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The Demand for Flood Insurance: Empirical Evidence

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Abstract

Flood damages that occur worldwide remain largely uninsured losses despite the efforts of governmental programs that in many cases make insurance available at below fair market cost. The current study focuses on the financial experience of the United States' National Flood Insurance Program (NFIP) from 1983 through 1993 to examine the hypothetical determinants of the flood insurance purchasing decision. The empirical analysis supports the hypotheses that income and price are influential factors in one's decision to purchase flood insurance. Flood insurance purchases at the state level are found to be highly correlated with the level of flood losses in the state during the prior year.

Key words: flood insurance, fixed-effects models, insurance demand

JEL Classification: D10, H40, H42

1. Introduction

The flood peril presents an important threat to the property and well being of a significant portion of the world's population. Like earthquake it has the potential to bring economic catastrophe to a broad geographic area. Of the 40 most costly insurance losses from 1970 through 1997, five involved incidents of flooding in the U.S., Western Europe and Eastern Europe. Of the 40 worst disasters in terms of fatalities during this period, five involved incidents of flooding in India and Bangladesh (SIGMA, 1998). Also similar to earthquake, little coverage against the flood peril is available through the private insurance market. For example, homeowners insurance policies in Australia and the Netherlands exclude the flood peril, and in Germany flood coverage is seldom bought (*Business Insurance*, February 6, 1995). Although Graff (1999) reports that since 1991 roughly two-thirds of private insurers in Germany technically offer some coverage against flood, less than 10% of private property in that country is insured against damage from this peril. In the U.S., individuals and small businesses wishing to purchase insurance against the

flood peril typically obtain it through the National Flood Insurance Program. Hence, although the focus of the research in this study is on evaluating the demand for flood insurance in the U.S., the research clearly has important implications for public policy internationally.

The National Flood Insurance Program (NFIP) was established with the passage of the 1968 Housing and Urban Development Act (Vaughan, 1997). Anderson (1974) states that the NFIP was created to provide flood insurance at subsidized rates to homeowners and businesses and to reduce the exposure to flood through land-use limits and other control measures. Flood insurance through the program is available if the community agrees to adopt and enforce flood mitigation and land-use measures.

The NFIP is divided into two phases, emergency and regular. Under the emergency phase, a flood hazard map is provided and residents are allowed to purchase limited amounts of insurance at subsidized rates. Once a flood insurance map has been drawn that divides the community into specific zones with the probability of flooding determined for each zone, and the community has agreed to adopt more stringent mitigation and land use measures, it is allowed to enter the regular phase of the program (Rejda, 1998, pp. 155–156). In the early years of the program many communities were covered under the "emergency plan." Under that plan limits for single-family dwellings were capped at $35,000 (building)/$10,000 (contents) compared with $185,000 (building)/$60,000 (contents) under the regular plan.[1] By the early 1980s the number of communities that had qualified for the NFIP regular program had leveled off at about 18,000. This is out of an estimated 20,000 communities that are located in flood hazard zones. Figure 1 shows the number of flood insurance policies in force per 1,000 population under the NFIP from 1971 through 1993.

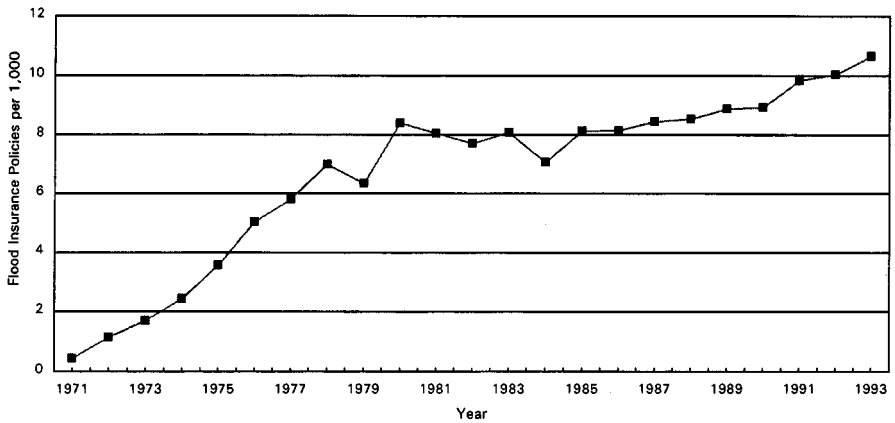

Figure 1. Flood insurance policies per 1,000 population.

