groome et al., 2021). The National Flood Insurance Program (NFIP) was established in 1968 to assist vulnerable residents with flooding costs. FEMA developed flood insurance rate maps (FIRMs) that define flood zones. The 100-year floodplain, also known as the special flood hazard area (SFHA), has a 1% annual change of flooding per year. SFHA property owners with a federally backed mortgage are required to purchase flood insurance.

Buyout programs tend to be reactive, in response to disasters, rather than proactive (Hashida & Dundas, 2023a). The process starts with states and/or local governments gathering a list of eligible properties for an application to FEMA. If they are granted funds, states distribute them to local governments. Local governments either work with property owners or contract out assistance for the buyout implementation. Since these are typically reactive, after a major disaster, they often operate inefficiently. The processes can be time consuming, there are overlapping bureaucracies involved, different levels of governmental authorities interacting leading to conflicts, and other complications that cause buyouts to take over five years. The drawn out process sometimes causes participants to walk away from the buyout altogether. (Curran-Groome et al., 2021).

Buyouts are voluntary, residents cannot be forced to sell their home. Though they are offered FMVs for their home, state or local governments can provide additional incentives. (BenDor et al., 2020). Sometimes, local governments will even provide incentives for groups of homes to move together. They can be used for parks, gardens, floodplains, but are typically left as vacant lots. Some homeowners decide to stay and ultimately have to rebuild their home after flooding. These residents are called “holdouts,” and among reasons for why they may refuse to relocate are inadequate incentives or information, strong ties to their community or location, or inability to afford relocation (BenDor et al., 2020).

* 1. **Harris County Buyout Program**

Flooding is a significant concern to the 4.7 million residents of Harris County, Texas. Harris County along the Gulf Coast has historically been a flood prone location, and is the site of some of the most catastrophic hurricanes and flooding events. The Harris County Flood Control District (HCFCD) was created in 1937 in response to severe flooding. The HCFCD is a special purpose district that deals with flood control in the county. Being a special purpose district, it has the power to buy and sell land. Hurricane Harvey of 2017 resulted in 36 deaths and $125 billion in damages (Harris County Flood Control District, n.d.). With growing population and economic development, it is critical that climate change risks are kept in mind when planning for the future. With more people and infrastructure comes costlier flood damages.

The Project Recovery Buyout Program buys homes from residents in high flood risk zones in Harris County and relocates residents out of high-risk areas. Buyouts are used to reduce flood damages when the costs of structural damages are not cost effective. They reduce flood damages and risk to residents by moving them out of the hazardous area. The land where homes were located is converted to natural floodplain or left as greenspace. The voluntary buyout program is operated through the Harris County Community Services Department (HCCSD), the Harris County Engineering Department’s Real Property Division (HCRPD), and the Harris County Flood Control District (HCFCD). Residents interested in the program can apply, and houses are inspected and appraised if deemed eligible. Homeowners can then sign an Appraisal Acceptance Letter. A Case Manager (CM) is assigned to the buyout to facilitate the process of selling the buyout home and purchasing the replacement home. The duration of this process is approximately nine months (Harris Recovery, n.d.).

Homes are bought out if it is not cost effective to construct flood control projects their instead. If the home’s value exceeds the estimated cost of implementing a flood control structure, it is not considered cost-effective. Properties are priorities by flood depth and life safety, future land use, percent of public ownership, owner and community interest, and maintenance.

Harris County encompasses Houston an is a racially, culturally, and economically diverse area. The county lies in low coastal plains and includes a system of bayous, and the area is vulnerable to both inland and coastal flooding. These problems are exacerbated by poor urban planning and consistent population growth. Despite the frequency and severity of flooding events, development is still permitted in the one percent floodplain. The program has existed since 1985, but buyouts have increased significantly since hurricane Harvey in 2017. 3,500 properties have been purchased through the program, making it the program with the highest number of buyouts in the US. The HCFCD prioritizes contiguous neighbors that meet Flood Insurance Rate Maps (FIRMs) criteria (Binder, Greer, & Zavar, 2023).

