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Inequities in Flood Management Protection Outcomes

By

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Abstract

Knowledge of low-income issues in floodplain management is spotty. Repeated flooding resulting from hurricanes striking North Carolina, and most recently Hurricanes Katrina and Rita, has raised concerns that vulnerable low-income communities may be more exposed to the devastating costs of flooding. This issue has been covered in the popular press but to date has received only modest attention in the academic literature. Shilling et al. (1989) and Browne and Hoyt (2000) evaluated insurance penetration for low income inhabitants. In this paper, we explore the relation of poverty and flood risk in a stratified sample of Census blocks located in special flood hazard areas (SFHAs).

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Inequities in Flood Management Protection Outcomes

Flood events cause more losses, on average, than any other natural disaster in the United States. Flood losses by income and ethnic group partly depend on whether flood management code programs reach disadvantaged populations and minorities, a key measure of program equity. Disadvantaged populations often lack flood insurance and the loss for the poor is in many cases irreparable. Indeed, if the population that lives in poverty is most significantly affected by flood hazards, more effective mechanisms for coordinating local, state and federal response are needed. The poverty line depends on the size and composition of the family with regard to the number of children, adults and persons age 65 or over. For example, the poverty line (or threshold) in 2002 was $9,183 for a one-person family, $18,244 for a four-person family with two children (under age 18), and $18,307 for a four-person family with three children. In this study, we use per-capita household income of less than $20,000 (under US Census 2000) as the threshold for poverty.

Knowledge of low-income issues in floodplain management is spotty. Repeated flooding resulting from hurricanes striking North Carolina, and most recently Hurricanes Katrina and Rita, has raised concerns that vulnerable low-income communities may be more exposed to the devastating costs of flooding. This issue has been covered in the popular press but to date has received only modest attention in the academic literature. Shilling et al. (1989) and Browne and Hoyt (2000) evaluated insurance penetration for low income inhabitants.

This paper evaluates flood losses of lower income brackets in varied Census Blocks in special flood hazard areas (SFHAs), i.e., area with a one percent annual probability of flooding and an expected value of one flood every 100 years. In particular, using Census Block data on property values, income brackets, and demographic information coupled with flood loss estimates, we determine whether damages inflicted to residences are different across ethnic and income groups, including those living under poverty.

The analysis reveals two interesting results. First, those in the highest income brackets (household incomes larger than $75,000) are more prone to live in higher flood hazard areas because of the esthetic attributes of living next to water. They can afford the premium from flood insurance. Second, low income households with incomes between $10,000 and $30,000 live in higher risk areas than the middle income households with incomes between $30,000 and $75,000. Presumably, low income households live in hazardous areas in order to find affordable housing. The analysis also estimates the impact of urbanization (population), race, and number of rental units on flood damages at the Census Block level.

Floodplain Management

Devastating natural disasters for communities include earthquakes, tornados, floods, and fires. The effects of flooding differ from other disasters in terms of their probability distribution, the nature of the damage caused, and the precautionary measures that could be taken. Among natural disasters, floods are the major source of financial stress to governments and individuals in the United States. Although the importance of the Federal role in flood protection was recognized at the turn of the 20th century, the prevailing view was that technological advances would prevent the effects of flooding. This view changed in the late 1950s, the need to manage flood prone lands was recognized.

In 1966, President Johnson submitted to Congress the study "Insurance and Other Programs for Financial Assistance to Flood Victims." The study concluded that Federal flood insurance was feasible and would promote the public interest. The Natural Flood Insurance Act (Title XII of the Housing and Urban Development Act of 1968) created the National Flood

Insurance Program (NFIP). However, participation in the NFIP did not become widespread until the Flood Protection Act of 1973 that made community participation in the NFIP a condition of eligibility for certain types of Federal assistance. The NFIP objectives were twofold: (1) constraining the cost of damage caused by flooding, and (2) providing economically feasible relief to victims through insurance.

To enforce NFIP regulations on flood management in SFHAs, communities issued new building permits conditional on compliance with the BFE requirement. In particular, the NFIP delegates to local governments the enforcement of national guidelines that require new houses and buildings in SFHAs to be protected against a one percent annual chance flood. Briefly, these guidelines require new structures to be built at or above the base flood elevation (BFE), which reduces the probability of flood damages in structures to a frequency event of less than one percent per year. To enforce these regulations, local governments control permits of development and construction in SFHAs in accordance to the BFE requirement. Freeman (2002) shows that residential health hazards are larger for renters than homeowners.

