Evaluation of the Financial Impact of Flood Management on Residential Losses

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Presently, there is very little empirical evidence on the impact the National Flood Insurance Program (NFIP) has had on flood costs and there is no information on the effect of the NFIP on equity. The lack of information on these two fundamental principles for evaluating an insurance program arises in part because of the inability of existing empirical methods to identify the effect of flood management on residential losses. The purpose of this study is to examine the impact of flood management norms on prevention of residential flood loss and their distribution among payers. The analysis probes the NFIP's financial impact, the centerpiece question about program effectiveness.

Surprisingly little currently is known about these issues. A time series analysis by the National Weather Service (Pielke et al. 2002) yielded some insight by analyzing a 60-year series of the federal government's annual estimates of the costs of flooding, with the number of communities participating in the NFIP included as an explanatory variable. Federal flood disaster costs dropped significantly as NFIP participation rose. Beyond this, our knowledge of costs and consequences largely comes from case studies (e.g., FEMA 2000, H. John Heinz III Center 2000, Gruntfest 1995).

Unfortunately, existing case studies (e.g., Philippi 1994) do not yield a representative picture of the situation nationally. Indeed, the range of mitigation approaches, flood sizes, warnings of flood arrival, flood insurance penetration, community characteristics, and recovery options probably is too diverse to credibly cover through case studies. Consequently, case study results are hard to generalize and the legitimate reasons that case study findings vary are hard to pinpoint. Exacerbating this problem, existing case studies almost all focus on spectacular disasters.

For the analysis, this paper develops a control experiment to decompose the costs to individuals and public finance from floods in SFHAs. The control experiment uses structure from national data on the distribution of elevations in SFHAs, and damage curves embedded in HAZUS-HM flood loss simulation model. The recently developed HAZUS flood loss simulation model offers the potential to systematically probe flood loss levels under alternative flood size. In effect, the flexibility provided by HAZUS together with the use of the national distribution of damages in SFHAs permits a unique investigation on the causes and consequences of flooding.

To simulate the financial impact of the NFIP under floods of different sizes, the paper creates add-on modules for the HAZUS analysis that allows calculation of the NFIP impact on who pays for the cost of flood disasters. The add-on modules decompose the payers of flood disasters based on federal assistance reaction functions. These reaction functions follow the Stafford Act and historical averages in the federal response to flood disasters.

National Flood insurance Program

Some devastating natural disasters on communities are earthquakes, floods, and fires. The effects of flooding are, nonetheless, different from other disasters in terms of its 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. Whereas 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. In the late 50's this view had changed, and it was recognized, rather, that management of flood prone lands was necessary.

In 1966, President Johnson submitted to congress the feasibility of a flood insurance program, and the study "Insurance and Other Programs for Financial Assistance to Flood

Victims" concluded that flood insurance is feasible and will 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 generalized 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 objective was 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 to 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 1 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 1 percent per year.

Methodology

This section builds add-on modules on an engineering model of flood damage (HAZUS-HM Flood Model) to determine who pays for flood losses of different sizes. The add-on modules serve to decompose the NFIP impact on uncompensated losses, insurance claims, and government losses. To parameterize a reaction function that provides relief to victims after a disaster declaration, this section builds three scenarios. First, we model losses and federal response to residences and nonresidences with insurance and NFIP mitigation. Second, we simulate NFIP's enforcement of mitigation, but without insurance coverage. Lastly, we assume an unregulated system with neither mitigation nor insurance coverage (i.e., no NFIP).

The simulation analysis will capture the NFIP impact on the level of uncompensated damages to both residences and nonresidences, and the NFIP impact on public finances. The first result will show the NFIP's effectiveness in reducing uncompensated losses, and the second result will determine the NFIP's impact on reducing the burden of flood costs on taxpayers.

Estimation of Expected Flood Losses in HAZUS-HM

The HAZUS-HM Flood Model is a simulation model that yields direct economic losses (shelter, buildings, agriculture, transportation, and utilities), as well as indirect losses (relocation losses, wage losses, rental income losses) under different types of flooding and different community structures. Economic losses in the flood model are built from actual geographical data extracted from Geographic Information System (GIS) maps.

