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A Methodological Approach for Pricing Flood Insurance and Evaluating Loss Reduction Measures: Application to Texas

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Executive Summary

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Acknowledgements

This research by the Wharton Risk Management Center and CoreLogic® aims at better understanding flood risk in the United States and the role that public and private insurance can play in providing financial coverage and reducing losses from this risk to residents in areas subject to water damage from floods and hurricanes. We discuss a methodology for assessing risks, measuring the costs and benefits of a selected number of loss reduction measures and comparing different pricing methods with those used by the National Flood Insurance Program (NFIP). We believe the methodology developed in this study will be of interest to key stakeholders and can be generalized for other states in the United States.

This report benefited from financial and research support from Swiss Re, the Travelers-Wharton Partnership for Risk Management and Leadership Fund, the National Science Foundation (grant SES-1061882), CREATE at USC, and the Wharton Risk Center's Managing and Financing Extreme Events Project. Wei Du and Don Parkes at CoreLogic were an integral part of the research team along with Pete Eschenbrenner at Wharton. We are grateful to Andy Castaldi, Jens Mehlhorn, Mark Way and to members of the Association of State Floodplain Managers, FEMA, and Resources for the Future for providing us feedback on a previous version of this report. Carol Heller provided editorial assistance.

Executive Summary

Introduction

If the natural disasters of recent years are any indication of what America will face in the future, it is time to recognize that our country has entered a new era of weather-related catastrophes. Because of increased population and more exposed assets in hazard-prone areas, one should expect more devastating and costly natural disasters in the coming years. Changes in climate patterns are likely to exacerbate this trend, bringing sea level rise, increased flooding from more intense hurricanes, and coastal erosion.

Hurricane Irene, which made landfall in mid-Atlantic and Northeast states in August 2011, is the latest reminder of our vulnerability to natural disasters. This hurricane claimed more than 50 lives and caused losses in the $7-to-10 billion range. Preparedness for the disaster was remarkable, indicating that some important lessons were learned following Hurricane Katrina in 2005. But if Hurricane Irene had not weakened, and if the required evacuation in cities had not taken place on a weekend, the human and economic impact could have been much higher.

As Hurricane Irene moved north along the coast in August 2011, the nature of the damages also changed from mainly wind in the Carolinas to coastal and inland flooding in northern states. Families who had flood insurance will soon be indemnified and be able to quickly repair or rebuild their house. From past experience, however, we know that many residents did not have flood insurance. Either they mistakenly thought that losses from flooding were covered by their homeowners' policy and/or they perceived the risk of flooding to be below their threshold level of concern so they did not feel they needed flood insurance. Some may also have decided not to purchase flood insurance because of budget constraints during difficult economic times: the cost of coverage competed against expenses that had higher priority.

These uninsured victims are likely to need and demand disaster assistance. This dynamic process is not specific just to Hurricane Irene; over the period of 1950–2010, two-thirds of Presidential disaster declarations were flood-related.[1] A significant portion of flood-related damage can be reduced if protective mitigation actions have already been taken. However, for reasons similar to not purchasing flood insurance, many individuals do not invest in these flood mitigation measures voluntarily.[2]

Background on Residential Flood Risk Insurance in the United States

In the United States, coverage for flood damage is explicitly excluded in homeowners' insurance policies. Since 1968 flood insurance has been available through the federally managed National Flood Insurance Program (NFIP) because insurers contended at the time that the peril was uninsurable by the private sector for the following reasons: (1) only particular areas are subject to the risk, so adverse selection would be a problem; (2) risk-based premiums would be so high that few property owners would be willing to purchase coverage; (3) flood

[1] Michel-Kerjan and Kunreuther (2011). Reforming Flood Insurance, *Science*, 333, July 22.
[2] Kunreuther, Meyer and Michel-Kerjan (in press). Overcoming Decision Biases to Reduce Losses from Natural Catastrophes. In E. Shafir (ed.), Behavioral Foundations of Policy, Princeton University Press.

losses could be catastrophic and cause insolvencies of some insurers; (4) there were no standards or building codes for construction in and near flood-prone areas; and (5) the level of sophistication in hazard assessment and mapping was quite limited in the 1960s, compared to what it is today.