Previous Studies

As Scanlon (1988) has observed, "…while it is obvious disasters are negative events causing injury and death, damage, and destruction, macro-economic studies show little long-term economic effects from disaster. That is because disasters create both losers and winners, and these balance out. Who loses and who wins is not random but a result of public policy decisions. The losers include individuals who are injured, lose their jobs, lose their homes, lose a wage earner, or lose a place of residence. The winners include individuals who earn extra money because they are involved in emergency response or restoration." Increasingly, good politics dictates helping all disaster-stricken communities to emerge as winners from a federal assistance viewpoint.

Extensive work has been done defining the categories of costs that result from disasters and agreeing on ways to estimate them through case studies. The guidelines are described in three documents:

- "The Impacts of Natural Disasters: A Framework for Loss Estimation," from the Committee on Coastal Erosion Zone Management of the National Research Council (1999).
- "The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation," which is a panel report from the H. John Heinz III Center for Science, Economics and the Environment (2000).
- An article derived from the Heinz Center report, "Uncovering the Hidden Costs of Coastal Hazards" (David et al. 1999).

The recently developed Hazards U.S. Multi-Hazard (HAZUS-MH) flood loss simulation model is a simulation model that estimates direct economic losses (building and contents losses), as well as indirect losses (relocation losses, wage losses, rental income losses) for varied types of flooding. The level of aggregation in HAZUS is at the Census Block, i.e., flood losses are calculated at the mean characteristics at the Census Block. In addition to the flood loss at each Census Block, we have information on the mean value of the property at each Census Block as well as income and population data. Analysis of the NFIP's financial impact may use damage curves in HAZUS for different structural flood elevations. The NFIP covers flood losses to buildings and contents, but it does not protect against the indirect costs of flooding (e.g., temporary housing) to residences.

Economic losses in the flood model are built from actual geographical data extracted from Geographic Information System (GIS) maps. HAZUS contains a hydrologic model of the United States. This model builds on the U.S. Geologic Survey (USGS) EROS 30-meter digital elevation model, gauge records, USGS regressions for ungauged reaches, National Oceanic and Atmospheric Administration (NOAA) data, and the hydrologic derivatives. Census data at the block level are merged onto the geo-coded database. Guided by U.S. Department of Energy building characteristics survey data, structure characteristics are estimated. The HAZUS data file contains square feet of residential property by block. Starting from the NFIP loss database, the model examines losses in known flood events, infers total losses by cost category (essentially structure and contents), then uses these to drive an engine for estimating losses by flood size. HAZUS stores most data at the Census Block level, with the ability to aggregate blocks into counties or other reasonable units.

Data Extraction

To evaluate the adequacy of floodplain management to reach low-income inhabitants, we use the HAZUS-HM Flood Model. The simulation model estimates direct economic losses to residences under different types of flooding and different community characteristics. In addition to the flood loss calculated by the engineering model of flood damage for each Census Block, we also have information on the mean property value, income, and demographic data for each Census Block. Our analysis uses a sample of 35,000 observations from flood losses extracted from flooded census blocks under a 100-year flood selected from 20 communities that pertain to special flood hazards areas (SFHA) across the United States and from NFIP communities included in Mathis et al. (2006) study of compliance with NFIP regulations.[2]

Econometric Analysis

The econometric analysis uses Census Block data to explain characteristics of residences impacted by flooding. In the analysis, we use HAZUS to simulate a water overflow of a 100-year flood, which results in the inundation of various Census Blocks. From the resultant flood levels in each Census Block, we determine economic losses for those in poverty, as well as other income groups. We also account for the population of each Census Block, number of rental units, and mean income and property values at each Census Block. From the available data, we formulate a fixed-effects model of flood losses:

$$F_{js} = a + r_j + \mathbf{C}_s\beta_1 + \mathbf{Y}_{js}\beta_2 + \mathbf{P}_{js}\beta_3 + \xi_{js} \quad (1)$$

where flood damages (flood damage under a 100-year flood) in Census Block s at region j are F_{js}; the vector $\mathbf{C_j}$ codes each community with an indicator variable; and the vector $\mathbf{Y}_{js}$ shows for each Census Block the number of households in each income bracket (including those in poverty). The vector $\mathbf{P}_{js}$ includes for each Census Block the population and number of household units, as well as the number of rental units, mean income, and property values. The econometric residual ξ_{js} captures prediction error in the econometric model.