The rationale for a government sponsored flood insurance program arose from the apparent failure of the private insurance market. Possible reasons for the failure of the private market were offered in an American Insurance Association study that Anderson (1974) references, *Studies of Floods and Flood Damage, 1952–1955*. The study concludes that "insurance against flood cannot successfully be written" for several reasons. First, losses are a virtual certainty in some areas. Second, flood losses can be catastrophic in nature. Third, consumers are not willing to pay premiums that are sufficiently high to cover the loss exposure. Fourth, insurers are unable to pool insureds with varying degrees of exposure to flood losses because lower risks will not purchase coverage at a pooled rate.

While not mentioned in the American Insurance Association study an additional factor contributing to market failure may be a charity hazard. We define charity hazard as the tendency of an individual at risk not to procure insurance or other risk financing as a result of a reliance on expected charity from others such as friends, family, community, non-profit organizations, or a government emergency program.

The subsidized flood insurance available through the NFIP was intended to appeal to property owners who did not purchase insurance in the private market. The subsidized insurance is only made available in communities that adopt permanent land-use and control programs. Following adoption of these measures subsidized insurance is made available to residents but it is not extended to new construction. According to the U.S. General Accounting Office (GAO), in 1994, 41 percent of NFIP policies were subsidized. Pasterick (1998) reports that the premiums paid on this group of subsidized policies are estimated to be less than 40 percent of the full-risk premium needed to fund losses expected in the long-run.

Loss statistics from two major storms inflicting flood damage in years following the creation of the NFIP indicate that significant amounts of property remain uninsured against the flood peril. Kunreuther (1984) reports that flood damage from Tropical Storm Agnes in June of 1972 exceeded $2 billion. Total damages paid by the NFIP were approximately $5 million. In 1993 the greatest single flood event in the United States occurred. Eleven million acres of farmland in the Midwest were inundated when the Mississippi River flooded, resulting in more than 50 deaths and causing $12 billion in total damages. Of the $12 billion in damages, less than $1 billion was covered by federal flood insurance. Only about $600 million of the total was covered by private insurance, mostly through commercial difference-in-condition (DIC) policies.[2]

Figure 2 shows by year both total flood damage and insured flood damage for the period 1983 through 1993. The figure indicates that the percentage of flood losses that are insured varies considerably from year to year and that for the decade as a whole a large portion of flood damage was uninsured. The variation in the level of insured flood losses per capita is presented in Figure 3.

Various explanations have been offered for why the NFIP does not insure a larger portion of flood losses. Kunreuther (1984) provides several possible reasons for individuals' failure to purchase flood insurance. These include the perception

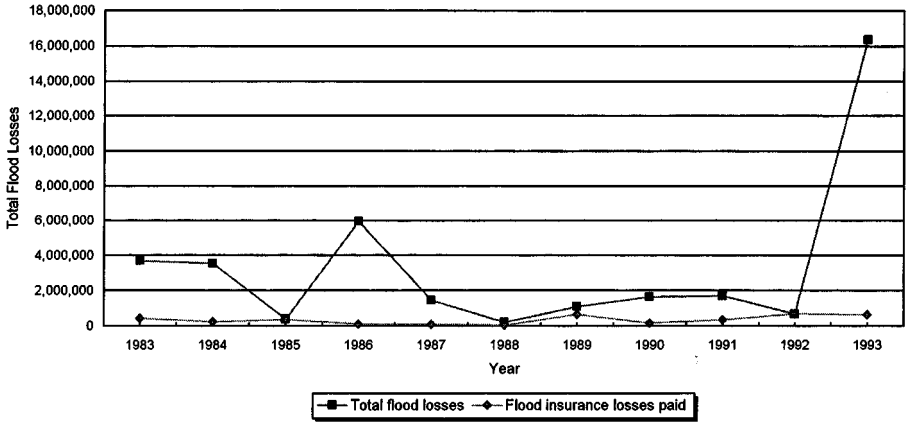

Figure 2. Total flood damage v. insured flood damage (thousands of $).