The NFIP has grown substantially over its 43 years of operation and today provides insurance to 5.6 million policyholders across the country in exchange for $3.3 billion in premiums paid in 2010. The program now covers more than $1.2 trillion in assets (a 250 percent increase since 1990, corrected for inflation).[3] In November 2011, the program was renewed for one month, until December 16, 2011. On December 23, 2011, President Obama extended it through May 30, 2012, as part of the FY2012 omnibus appropriations bill.

The NFIP's goals with regard to setting premiums differ from those of a private insurance company because the NFIP does not expect to make a profit. Its rates do not reflect the market's cost of capital nor the need to set aside a large reserve to handle truly catastrophic losses since it can borrow from the government if it faces a deficit. Moreover, properties built before flood maps were established are offered subsidized rates. (New structures are charged the full-risk premium based on their location in specific flood zones determined by FEMA, with the exception of those properties eligible for grandfathered rates.)

Under this pricing strategy, NFIP insurance rates are not necessarily risk-based for a given residence (probabilistically defined), so prices can be "too high" for some and "too low" for others, as is indicated in this report. The NFIP does not necessarily aim at fiscal solvency in a given year, but at collecting enough premiums to cover the operating expenses and losses associated with the historic average loss year. Unfortunately, between 2005 and 2008 a series of catastrophic flood events occurred in Louisiana and Texas that were much more devastating than the average annual flood losses. The NFIP was thus forced to borrow $19.3 billion from the U.S. Treasury to cover the deficit produced by these disasters. As of December 15, 2011, the outstanding debt from claim payments and accrued interest cost stood at nearly $17.8 billion.

Improving Flood Insurance: Focus of the Report

In the past few years there have been calls for reform of the NFIP from experts, insurers and reinsurers, local, state and federal government bodies, and from Congress.[4] A major difficulty in judging the validity of the proposed reforms, however, is that they typically provide a conceptual vision without an in-depth quantitative analysis of the pros and cons of the proposed strategy, how it will impact different stakeholders and how it compares with the status quo. Notably, Congress and the President renewed the NFIP twelve times (sometimes for only one month) between 2008 and 2011, without ordering in-depth analyses. (Several bills now do, but none have become legislation, yet.)

During the past two years, the Federal Emergency Management Agency (FEMA) has worked openly at proposing several reform options as well. One option under consideration is to end the NFIP and to privatize flood insurance. At this time, we do not necessarily believe that full privatization of flood insurance is practically feasible. For flood insurance to be entirely privatized, a number of policy issues must be addressed. These include but are not limited to: the ability of insurers to charge rates reflecting risk predicated on probabilistic modeling in a highly regulated market, special treatment being given to those who cannot afford risk-based premiums, a strategy for transitioning existing NFIP policies into the private market, the management of high-risk repetitive loss locations, data sharing and accurate mapping. Until at least these and possibly other issues are addressed, primary insurers are unlikely to want to sell flood insurance on the scale the NFIP does today. Many of these points are discussed in more detail in the final section of the report.

While the NFIP faces challenges that must be addressed, the program continues to provide enormous benefits to millions of Americans. Nevertheless, we feel it is possible to envision an increased role for private insurers to sell flood insurance as a *complement to*, and potentially in competition with, the NFIP; if this dual source of flood insurance supply were tailored to residential demand, this could significantly increase the number of homeowners with flood coverage. More people would be covered when they suffer water damage from the next flood or hurricane, thus reducing the need for federal relief to be paid by all taxpayers. This would be a positive change, as demonstrated by the recent debate over federal relief for the flood victims of Hurricane Irene.

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[3] Michel-Kerjan (2010). Catastrophe Economics: The National Flood Insurance Program. *Journal of Economic Perspectives*, 24(4): 165–86.

[4] The Wharton Risk Center has been at the forefront of studying flood insurance and possible reform options of the NFIP; findings from previous studies can be obtained upon request.