HAZUS uses maps from a national database that contains elevations, hydrology, and hydraulics across the United States as well as geographical designations of census blocks. HAZUS simulates a water overflow for a given flood level, which results in the inundation of various census blocks in a community. From the resultant flood levels in each census block, HAZUS estimates economic losses through damage curves that are a function of the elevation of structures. The flexibility of HAZUS thus allows calculation of damages for different flood levels with a corresponding probability distribution while controlling for location. It thus permits both *ex ante* and *ex post* estimation of flood losses.

In the simulation, expected damages for structures located below BFE are identified by observing whether a structure floods under a 100-year event, while expected damages for structures at and above the BFE are calculated in terms of structures that are damaged only in the event of a flood level that surpasses a 100-year flood level. The level of aggregation in HAZUS is at the census block, and therefore, this criterion specifically observes whether the mean structure in the census block floods under a 100-year event. To derive expected flood damages at different elevations, the empirical analysis will use a stepwise distribution that calculates the risk of having a flood that "equals or exceeds" the x-percent-annual-chance (e.g., 100-year) flood. The runs anticipated are, by flood size, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood.[1]

To find the expected flood loss at the aggregate level across all SFHAs, the financial analysis uses structure from the national distribution of elevations in SFHAs. This national distribution of elevation is built into the HAZUS analysis by Sarmiento and Miller (2005).

Who Pays?

The next sections develop add-on modules that capture HAZUS cost estimates that are not differentiated by payer and distribute them in proportions derived from data about NFIP coverage in force and payments by selected payers in floods of record. We supplement values extracted from the literature with secondary analyses of existing data to derive factors needed to break out the direct costs among payers, factoring in how the extent of damage affects the payer distribution. The add-on modules will be used to break down the cost estimates by payer, yielding:

- Federal disaster relief costs
- Costs to government
- Costs to flood victims
- Costs to other taxpayers

[1] These flood levels are generally used to describe the probability distribution of a flood; therefore, for these flood levels, there exist well-defined correspondences between flood discharges and probability of the flood.

Among other results, we will determine the extent to which the NFIP has contributed to alleviating victims and the federal relief effort and, furthermore, the extent to which the NFIP has contributed to the aim that those who choose to live in flood hazard areas pay the risk premium associated with their choices. The analysis will thus measure the NFIP impact by payer of flood losses. To develop add-on modules for HAZUS, the next sections construct flood assistance reaction functions on federal relief to individuals based on Stafford Act and historical averages in the federal response to flood disasters.

Empirically Based Assumptions

Food insurance covers flood losses to buildings and contents, but it does not protect against the indirect costs of flooding. The latter includes possible losses due to temporary housing and income/wage loss. In the calculation of expected flood loss, HAZUS reports both direct and indirect damages to residences and nonresidences. The simulation allows insurance to compensate direct costs, while federal relief may compensate both direct and indirect losses. Conceptually, federal relief is best justified when designed to compensate losses from risk that is not insurable or affordable to the population. Still, by the Stafford Act, specific types of assistance (e.g., temporary residence) under a disaster declared area cannot discriminate on the basis of individual (e.g. income) or residential (e.g., level of flood insurance) characteristics.

NFIP payments for insurance claims that stem from actuarially rated policies are not treated as a cost to the government because premiums pay for these losses. Hence, in the accounting of the payers for flood losses, the subsidy provided by the NFIP to pre-FIRM structures is a direct cost to the program. This subsidy thus constraints the program's flexibility to achieve some of its goals, e.g., better mitigate the costs of flooding.

From secondary data, the premium of pre-FIRM structures is 40 percent of the full price. The General Accounting Office, moreover, reports that 29 percent of the current policyholders are paying pre-FIRM rates. In the assistance response function, the subsidy program thus incurs a fraction equal to (0.6 x 0.29) of insurance claim payments.