by some that the flood peril is less threatening to their property than it actually is. Individuals may underestimate the probability that they will suffer flood damage as a result of having little or no past experience with the peril. Others are unaware that they can purchase flood insurance coverage. Another possible explanation is that consumers feel the price of flood insurance, even when subsidized, is still too expensive. Additionally, Lewis and Nickerson (1989) posit a model for expenditures to mitigate the effects of natural disasters when individuals are partially insured against financial loss by a public relief program (e.g., disaster loans, grants, etc.). Their model suggests that underinvestment in loss mitigation and insurance, that is, reduced incentives to spend personal resources on loss mitigation and insurance,

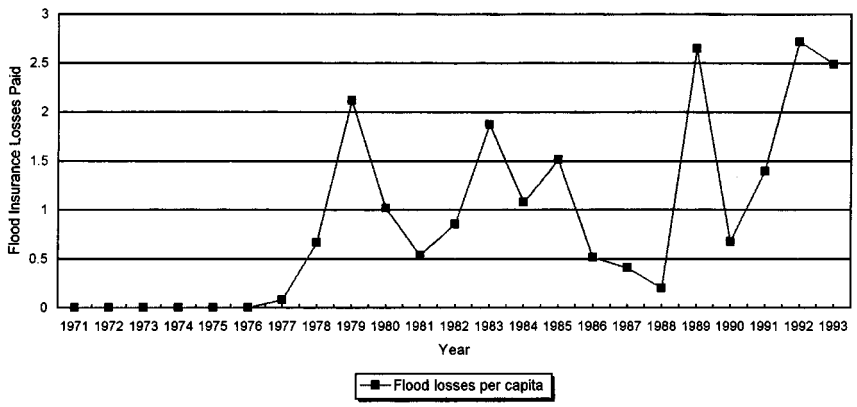

Figure 3. Flood insurance losses per capita.

is a consequence of the limited liability provided by government programs of disaster relief.

In the current study we estimate a flood insurance demand model. This allows us to test a number of different hypotheses that prior researchers have offered to explain why relatively little flood insurance is purchased in the United States. The model allows us to test whether price is a significant factor in the decision to purchase flood insurance. The model provides estimates of income and price elasticities. We also test whether the purchase of flood insurance is associated with recent flood experience. To the extent the purchase of insurance coverage depends on the consumer's perception of the need for coverage, greater insurance purchases following floods are expected. We test whether mitigation efforts undertaken by the federal government to reduce the frequency and severity of flood losses influence insurance consumption. Finally, we test whether increased federal disaster relief payments are associated with reduced purchases of flood insurance.

Our data analysis provides support for many of our hypotheses. We find that flood insurance purchases are positively related to income and negatively related to price. Consistent with prior research we find that the purchase of flood insurance policies in a state is positively related to the dollar value of flood losses that occurred during the prior year in that state.

In Section 2 we specify the hypotheses of the study. Our empirical methodology and results are presented in Section 3. The paper concludes with a summary of our major findings and suggestions for future research.

2. The demand for flood insurance

The theory underpinning the demand for insurance has received considerable scholarly attention. An extensive review goes beyond the aims of this paper. Instead we touch on several of the more important works to establish the hypotheses of this empirical study. As both individuals and businesses purchase flood insurance, we consider the factors motivating the purchase of insurance by each.

2.1. The demand for insurance by individuals

Smith's (1968) theoretical model of the demand for property insurance by individuals implicitly assumes that individuals are able to form correct estimates of the probabilities associated with all possible loss outcomes. In his analysis, factors which are important determinants of insurance consumption include wealth, the probability of loss, the price of insurance, the value of the item exposed to risk, and the utility function of the individual considering the purchase of insurance.