Dummy (indicator) variables for each community account for fixed (or non-random) differences in flood damages across communities. Similarly, the variance of the econometric

[2] Mathis *et al.* 2006. Evaluation of Community Compliance with Building Requirements – Part B. Prepared as a part of the 2001-2006 Comprehensive Evaluation of the National Flood Insurance Program. FEMA, In Progress

residual ξ_{js} is likely to differ across communities. Heterogeneity from random effects is captured by the assumption:

$$Var(\xi_{js}) = a + \mathbf{C}_s\beta^* + u_{js}$$

Tables 1 thru 3 show coefficient estimates under different estimators. Table 1 shows coefficient estimates without fixed or random effect, Table 2 shows the estimation with only fixed effects, and Table 3 shows estimation with both fixed and random effects.

Inspection of Table 3 shows that the existence of fixed effects for community heterogeneity is significant. This explains the anomalous result that the price of the residences negatively explains flood damages in Table 1 (that excludes heterogeneity). Furthermore, Table 3 shows that random effects for community heterogeneity are likewise important in explaining flood damages. Comparisons of the tables reveal some sensitivity of results to the choice of estimator. Henceforth, estimation results will refer to Table 3.

Results

Two fundamental principles for evaluating a federal program are overall cost effectiveness and equity. A shortcoming for evaluating flood losses by income is that wealthier residences embed by definition a larger potential damage (e.g., larger replacement value). Consequently, to measure the NFIP's impact on equity, this damage needs to be standardized by the value of property. As a result, we included value of property in the regression. Table 3 obtains the expected result that damages increase with the value of property.

Table 3 shows statistical correlations between flood damages and number of households and population in each Census Block. The table also shows whether flood damages are different among ethnic groups. Interestingly, results connect the number of households in each income group with flood damages. The table also shows the statistical correlation between renters and flood damages.

TABLE 1: OLS Coefficient Estimates

Variable	Estimate	Standard Error	t Value
Intercept	512.90	264.69	1.94
Households	10.73	9.62	1.12
Population	-4.30	2.29	-1.87
African American	35.90	3.90	9.2*
Hispanic	3.65	2.57	1.42
IncLess10	-187.44	25.26	-7.42*
Inc10to20	87.80	21.25	4.13*
Inc20to30	121.82	25.80	4.72*
Inc30to40	-158.24	28.28	-5.6*
Inc40to50	-4.85	30.96	-0.16
Inc50to60	-89.17	36.00	-2.48*
Inc60to75	53.05	34.64	1.53
Inc75to100	132.36	32.45	4.08*
IncOver100	111.16	16.39	6.78*
AvgValue	-0.0042	0.0007	-5.79*
RenterSingleUnits	109.32	22.67	4.82*
MeanIncome	0.012	0.005	2.52*

NOTE: The asterisk indicates statistical significance at the 95% confidence level.

TABLE 2: OLS Coefficient Estimates with Fixed Effects

Variable	Estimate	Error Standard	t Value
Households	4.21	9.37	0.45
Population	-5.20	2.30	-2.27*
African American	34.45	4.08	8.43*
Hispanic	4.38	2.69	1.63
IncLess10	-169.48	25.00	-6.78*
Inc10to20	93.21	20.78	4.49*
Inc20to30	117.75	25.14	4.68*
Inc30to40	-141.51	27.75	-5.1*
Inc40to50	5.61	30.15	0.19
Inc50to60	-60.52	35.26	-1.72
Inc60to75	81.58	34.14	2.39*
Inc75to100	137.55	32.28	4.26*
IncOver100	104.24	16.19	6.44*
AvgValue	0.003	0.001	2.34*
RenterSingleUnits	143.61	22.90	6.27*
MeanIncome	0.0009	0.0050	0.19
F-value for Existence of Fixed Effects	14.57*		

NOTE: The asterisk indicates statistical significance at the 95% confidence level.

TABLE 3: GLS Coefficient Estimates with Fixed and Random Effects

Variable	Estimate	Standard Error	t Value
Households	29.33	7.57	3.88*
Population	-6.41	1.84	-3.49*
African American	42.10	3.89	10.81*
Hispanic	3.54	2.34	1.51
IncLess10	-136.03	20.06	-6.78*
Inc10to20	44.57	16.67	2.67*
Inc20to30	57.22	20.33	2.81*
Inc30to40	-98.25	23.46	-4.19*
Inc40to50	-72.01	27.52	-2.62*
Inc50to60	-42.79	29.91	-1.43
Inc60to75	43.89	27.78	1.58
Inc75to100	198.10	26.92	7.36*
IncOver100	36.24	13.13	2.76*
AvgValue	9.98E-07	2.46E-07	4.05*
RenterSingleUnits	43.08	21.21	2.03*
MeanIncome	-1.1E-06	8.05E-07	-1.41
F-value for Existence of Random Effects	10.14*		

NOTE: The asterisk indicates statistical significance at the 95% confidence level. The random effects test only includes random effect for two communities.