As this report shows, technology has radically improved since the 1960s, allowing insurers to more accurately assess flood risk. Four decades of claims from the NFIP provide insurers with important historical data as inputs to assessing future flood risks. This reduces many of the barriers previously considered as such by the insurance industry. Moreover, the conventional wisdom—that insurers will always price individual flood policies at much greater premiums than the NFIP because they would require higher loading cost—is incorrect. Our findings show that there are potential market opportunities for insurers, as well as societal value, in increasing the overall supply of flood insurance.

This report importantly provides the aforementioned missing quantitative analysis of flood risk, utilizing a catastrophe risk model to ascertain the probabilistic flood risk at the single-family residence level. The report is organized as follows. ***Chapter 2*** describes the operation of the NFIP, and provides a financial analysis of the program from 2001-2009 based on the Wharton Risk Center's access to NFIP accounting records. It also highlights challenges the program currently faces. ***Chapter 3*** discusses the rationale for choosing Texas for this study, specifically the counties of Travis and Galveston, and how one builds a flood catastrophe risk model. Texas has the second highest number of NFIP policies-in-force of all states in the nation (Florida being the highest), and is exposed not only to significant *riverine flooding* but also to *storm surge related flooding* from hurricanes and tropical storms. Hurricane Ike in 2008, a Category 2 hurricane at landfall, triggered the second largest NFIP payment sum in the history of the program (after Hurricane Katrina), with $2.6 billion in flood insurance claims (2008 prices). The majority of those claims were filed by policyholders in several Texas counties, including $1.3 billion in Galveston County alone. ***Chapter 4*** examines alternative flood loss scenarios (including worst cases) and implements a methodology for determining risk-based *insurance premiums* required to cover these expected losses at a given location. ***Chapter 5*** compares these risk-based premiums with the prices currently charged by the NFIP for the counties of Galveston and Travis in Texas as a pilot case. ***Chapter 6*** quantifies the costs and benefits of individual risk reduction measures to homes in these two Texas counties. ***Chapter 7*** concludes and discusses future research.

Main Findings

Worst-Case Scenarios

The analysis throughout this study focuses on two counties: Galveston and Travis (which includes the city of Austin); together they total 1.3 million residents and rank among the most flooded counties in Texas during the period of 1960-2009. For Galveston County, the worst-case scenario (calculated as a storm-surge flood event with a 10,000-year occurrence) is a $2.3 billion loss to residential properties. This translates into 17 percent of the county's $14 billion single-family residence property values exposed to some flood hazard. The worst-case scenario for riverine flood in Galveston would be $825 million in residential loss; that is 6 percent of this same total county exposure. In Travis County, the worst-case scenario (a 10,000-year flood event) is an $890 million loss to residential properties from riverine flood, or 7.4 percent of the county's $12 billion in single-family residence property values exposed to some flood hazard risk.

Quantification of the Pure Premium

The *pure premium* is defined as the expected average annual loss over a 10,000-year period of time across thousands of possible scenarios. It is generated by the CoreLogic and Swiss Re flood models which are currently used in the industry to assess and manage the inland and coastal flood risk associated with trillions of dollars of residential and commercial exposure around the world. It does not include the cost of marketing the insurance policy, claim adjustment or any other cost faced by a public or private insurer in selling flood insurance.

For Travis County, the study results indicate that the pure premium per $1,000 of exposure is more than 12 times lower on average than in Galveston County, illustrating a significant disparity in flood risks between coastal and inland counties. The analysis is also undertaken to correspond with the existing FEMA-defined flood zones (see appendix of Chapter 2 for definitions). For Travis, pure premium per $1,000 of exposure for residences in the high risk A zone is more than 3 times higher on average than for those in the moderate risk X500/B zones, and nearly 78 times greater on average than for those in the low risk X/C zones. However, for Galveston, the pure premium per $1,000 of exposure range across flood zones is not nearly as large: the high risk A zone pure premium per $1,000 of exposure is 1.5 times greater on average than residences in the moderate risk X500/B zones and 4 times greater on average than those in the low risk X/C zones. The mean pure premium for Galveston's high risk A zone is similar to that for residences in the coastal high risk V zones.

According to the FEMA flood zone classifications, V and coastal A zones are the only areas subject to some level of storm-surge flood risk. However, our probabilistic model-based results identify a significant amount of storm-surge exposure and risk outside of the V and coastal A zones in Galveston County. For example, in the Galveston X500 and X flood zones, there is $3.1 billion of property exposure at risk to storm-surge only.