Smith finds that when the price of insurance per dollar of coverage is less than one and the probability of no loss is greater than zero the optimal insurance

purchasing decision may entail either purchasing or not purchasing coverage. In this context, self-insuring may be optimal. Other things equal, self-insurance will be optimal the less risk-averse an individual is and the greater the probability of loss. Self-insurance will also be optimal the greater one's wealth, assuming the individual's utility function is characterized by decreasing absolute risk aversion. Given a particular price of insurance, utility maximization suggests that an individual is more likely to self-insure the lower the probability of loss. In contrast, given a fixed probability of loss an individual is more likely to insure the lower the price of insurance. Insurance purchases are also theorized to be positively linked to the value of the item at risk, other things equal.

As mentioned above, the probability of loss parameter in Smith's model is assumed known to both insureds and insurers. This assumption is frequently made by researchers who model the demand for insurance. See for instance, Raviv (1979), Mossin (1968), Borch (1960), and Gould (1969). The adverse selection literature is based on the assumption that insureds form more accurate estimates of the probability of loss parameter than insurers. See for instance, Rothschild and Stiglitz (1976), Wilson (1977), and Miyazaki (1977). These models, while leading to different results in some aspects, all find that low risk insureds will purchase less insurance in a market with adverse selection than in a market free of adverse selection.

In contrast to the adverse selection literature which posits that insureds are better informed about their actual probability of loss than insurance companies, Kunreuther's (1984) contention, that property owners may not purchase flood insurance because they underestimate their true probability of loss, suggests just the opposite. Kunreuther's suggestion points to a possible second difference between the flood insurance market and those insurance markets characterized by adverse selection. In the adverse selection literature the market is composed of high risk and low risk insureds, each with different probabilities of loss. The high risks estimate that their probability of loss exceeds the insurance company's estimate. The low risks perceive that their probability of loss is less than that estimated for them by the insurance company. In the case of flood insurance, Kunreuther's suggestion is that without distinction to risk class insureds underestimate their loss probability.

From the perspective of an individual who underestimates the true probability of loss and must make the decision whether or not to purchase insurance as modeled by Smith, the price of insurance quoted by the insurer would seem high. If the insured underestimates the actual loss probability, subsidized insurance rates may even seem expensive.

An alternative, or in some cases complement, to insurance is an investment in reducing the likelihood or severity of the loss. The federal government makes considerable investments each year in flood loss mitigation. Although mitigation can reduce the probability and severity of flood losses, it may also produce a sense of security which results in further development in floodplains and reduces the perceived value of flood insurance (Pasterick, 1998, p. 125). We do not have direct

information on how finely NFIP reflects changes in flood risk in its premium pricing structure. However, the continued high level of subsidy in the program suggests that prices are unlikely to fully reflect changes in risk resulting from mitigation. If this is the case, then increased expenditures on mitigation would decrease the demand for flood insurance. Additionally, Pynn and Ljung (1999) surveyed residents in Grand Forks after the severe flooding in 1997 and asked them to evaluate the importance of 18 factors in influencing their decision not to purchase flood insurance. The respondents ranked as number 2, "I believed that dikes and other flood control devices would protect me from experiencing flood damage." Number 1 was the "National Weather Service did not predict the river to crest so high." This result provides a rather compelling argument for the expectation of a negative relation between mitigation and flood insurance demand.

Finally, to the extent that individuals expect to be eligible for other forms of disaster assistance after suffering flood losses, their incentives to purchase federal flood insurance will be reduced. This assistance could come in the form of disaster loans, grants and other aid.

2.2. The demand for flood insurance by businesses

The National Flood Insurance Program makes insurance available to businesses as well as individuals. Since businesses do not have utility functions, standard utility maximization arguments do not provide an explanation for their purchase of insurance. Mayers and Smith (1982) argue that profit maximization provides a rationale for the purchase of insurance by businesses. They contend that the purchase of insurance may result in greater profitability if it leads to more favorable terms in a variety of different transactions. Examples include lower interest rates on debt, and better relationships with suppliers, buyers, and employees. The business's decision to purchase insurance coverage therefore depends not on its own utility function but that of the parties with which it enters into different transactions.

While the economic rationale for purchasing insurance is different for businesses than it is for individuals, the same set of factors are important—price, the probability of loss, the amount of loss. In the case of a business, the income, wealth, and shape of the utility functions of parties to transactions are determinants of insurance purchases. Just as in the case of demand for flood insurance by individuals, an incorrect estimate of the probability of loss may result in the business choosing not to purchase flood insurance.