Flood Loss and Census Block Characteristics

Results in Table 3 show that the rise in flood damages with number of structures (households) in the Census Block is statistically significant at the 95 percent significance level. Therefore, urbanization increases damage per-structure after factoring out the price of the property.

Freeman (2002) shows general physical deficiencies in residences are larger for renters than homeowners. As a result, health risks from residential hazards are higher for renters and low income groups. Estimation results in Table 3 show that Census Blocks with more renters also have larger flood losses. The association of renter units with higher flood losses may indicate that renter structures have less stringent codes of protection against flood hazards. It also may relate to losses in beachfront investment property. The consequences of this result are very important given that renter properties are not subject to the mandatory purchase provision of flood insurance, which requires that homeowners carry flood insurance to qualify for a mortgage loan in SFHAs. Mandatory insurance flood protection laws thus exclude household contents of more vulnerable populations (renters).

Flood Loss across Income Groups

The distribution of population by flood hazard levels at the Census Block level provides a measure of NFIP adequacy to serve low income inhabitants. Results in Table 3 account for property values and other factors and thus evaluate the impact of poverty (household income of less that $20,000) on flood hazards. Households in extreme poverty (households income less that

$10,000) have lower flood damages than any other income group. Yet, the majority of the population in poverty (household income between $10,000 and $20,000) suffer greater flood damage impact than middle class households with incomes between $30,000 and $75,000. Low income households above the poverty rate (income between $20,000 and $30,000) also have larger flood losses than the middle income families (income between $30,000 and $75,000). Higher income families with incomes of $75,000 (or larger) also face larger flood hazards than middle income families.

The analysis reveals two interesting patterns. First, higher income households often live in high risk areas because of the esthetic attributes of living next to water, and their ability to afford the premium from flood insurance. Second, low income households live in higher risk areas than middle income households in order to find affordable housing.

Therefore, the poor are more exposed to flood hazards than middle income households. This is a public policy issue because the poor are less likely to recover from economic losses. These shortcomings are accentuated by the fact that the poor generally lack flood insurance, and flood disaster relief is generally confined to $2000 plus temporal housing assistance. Moreover, the SBP rejected 70% - 85% of disaster relief loan applications in both the Great Mississippi flood and Hurricane Katrina, claiming applicant assets and income were too low to provide reasonable assurance of repayment.

Race and Flood Hazards

Perhaps one of the most controversial issues is whether certain ethnic groups are exposed to larger hazards. Results in Table 3 show that, in controlling for incomes, African Americans suffer more flood damages on average than other races. This result suggests that African Americans are more exposed to flood hazards.

Analysis and Conclusions

It has been well documented that the poor confront larger risks that decrease their expected lifespan. Hurricane Katrina illustrated the devastating effects of flooding on low income households. This paper explored the relation of poverty and flood risk in a stratified sample of SFHAs. The analysis included 3,500 Census Blocks and 35,000 people.

Estimation results showed that the population in the income group of $10,000 to $30,000 are more exposed to flood hazards than the other groups of the population (excluding those in the highest income brackets). The population in poverty gravitates to areas of high flood risk, possibly because of economic opportunities (e.g., jobs at hotels) or because of marginalization into high risk areas.

The need for low-cost labor in the service industry means that many low income inhabitants live close to coastal areas. Low income households also may choose to live in hazardous conditions in exchange for affordable housing. In particular, this is a public policy issue because low income homeowners store almost all their wealth in their home investment. If that investment is destroyed, they are unlikely to recover from the economic losses.[3] Moreover, low income homeowners generally cannot afford – and therefore lack – flood insurance. Their flood disaster relief generally is confined to $2000 plus temporal housing assistance.

[3] See http://www.huduser.org/publications/HOMEOWN/WAccuNHomeOwn.html

Those with sufficient income to afford the amenity of living close to the water are also exposed to large flood hazards. The severity of flood damage thus follows a bi-modal distribution with respect to income.

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