In the simulation, an additional source of relief to flood losses in a declared disaster area is federal relief in the form of grants and subsidized loans. For uninsured damages to residences and nonresidences, the SBA makes loans available for damages. Although compensation through SBA loans provides temporary relief, it also increases the burden of the cost to victims of the disaster in the form of interest payments. The interest rate for a 20-year loan is currently 4 percent, and this rate is tied to the Fed Prime Rate. To determine damages to residences and nonresidences paid with SBA loans, this chapter assumes that loans are acquired consistently with the debt to income ratio held by U.S. households (150 percent). That is, in the simulation, 75 percent of uncompensated property losses will be paid with SBA loans for those that qualify. (Given the long-term nature of SBA loans, the minimum SBA loan in the analysis is $2,000). Moreover, to determine who qualifies, we use secondary data that reports 30% acceptance rates for SBA application loans. Therefore, SBA loans are the product of uncompensated losses, percent of loan requested (75%), and acceptance rates (30%).

In case the individual fails to fully qualify for a SBA loan, the individual may alternatively qualify for individual assistance grants under the Individuals and Household Program (IHP). These grants to households and individuals are primarily intended to reduce housing disruption. For residences, federal assistance in the form of grants to residences will be determined based on uninsured damages of (well-reported) historic ranges of the grants approved, $2,000 - $4,000, and the average historic grant value of $2,500.

From historical records, to determine individual assistance grants, we use the average value of IHP grants in declared areas ($2,500), and to determine who qualifies, the simulation uses the quotient of those that did not qualify for SBA loans (conditional on damages larger than $2,000), and multiply it by the acceptance rates for IHB loans (64%). To obtain the total assistance to individuals, the temporal reallocation losses (temporal housing assistances) estimated in HAZUS is added to the cost of grants to residences. From the total sum of federal relief to residences, the proportion of federal to state resources in the assistance reaction function can be determined from the Stafford Act.

A potentially important source of relief to victims of a natural disaster is in the form of tax breaks. In the simulation, the proportion of individual losses entitled to tax breaks is calculated as the difference between flood losses and protection provided by insurance and federal relief grants. Specifically, in the assistance reaction function, the tax deduction that flood victims are entitled to deduct is delineated by law: victims of a natural disaster can deduct nonrefunded losses after the natural disaster if losses are larger than 10 percent of the victim's annual income. For the deduction, we will assign a default rate from tax-rate tables. Three income groups are considered: $0-30K, $31k-60k, > $60K with marginal tax rates of 20 percent, 26 percent and 30 percent respectively. Total uncompensated damages are, therefore, flood loss minus compensation in the form of flood insurance, federal relief, and tax breaks. Different from residences, nonresidences are not entitled to federal grants, but they are entitled to casualty loss deductions, and subsidized loans from the SBA program to provide relief to industry and businesses in recovery.

Evaluation of payers of flood losses to residences in the add-on modules to HAZUS output will thus depend on the flood damage and the parameterizations in the assistance reaction function. The components of the federal reaction function that determine payers for residences after a flood disaster are detailed in Table 1, and the payments for nonresidences are shown in Table 2.

The distribution of the burden of flood losses and NFIP impact to private nonresidential buildings likewise will be calculated based on these historical averages. Yet, nonresidences are not entitled to federal grants, and although loans under the SBA program provide temporal relief to industry and businesses, these flood costs (loans) ultimately will be paid by the affected agent that owns property that is not a primary residence. The SBA program generally involves a cost to the federal government that stems from expenses to operate the program, interest rate subsidies, and defaults. SBA budget reports for 2000 and 2002 indicate that the loss of the SBA program for disaster assistance is 9.8 percent.

Table 1: Components of Damage Assistance Relief for Residences

Equation A: Federal Relief to Residential Damages
Equation B: State Costs = State share × Equation A. where the state share is calculated based on distribution of upper bound of assistance relief to individuals delineated by Stafford Act,. i.e., state share = 2,500/22,500 = 0.11
Equation C: Latent Tax Relief = $\sum_{i}^{N_1+N_2} D_i \times$Tax Relief agent i where $D_i = 1$, if non-refunded loss > 10 percent annual income, and $D_i = 0$, otherwise. Tax Relief agent i ={Damage Uninsured Property$_i$ − Federal Relief$_i$ } × Tax Rate where the analysis will use marginal tax rates of 20 percent, 26 percent and 30 percent for the income groups ($0-30K), ($31k-60k), and > $60K, respectively.
Equation D: Program Losses from the NFIP Subsidy = 0.6 × .29 × (Total Residential Insured Losses) .
Equation E: Uncompensated Damages = Damage Uninsured Property − Eq A + Eq C
Equation F: Value of SBA loans
Equation G: *Government Loss from SBA Loans: 0.098 × Equation F*