The major hypotheses of the study are summarized in Table 1. In addition to reporting each variable expected to affect the demand for flood insurance and its hypothesized sign, the table also reports the proxy variables used in the analysis. The following section contains a discussion of the proxy variables and the empirical model.

Table 1. Hypotheses

Variable	Definition	Hypothesized Sign
Mitigation	Federal government expenditures on mitigation	−
Disaster_Relief	Disaster relief expenditures by the federal government	−
Price	Premium per $1,000 of insurance in force	−
Income	Disposable personal income per capita ($,000)	+
FHA_Loan	FHA mortgages per 1,000 population	+
Recent_Flood	Total flood damages during the prior year	+

3. Empirical analysis of the demand for flood insurance

3.1. Empirical model

The hypotheses of the study are tested with equations of the general form:

$$\begin{aligned}\log(\textit{Insurance Demand}) &= \beta_0 + \beta_i(\textit{State}_i) + \beta_1(\textit{Mitigation}) + \beta_2(\textit{Disaster\_Relief}) \\ &\quad + \beta_3\log(\textit{Price}) + \beta_4\log(\textit{Income}) + \beta_5(\textit{FHA\_Loan}) \\ &\quad + \beta_6\log(\textit{Recent\_Flood}) + \epsilon. \end{aligned} \tag{1}$$

As the data are both cross sectional and time series in nature, we estimate Equation (1) as a fixed-effects model.[3] The fixed-effects model we estimate is similar to an ordinary least squares model but contains a series of dichotomous variables representing the different states. When an observation is from a particular state, indicated in the model by the subscript i, the corresponding state variable takes the value of 1, and takes the value of 0 otherwise. We estimate a fixed-effects model in order to control for variation in the dependent variable that is not accounted for by the other independent variables in the model and is due to differences between the states.[4]

We estimate the demand model over 50 states for the period 1983 to 1993, with the year 1983 providing only lagged data for the variable *Recent_Flood*. We chose this time period for the following reasons. First, the flood insurance program went through dramatic changes throughout the 1970s. Mandatory loan requirements were established in 1973, in 1979 FEMA was established and assumed responsibility for the NFIP, there were no rate increases prior to 1981, and then rates

increased 100 percent from 1981 through 1982. Second, until the early 1980s many communities were still in the emergency program with the much lower maximum coverage limits, or had not entered the program at all. Finally, a major reform act, the National Flood Insurance Reform Act, was passed in 1994. As mentioned above, this act raised coverage limits and instituted a number of other changes. We wanted to assure that the structure of the NFIP was relatively consistent throughout the period of our study.[5]

3.2. Empirical proxies

The model is estimated two times using different definitions of insurance demand. These definitions are the number of flood insurance policies purchased per 1,000 population in a state during a year; and, the face amount of flood insurance in force per capita in a state during a year.

The number of flood insurance policies in force proxies the number of individuals and businesses that have purchased coverage. Although it does not indicate the depth of coverage held by individuals, it does measure what portion of the population has some amount of flood insurance. A GAO (1983a) study of flood insurance demand also used the number of flood insurance policies in force as its dependent variable. The GAO study considered data on a monthly basis over the period 1978 to 1982. The data were aggregated for the entire U.S.

The face amount of flood insurance in force represents the total value insured in a state during a year. Browne and Kim (1993) argue that the amount of insurance in force is a better measure of insurance coverage than premiums which has been extensively used in prior studies of the demand for insurance. They use this measure in their study of the international demand for life insurance. Similarly, Core (1997) uses a coverage limit as his measure of insurance consumption in his study of the demand for directors' and officers' (D & O) insurance.

We measure the effect of mitigation by including a variable in our model which is the dollar value of expenditures by FEMA each year in each state on emergency planning, preparedness, and mitigation divided by population (*Mitigation*). We cannot identify those mitigation expenditures that were specifically related to flood exposures. Additionally, other federal and state expenditures not included in our measure could have an impact on flood loss mitigation.