Several conclusions can be drawn from the above analyses. First, there is substantial variation in flood exposure (and hence pure premiums) between coastal and inland locations within zones of similar risk classification. For instance, homes in the designated moderate risk X500/B zones in Galveston are exposed to a flood risk 2.5 times greater than residences in X500/B zones in Travis. Second, there is substantial variation of flood risk within a given coastal or inland county: the range of average values between high and low risk are much wider in Travis than in Galveston County. Third, FEMA characterizes only an average flood risk in a given zone without indicating the variance across properties. Finally, the model results indicate a significant amount of storm-surge exposure outside of the V and coastal A zones. These findings highlight the importance of undertaking a microanalysis of the exposure of residents to riverine flood and storm surge to determine the pure premium associated with a given home. All told, similarly classified FEMA flood zones in different parts of the country can have significantly different flood exposure; thus, one cannot simply average the risk in a given flood zone.

Would Private Insurance Charge More or Less Than Existing NFIP Premiums?

We then compared the premiums generated by the CoreLogic and Swiss Re probabilistic flood models with NFIP premiums from the database FEMA provided to the Wharton Risk Center.

- **Unloaded premium comparison.** The unloaded NFIP premiums were determined by subtracting the administrative cost and fees the program pays to participating insurers and agents. These costs translate into a 50 percent loading charge on the NFIP premiums. The current unloaded NFIP premiums are “too high” in some areas and “too low” in others relative to the probabilistic flood model results. For example, in Travis County, the NFIP on average *underprices* the risk in A zones (high risk) and *overprices* the risk in the X500 and X zones (moderate and low risk) compared to the probabilistic model results in these zones. By not charging enough in the Travis County high risk zone, and overpricing in the moderate and low risk zones, the NFIP may be fostering adverse selection. More specifically, residents who are high-risk are likely to purchase insurance while many homeowners who live in a low risk area will not want coverage because insurance is too expensive relative to the true risk. If this behavior occurs, it can lead to fiscal insolvency.

  In Galveston County, our findings reveal that the NFIP on average *underprices* the flood risk in the A, X500 and X zones by not charging enough against the risk of storm surge in these areas compared to the probabilistic model results in these zones. On the other hand, NFIP premiums are higher than what the probabilistic loss model predicts in V zones. This pricing policy can have important implications for the financial balance of the program for Texas. To illustrate this point, Galveston County has only about 3,000 policies in V zones; however, there were 20,000 claims for Hurricane Ike’s related storm surge flooding in 2008 in the county, potentially 85 percent of which were underpriced because they were in the A, X500 and X zones.

- **Loaded premium comparison.** We undertook comparative analyses between the full premium charged by the NFIP (that is what residents actually pay) and what would be charged by private insurers if they applied a loading cost of 50, 100, 200, and 300 percent on top of the pure premium to reflect expenses such as taxes, cost of capital, dividends to their shareholders as well as correlation between risks (i.e., wind and water in coastal areas). To our knowledge, this type of comparison has not been undertaken in earlier studies of flood insurance.

  In flood zones where the NFIP underprices the risk on average relative to the probabilistic model results, such as the A zones in Travis and Galveston Counties, the price discrepancy between private insurance premiums with high loading costs and NFIP full premiums will be magnified over the unloaded premium comparisons. However, for those areas where the NFIP overprices the risk on average, relative to findings from the probabilistic model, such as the Travis County X500 and X zones and the Galveston County V zones, we find that in general, a private insurer’s loading factor of 200 percent must be applied for private insurers to charge more than the NFIP.

  To the extent that a private insurer has a relatively lower loading factor (for example, in the case of most riverine exposure), there are targets of opportunity for that insurer to actively sell flood insurance today. This could increase take-up rates and ensure that more individuals are effectively covered against floods.