Table 2: Components of Damage Assistance Relief for Nonresidences

Equation NA: *Program Losses from the NFIP Subsidy = 0.6 × 0.29 (Total Non-Residential Flood Losses)*
Equation NB: *Uncompensated Damages = Damage Uninsured Property – Casualty Loss Deduction*
Equation NC: *Value of SBA loans*
Equation ND: *Casualty Loss Deduction = Capital Gains tax × Damage Uninsured Property*
Equation NE: *Government Loss from SBA Loans: 0.098 × Equation NC*

Analysis

Diagrams of this section use Table 1 show the flood assistance reaction function that transforms HAZUS estimated cost of flood losses and differentiates the flood losses by payer. These diagrams of who pays for flood losses under a disaster declaration are illustrated in Figures 1-3.

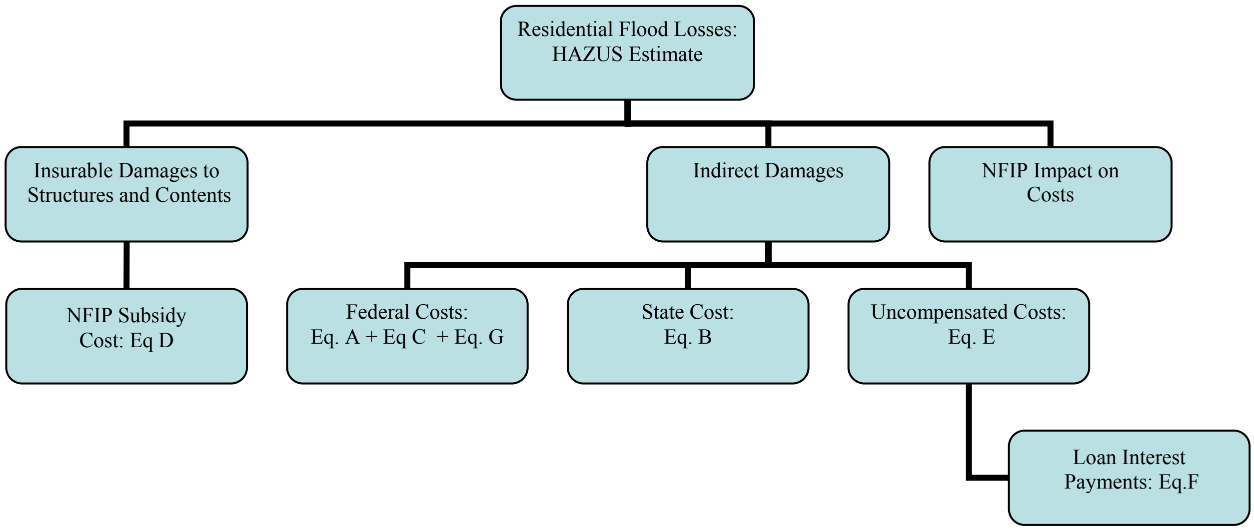

Figure 1. Assistance Reaction Functions for Insured Residences

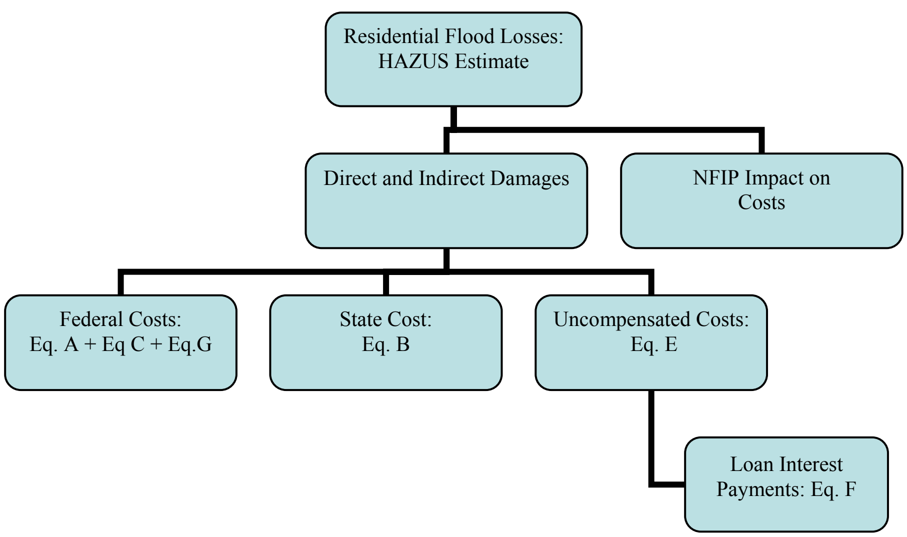

Figure 2. Assistance Reaction Functions for Uninsured Residences

Levels of compensation in the simulation under actual levels of insurance penetration are derived from a weighted average of estimates from modules in Figures 3 and 4. In addition for the analysis of the impact of insurance on who pays for flood disasters, it is useful to evaluate the impact that the BFE requirement has had on who pays. The NFIP impact on flood costs will stem from evaluation of aggregate flood losses under the distribution of structures below BFE in the simulated scenarios of NFIP and no-NFIP provided in Sarmiento and Miller (2005).