To measure the effect of disaster aid above and beyond payments available from federal flood insurance we include the dollar value of disaster relief expenditures by FEMA scaled by population (*Disaster_Relief*). This proxy still understates the extent of disaster assistance since numerous other programs (e.g., food stamps, public assistance, housing subsidies, etc.) also could provide financial aid to victims of flood losses. However, we are not able to isolate disaster-related payments within these other programs. A negative correlation between flood insurance purchases and disaster relief would be consistent with charity hazard existing in the flood insurance market.

The proxy we use for the price of flood insurance is the dollar value of premiums paid for flood insurance in the state during the year divided by the dollar value of insurance in force (in thousands) in the state during the year (*Price*). This is an intuitively appealing measure as it is the cost per dollar of coverage.

The income measure we use is disposable personal income per 1,000 population (*Income*). Prior research, both theoretical and empirical, suggests a positive relationship between income and insurance purchases.

The FHA requires flood insurance for those seeking FHA-backed mortgages in flood zones. This requirement serves as a powerful incentive for the purchase of flood insurance. Other things equal this requirement will result in increased purchases of flood insurance. We include the number of FHA mortgages per 1,000 population in the model to control for this effect (*FHA_Loan*). As FHA backed mortgages and flood insurance are essentially complimentary goods as a result of the FHA's requirement, a positive relationship between the two is hypothesized. Kunreuther (1996) questions whether FHA requirements are easily avoided. He cites a study by the GAO (1990) that reports that 79 percent of victims of a major flood in Texas in 1989 that were required to purchase flood insurance were not insured. The implication he makes is that it would not be surprising if many of these individuals bought flood insurance when they received their mortgage and later dropped the coverage.

A growing literature supports Kunreuther's contention that individuals' perceptions of the risk of loss influence their decision to purchase insurance. Kunreuther et al. (1978) discovered through in-person interviews that the likelihood that an individual purchases disaster insurance is related to whether property owners' homes have been damaged in the past by a disaster. Whether individuals are irrational in their insurance purchasing patterns, as these findings might indicate, or are exhibiting behavior consistent with a Bayesian learning model as Viscusi (1991) suggests, the relation between recent disaster losses and awareness of the need for disaster insurance has been repeatedly documented in the literature. For instance, Palm et al. (1990) report that surveys taken of property owners before and after the Loma Prieta earthquake of 1989 reveal that the percent of respondents who felt earthquake insurance was unnecessary after the earthquake was significantly less than the number who held that belief before the earthquake.

To control for the effect that a recent flood may have on individuals' perceptions of the likelihood of flood and their demand for insurance, we include the variable *Recent_Flood*. *Recent_Flood* is defined as the dollar value of total flood damage (not just insured losses) in the state during the preceding year. We anticipate a positive relationship between *Recent_Flood* and insurance consumption.

The data used in the study come from several sources. All data on flood insurance purchases were obtained from NFIP. Data on total flood damage comes from the U.S. Army Corp of Engineers, data for FEMA expenditures on disaster relief and mitigation come from *Federal Expenditures by State* published by the U.S. Bureau of the Census, and all other data were obtained from the *U.S. Census Bulletin*. To control for inflation during the time period of the study we scale

Table 2. Summary statistics

Variable	Definition	Mean	Std Dev
Insurance in Force	Insurance in force per 1000 population	$411.778	$766.48
Policies	Number of policies purchased per 1000 population	7.005	11.44
Mitigation	Mitigation expenses per capita	$0.463	$0.533
Disaster_Relief	Disaster assistance per capita	$1.815	$3.162
Price	Premium per $1000 of flood insurance in force	$5.219	$3.182
Income	Disposable personal income per capita in thousands ($)	$11.276	$1.728
FHA_Loan	FHA mortgages per 1000 population	2.817	2.316
Recent_Flood	Flood damage per capita during preceding year	$9.825	$36.052

variables denoted in dollars by the CPI. Table 2 reports summary statistics for the variables described above.