Evaluating the Cost Effectiveness of Flood Loss Reduction Measures

The analysis of the cost effectiveness of flood loss reduction measures (i.e., mitigation) reveals that they can have an enormous impact. For a 100-year event, elevating all existing houses by two or eight feet would reduce the total losses from riverine flood in Travis County by 40 percent or 89 percent, respectively. For a 100-year storm surge event, elevating all existing houses by two or eight feet would reduce the total losses in Galveston County by 16 percent or 64 percent, respectively. Elevation is more effective in reducing future losses from riverine flooding than for storm-surge flooding. Combining all possible future scenarios through the probabilistic flood model, the average annual reduction in expected flood losses when all homes are elevated by eight feet is 92 percent in Travis and 82 percent in Galveston. Providing 100-year flood protection to all homes (for example, installing individual home floodwalls) reduces flood losses by 62 percent in Travis and 28 percent in Galveston.

We analyzed the benefits of elevating existing homes in relation to the cost, using discount rates of 0 percent, 5 percent, 10 percent, and 15 percent and time horizons of 1, 5, 10 and 25 years. The benefit-cost analysis undertaken for 89,000 homes in Galveston and 226,000 in Travis County reveals that on average, dollar savings associated with these significant loss reductions are not enough to balance the costs for a homeowner to want to undertake such measures for existing construction. The primary factor responsible for this economically unfavorable result is the relatively high cost of elevation to existing structures. For example, elevating a 2,000 square foot wood-frame home with a crawlspace by two feet would cost $58,000. Still, there are some specific examples where elevation is economically worthwhile, suggesting that mitigating existing houses could be cost effective if done selectively. FEMA's five hazard mitigation grant programs are designed to include the option of elevating existing structures where it is cost effective to do so. This is likely to be the case for structures with their lowest floor below the base flood elevation. Elevation costs for new construction would be significantly lower than for existing construction, which could make mitigation of new homes much more appealing.

Note that we have calculated only the direct economic benefits stemming from elevation and not considered other direct benefits, such as reduced fatalities and injuries or reduced damage to infrastructure and the environment. Nor have we looked at the indirect economic benefits such as the savings to the government in the costs of permanently relocating residents.

Conclusions

This report provides the first systematic analysis of the potential for private flood insurance to complement the current NFIP operation so as to increase the number of homeowners who have proper coverage, and thus reduce the need for post-disaster federal relief. Our findings show that current NFIP pricing does not always reflect local conditions so that some properties are being undercharged while others are paying premiums that are greater than the actuarial risk. Those findings also reveal that private insurers could cover some of the risk at premiums below those currently charged by the NFIP.

Of course, the decision by primary insurers to sell flood insurance also depends on other factors that have not been studied here, such as their ability to charge rates reflecting risk in a highly regulated market and the possible correlation or diversification of flood risk with wind exposure from hurricanes or other risks in an insurer's portfolio.

Mitigation also can play a critical role in reducing exposure to future floods, which translates into lower flood insurance premiums if rates reflect risk. Our analysis reveals, however, that risk reduction measures for existing homes could be expensive and are normally not cost-effective except for certain homes in flood-prone areas. These findings suggest the need for a holistic approach to mitigation such as implementing land-use restrictions or community based-mitigation efforts in addition to individual measures.

We look forward to continuing this research effort across many of these fronts in order to provide further value to both Congress and the Office of Management and Budget at the White House as they decide upon reforming flood insurance, and to the insurance industry and other stakeholders to reconsider the insurability of flood risk and how to reduce America's exposure to future floods.

Please contact the authors for more information.

About the Wharton Risk Management and Decision Processes Center

For nearly three decades, the Risk Management and Decision Processes Center at the Wharton School of the University of Pennsylvania has been at the forefront of basic and applied research to promote effective corporate and public policies for low probability events with potentially catastrophic consequences. Building on the disciplines of economics, finance, insurance, marketing, psychology and decision sciences, the Center supports and undertakes field and experimental studies of risk and uncertainty to better understand the linkage between descriptive and prescriptive approaches under various regulatory and market conditions.

The Center now includes 70 faculty, research fellows, and visiting scholars from all over the world to undertake large-scale initiatives. Providing expertise and a neutral environment for discussion, the Center team is also concerned with training decision makers and promoting a dialogue among industry, governments, interest groups and academics through its research and policy publications and through sponsored seminars, roundtables and forums.

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