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* 1. **Economic research on flood buyout programs**

Most research indicates that flood buyout programs provide economic impacts. If residents move to lower flood risk areas that are still near their origin location, they can still support their local economy while reducing costs of flood damages (Elliott et al., 2023). Another way they flood buyouts may provide benefits is through steering development away from risky areas. These findings are important because, since 1998, FEMA has only allocated approximately 4.5% of their funding toward buyout programs, and because many residents are reluctant to participate in these programs. Local government agencies may be reluctant to encourage buyouts, because they may signal risk (Hashida & Dundas, 2023). The voluntary nature of these programs in part determines the economic effects of the programs. BenDor et al. (2020) attribute the economic outcomes of buyouts to the spatial patterns that follow buyouts. One common spatial pattern that results from buyouts is called checkerboarding, where there are scattered patches of participants and holdouts.

There have been two stated preference (SP) studies on buyouts. Landry et al. (2020) find homeowners are willing to pay $22 per household per year for a buyout in North Carolina. Ando and Reeser (2022) estimate homeowners are willing to pay $600 for a hypothetical contract for a pre flood buyout.

increased mean property values by $33,407 for homes nearest the buyouts, and that benefits attenuate with distance. Hashida and Dundas (2023) …

There have also been several revealed preference (RP) studies. Guo et al., (2023) use sales data from Zillow and find that buyout and acquisitions provide a 3.7-9% increase in property values from the mean in New York’s buyout program. Nelson & Camp (2020) estimate $2 billion in benefits from avoided structural and building damages using a FEMA method and property sales data from the Tennessee buyout program. They estimate that avoided relocation and volunteer labor costs are an additional $980 million using data from a household survey. They also estimate that buyouts generate over $670 thousand from reduced stormwater infrastructure costs.

Cost-benefit analyses (CBAs) that show benefits exceed costs are required for implementation of buyouts. A review of HMGP funded buyout between 1993 and 2003 found that the average BCA was about 5 to 1 (BenDor et al., 2020). BenDor et al. (2020) calculate the financial impacts of buyouts including avoided infrastructure costs, avoided response and recovery costs, net tax revenue loss, and buyout site maintenance costs. Carran-Groome et al. (2021) review CBAs of buyouts to attempt to calculate full cost of buyouts, the costs associated with the design, administrative, and implementation, and conclude that there is a lack of reporting of these government expenditures.

There is concern that flood mitigation policies encourage development on flood-prone areas. This is consistent with the fact that NFIP flood insurance payouts are mostly used for rebuilding flooded properties, rather than on reloation (Miao & Davlasheridze, 2021). Miao and Davlasheridze (2021) also find that counties with higher NFIP insurance rates are less likely to participate in buyouts because of reduced risk perception. They hypothesize that underpriced flood insurance reduces the true cost of living in risky areas that could lower incentive to relocate.

Buyouts also present environmental justice concerns

Table 1 summarizes the literature on the economic effects of flood buyout programs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Paper | | | | Type of effects | | | |
| Authors | Program | Methods | Benefit type | Spatial | Temporal | Racial | Income |
| Guo et al., (2023) | Hurricane Sandy acquisition and buyout program | DID | Property values, enhanced resilience, and job creation | Y | Y | N | N |
| Nelson & Camp (2020) | Tennessee buyout | FEMA algorithm | Avoided structural damages plus relocation costs and volunteer labor | N | N | N | N |
| Ando & Reeser (2022) | Hypothetical pre-flood contract for post-flood buyout | CVM | WTP for hypothetical program | N | N | Y | Y |
| Jowers et al. (2023) | Various programs between 1989 and 2017 | Hedonic | Difference between FMV and buyout value for White, Black, and Hispanic owners | N | N | Y | N |
| Schoder (2024) | Various programs between 1989 and 2017 | Propensity score weighted DID | Property value increase | N | N | Y | Y |
| Holloway, BenDor (2023). | Mecklenburg County, NC buyout program | Hedonic | Property value increase | Y | Y | N | N |
| Hashida & Dundas (2023) | New York Rising Buyout and Acquisition Program | Hedonic repeat sales DID and event study | Property values | Y | Y | N | N |