3.3. Empirical results

The empirical analysis reported in Table 3 is largely consistent with our hypotheses. The R^2 values are 0.98 for the flood insurance policies model and 0.99 for the flood insurance in force model. While the model should not be interpreted as indicating that there is a causal relationship between variables, the results of the estimation provide statistical support for many of the hypotheses of the study.

Table 3. Flood insurance demand: 1984–1993 empirical results (n = 500)

	Log (Flood Insurance in Force Per 1,000 Population) (R^2 = 0.99)		Log (Policies in Force per 1000 Population) (R^2 = 0.98)	
Variable	Coefficient	*t*-stat	Coefficient	*t*-stat
Intercept	5.78	18.874	0.807	2.617**
Mitigation	−0.007	−0.467	−0.007	−0.467
Disaster_Relief	0.008	4.287**	0.009	4.282**
Log (Price)	−0.997	−49.276**	−0.109	−5.337**
Log (Income)	1.506	11.872**	1.400	10.951**
Log (FHA_Loan)	−0.044	−3.265**	−0.056	−4.090**
Log (Recent_Flood)	0.011	2.203*	0.017	3.474**

* Significant at .05 level.
** Significant at .01 level.

In both models the price variable, the premium per thousand dollars of coverage, is negative as hypothesized and highly significant. The coefficient estimates are interpreted as price elasticities. These are -0.109 in the policies per capita model and -0.997 in the insurance in force per capita model. The GAO (1983a) estimated a price elasticity of demand for flood insurance based on total policies issued and average premium per policy to be -0.38. The estimate in the GAO study was based on aggregate monthly data for the four-year period from 1978 to 1982. Prior studies of price elasticities of demand for federal crop insurance, a program that is similar in many respects to NFIP, obtained elasticities in the range of -0.14 to -0.33 (see Barnett and Skees, 1995). Browne and Kim (1993) estimated the price elasticity for life insurance as -0.24. Their dependent variable was life insurance in force. For comparison, price elasticities for other goods and services have been estimated as follows (see Hoyt, 1990, for references for these price elasticities): food (-0.21); automobiles (-1.20); during out (-2.27); auto insurance (-0.56); health insurance (-0.16); medical services (-0.20). Taken together, the results suggest that demand for flood insurance policies is relatively insensitive to changes in price, but demand as measured by the amount of insurance in force is sensitive to price changes.

The income proxy is positive and statistically significant in both the insurance in force and policies per capita models. These findings suggest that higher income individuals are more likely to purchase insurance and purchase greater amounts of insurance than lower income individuals. The estimated income elasticities are 1.506 in the insurance in force model and 1.400 in the policies per capita model. For comparison, income elasticities for the following goods and services have been estimated: 0.28 for food, 3.00 for automobiles, and 0.22 for medical services. Our estimates suggest that demand for flood insurance, whether measured by policies purchased or insurance in force, is relatively sensitive to income.

The variable *Recent_Flood*, the amount of flood insurance damages paid in the preceding year, is positive and statistically significant in the policies per capita model. The variable is also significant in the insurance in force per capita model. These findings suggest that recent flood experience in a state is associated with greater flood insurance purchases.[6]

Contrary to our hypothesis, we find that the number of FHA mortgages per capita is negatively related to the number of policies purchased per capita. While the literature (see for instance, Kunreuther, 1996) contends that FHA requirements are easily avoided, the strong negative correlation between FHA loans and flood insurance policy purchases is still surprising. GAO (1983a) found a similar negative relation between FHA mortgages and the demand for flood insurance. The authors of the GAO report expressed similar surprise over this result and were unable to provide an explanation for it. Since FHA mortgages tend to be utilized by middle and lower income home buyers with relatively little accumulated wealth, it may be that the level of FHA mortgages is serving as a proxy for wealth and income effects that are unexplained by our other variables. Under legislative changes that were enacted in 1994 (National Flood Insurance Reform Act of 1994),

much greater pressure has been brought to bear on lenders to not assure that federally-insured mortgages in flood hazard areas are covered, and remain covered, by flood insurance. These changes may affect the direction of the relation between flood insurance demand and FHA mortgages in the future.

Our proxy for mitigation efforts by the federal government is not significant in either model. As mentioned earlier, our proxy is imprecise for two reasons. First, it does not capture all expenditures by governmental agencies to mitigate the flood hazard. Second, it includes governmental expenditures to mitigate hazards in addition to flood.