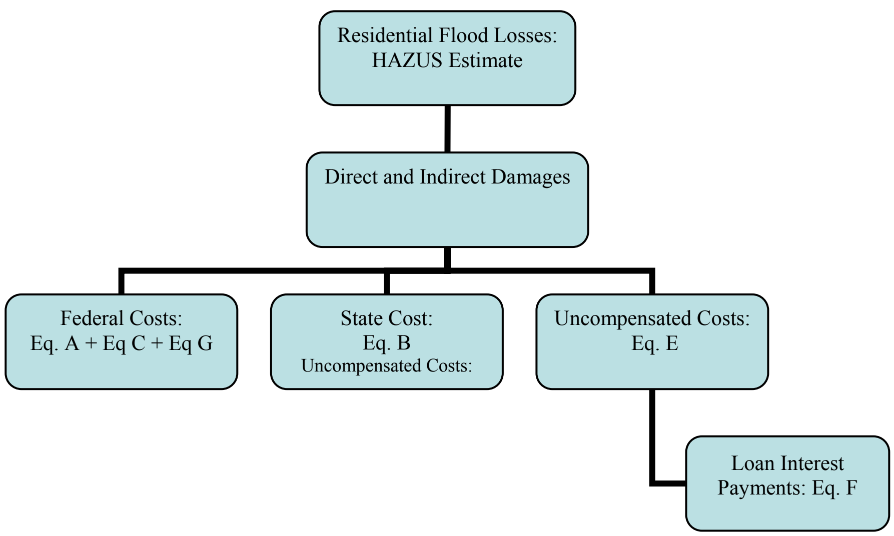

Figure 3. Assistance Reaction Functions for Uninsured Residences and No-Mitigation

From Figures 1-3, we simulate the percentage of uncompensated damages to residences and the percentage of compensation to residences paid by taxpayers for insured and uninsured properties. The analysis will also measure the NFIP's impact on this distribution of payers of flood losses. The evaluation of the cost uses over 3000 census block extracted from HAZUS supplemented with the parameterizations on SFHAs averages (see Sarmiento and Miller, 2005).

Thus far, preliminary results of the simulation analysis of who pays establish that flood mitigation and insurance reduce annual total flood losses in SFHAs. With current levels of insurance penetration in SFHAs, for example, the simulation shows that the NFIP reduces annual expected costs to the federal government by $484 million (from $859 million to $375 million, with $286 million of the savings due to improved flood outcomes and $196 million due to insurance coverage of losses), whereas the expected cost to the NFIP on subsidies to pre-FIRM structures is $132 million. The expected cost of the subsidy is paid by premiums charged to post-FIRM structures. The expected reduction of uncompensated losses to individuals through flood management is $770 million. Insurance reduces expected annual uncompensated losses by an additional $583 million (with residual losses at $917 million).

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