Table 1.1 Race and income results

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| --- | --- | --- | --- |
| Author(s) | Program | Race outcomes | Income outcomes |
| Guo et al., (2023) | NYRBAP | Mortgage applicants have a higher share of racial minorities following nearby acquisitions | Mortgage applicants have a higher average income following nearby acquisitions |
| Ando & Reeser (2022) | Hypothetical | Black residents have higher WTP for flood buyout coupled with insurance than other race groups | Households with higher incomes have higher WTP for flood buyout policy |
| Jowers et al. (2023) | Various programs | Black and Hispanic owners receive  a greater buyout discount on their property relative to the property’s FMV than White owners |  |
| Schoder (2024) | Various programs | The buyout effect is positive but lower in magnitude among zip codes that are predominantly White | The buyout effect is positive but lower in magnitude among zip codes that have income levels above the median and higher in magnitude among zip codes that are more rural and lower income. |
| Hashida & Dundas (2023) | NYRBAP | Areas with acquisitions tend to be whiter. | Areas with acquisitions tend to be more educated, wealthier, and have a higher  percentage of owner-occupied houses |

* 1. **Environmental justice and sorting models**

Estimating the disparities in welfare consequences among racial, income, ethnicity, and other minority groups, is a crucial duty in the field of environmental economics. The goal of environmental justice is that everyone receives the same benefits from environmental goods and the same protection from environmental hazards. Minority groups often receive less benefits (more harms) from environmental amenities (disamenities) compared to high income, white people. Historical and current discrimination contributes to the gap in benefits. Environmental justice has become a growing area of research in economics. Research has focused on the differences in exposure to pollutants between minority and nonminority groups (e.g. exposure to air pollutants). Welfare estimates produced by economists are crucial for designing policies that minimize this gap and contribute to equity. Another important area of research in environmental justice studies the distributional consequences of environmental policies among different groups (e.g. which groups benefit from the CAA) (Cain et al., 2024).

* Environmental justice: buyout specific

Because of historical discrimination in housing, minority groups are disproportionately vulnerable to injustices from housing related policy. Thus, studying the distributional consequences of buyout programs is a pressing matter. 80% of FEMA buyouts have occurred in mostly White census tracts. Additionally, White residents are willing to tolerate more flood risk before retreating. This could be because there is more investment into Whiter residential areas after disasters, making them safer to stay at despite risks. Additionally, homeowners of color may have stronger community attachment and distrust of government (Elliott et al., 2023). Mach et al. (2019) find more buyouts occur in counties with higher population and incomes. However, using zip code level data, they find that bought out properties are located in communities with lower income, lower population density, lower education, and greater racial diversity.

* Exposure vs vulnerability

Residential sorting is how households choose where to locate. When deciding where to locate, a household considers the tradeoffs between the characteristics of different locations. The decision of where to locate provides information about preferences of households, because it reveals what characteristics they value more than others. Economists can model the tradeoffs people make when deciding where to locate, including exposure to environmental goods and/or bads, to estimate the welfare gains/losses from those environmental resources) (Cain et al., 2024).