Contrary to our hypothesis of a negative relationship between governmental aid and flood insurance purchases, our analysis indicates a positive correlation that is statistically significant. This relationship exists both when flood insurance purchases are measured by the amount of flood insurance in force and by the number of policies purchased. Exposure to the flood peril may increase both purchases of flood insurance and receipt of disaster assistance, thus explaining the positive relationship between the two.

4. Conclusions

In the United States a significant portion of the flood losses that occur each year remains uninsured. The National Flood Insurance Program, a federal government program which Anderson (1974) argues was created to provide flood insurance to homeowners and businesses, plays an important role in financing the cost of flood damage, but many remain uninsured. Our analysis of flood insurance demand provides support for several hypotheses that attempt to explain why individuals fail to purchase flood insurance.

We find that income is positively related to the amount of flood insurance purchased. Individuals with greater financial resources are more likely to take advantage of the government's flood insurance program. An important question that could be raised is whether or not insurance is the best approach to providing disaster protection to the low-income segment of the population. The low levels of participation in the NFIP and our finding that income matters suggest that perhaps this is not the best approach.

Our empirical results indicate that the price of flood insurance, measured as written premiums per $1,000 of flood insurance in force in the state, is negatively correlated with flood insurance purchases. Our analysis suggests that if the government decreased the price it charges for flood insurance, more insurance policies would be sold and the amount of flood insurance in force would increase. However, the demand for additional policies is relatively price inelastic.

Our study provides evidence consistent with Kunreuther's (1996) hypothesis that risk perceptions influence insurance purchasing behavior and Viscusi's (1991) Bayesian learning model. We find that the number of flood insurance policies sold during the current period is positively correlated with flood losses during the prior

period. If, as our evidence indicates, perceptions of the risk of flood loss are an important determinant of insurance purchases, informational materials directed at increasing the public's awareness of the danger posed by the flood peril may be an effective means of increasing the purchase of flood insurance.

The current study uses economic data to explore the reasons why individuals purchase flood insurance. A number of interesting questions that we were not able to address await future research. We know relatively little about how people form estimates of the likelihood of suffering flood damage. The relationship between the recent occurrence of flood damage and the decision to purchase coverage emerges in our data analysis. While it is plausible that the government could increase sales of flood insurance by modifying individuals' perceptions of potential loss; how this could be best done and the cost are open questions. Similarly our analysis supports the hypotheses that income and price are important determinants in the flood insurance purchasing decision. This suggests that vouchers to purchase flood insurance may be an effective means of increasing coverage. Analysis of household level data likely would yield more accurate estimates of price and income elasticities than we are able to derive. Such an analysis would help to determine what the potential costs of increasing participation in the flood insurance program through a voucher program would be.

Our data show that a large portion of flood losses are not insured by the National Flood Insurance Program. Information on how individuals do pay for flood losses may shed light on why individuals choose not to purchase flood insurance.

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Notes

1. The limits were raised in 1994 by the National Flood Insurance Reform Act. Limits today for single-family residences are $250,000 (building)/$100,000 (contents).
2. A program which is similar in many respects to the NFIP was established by the Federal Crop Insurance Act of 1980. The intent of this act was to replace federal disaster assistance payments to farmers with federal crop insurance. However, in 1993 participation levels even with an average premium subsidy of 30 percent were only about 35 percent of eligible acres (Barnett and Skees, 1995).

3. The coefficients for the state-specific intercepts are not reported in the tables. Readers interested in these estimates are encouraged to contact the authors.
4. Similar results were obtained when weighted least squares was used to estimate the model.
5. See GAO (1990) and Vaughan (1997) for additional discussion of developments in the NFIP.
6. During the period of the study, 1983 to 1993, federal flood insurance became effective after a five-day waiting period. In 1993 during the Midwest floods, 7,800 policies were taken out while rivers were flooding leaving the federal government with $48 million in claims but only $625,000 in premiums (*Economist*, May 27, 1995). In 1994 NFIP increased this waiting period to 30 days.

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