1. **Data**
2. **Analysis**

I estimate household economic benefits from changing the Harris County flood buyout program from voluntary to mandatory using a residential sorting model. The choice of housing is a combination of geographic and house characteristics. Also, the choice set may not be the same each year and for all individuals. Let and be vectors of house and neighborhood characteristics, respectively. Let be a dummy variable equal to one if property *j* was part of a mandatory buyout in at . denotes demographics (race, income, tenure, primary language spoke in household) of individual *k= 1,…, K.* A household receives the following utility from choosing to move to house at time

where is a parameter to be estimated showing the change in marginal utility from attribute after the mandatory buyout. Also

I estimate household economic benefits from changing the Harris County flood buyout program from mandatory to voluntary using a residential sorting model. The choice of housing is a combination of geographic and house characteristics: census tract, flood risk indicator (?), house characteristics (list), and distance to coast (bins?). The distance to coast bins are used to control for the amenity impact of proximity to water. Also, the choice set may not be the same each year and for all individuals. We could either (1) assume they face the same choice set or (2) figure out how to do something about that.

Each house chooses to live in a location at time , where is what is available from the choice set at that time. A household receives the following utility from choosing to move to house at time

1. ,

where is the component of utility that is common to all homeowners and is the component of utility unique to each individual, which are functions of observable location attributes. Utility also depends on location attributes and idiosyncratic tasteswhich is distributed extreme value. Let denote the price of living at house at time and let denote location attributes that households have homogenous preferences over, like median income. Then we can rewrite the observable component of utility as,

where the ’s are preference parameters. I model the effect of changing the Harris County flood buyout program from mandatory to voluntary in the individual-specific component . The individual- specific household utility model is,

where is a dummy variable equal to one if a sale took place after the initiation of the mandatory buyout program (2020) and is a dummy variable for homes that were part of the mandatory buyout program. is our variable of interest. It measures the benefits of making the buyout program mandatory. is variable for the number of months the buyout process took from initiation to sale of the origin house. is a dummy variable equal to one if the destination house is in the same county as the origin house. is a variable that measures how much their flood risk changed from origin to destination location.  are location attributes that households have homogenous preferences over and are location attributes that households may have individual-specific preferences over. includes tract-level income, education, and crime. The attributes include the percent of Black and percent of Hispanic residents. The ’s are preference parameters describing the effect of each attribute on WTP.

Furthermore, we break down the regression by race, income, and primary language by decomposing the ’s with the equation is the preference parameter for the base group, which measures the effect of the attribute on utility. includes the race, income, and language of the household. Thus, is the additional effect of the attribute on utility relative to the base group associated with .

Next, I estimate using Maximum Likelihood Estimation. Since is distributed as a Type 1 Extreme Value, we can use the multinomial logit to specify the probability that household moves to house at time

where are all possible destination locations. The likelihood function is based on the destination decisions people make. If chooses , the likelihood contribution for that household is . Where is the vector of β parameters to be estimated. The total likelihood is the product of the individual likelihoods, For computational ease, we instead maximize the log-likelihood function, .

Since sales prices are probably correlated with unobservable attributes , we have an endogeneity issue. Thus, we regress on instruments as follows,

The residuals capture the unobserved price variation. We incorporate the residuals into the regression,

(1’) .

Stata steps:

1. Define variables
2. Define utility function Uijt = …
3. Define the probability of choosing j:
   1. expUijt = exp(Uijt)
   2. bysort sale\_id: egen sumexpUijt = total(expUijt)
4. Define likelihood function
   1. Pijt = expUijt / sumexpUijt
5. Define log likelihood function
   1. lnPijt = ln(Pijt)
6. Run MLE

Sorting mode l estimation:

* Melstrom uses logit (not 2 stages) using MLE. Use IV to control for unobserved location attributes and price endogeneity.
  + He controls for price endogeneity with a control function approach. First, constructs instruments based on distant location attributes. Second, he regresses price on location attributes and instruments. Third, he inserts the residuals from the regression into the utility function.
  + So, for example, use the crime rate far away as an IV.
  + Price endogeneity occurs because price is correlated with unobservable attributes

One concern with buyouts is that if homes are removed from a hazardous area, the tax base of the local government for the remaining homes may be reduced if participants relocate far from their origin. Thus, it is important to understand how buyouts effect those remaining in the location.

We develop a residential sorting model to estimate the benefits of buyouts on different groups of residents.

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