Making America More Resilient toward Natural Disasters:

A Call for Action*

Howard Kunreuther, Erwann Michel-Kerjan and Mark Pauly

Environment Magazine (forthcoming)

Howard Kunreuther
James G. Dinan Professor of Business and Public Policy
Wharton School, University of Pennsylvania
3730 Walnut Street, Suite 500
Philadelphia, PA 19104
Phone: 215-898-4589
Fax: 215-573-2310
Email: kunreuther@wharton.upenn.edu

Erwann Michel-Kerjan
Managing Director, Center for Risk Management and Decision Processes
Wharton School, University of Pennsylvania
3730 Walnut Street, Suite 500
Philadelphia, PA 19104
Phone: 215-573-0515
Fax: 215-573-2310
Email: erwannmk@wharton.upenn.edu

Mark Pauly
Bendheim Professor in the Department of Health Care Systems
Wharton School, University of Pennsylvania
208 Colonia Penn Center, 3641 Locust Walk
Philadelphia, PA 19104
Phone**:** (215) 898-2837
Fax: 215.573.7025
Email**:** pauly@wharton.upenn.edu

*We thank our colleagues Karen Campbell, Jeff Czajkowski, Dena Gromet and Robert Meyer as well as the Sponsors of the Wharton Risk Center Extreme Events Project for insightful comments. Carol Heller provided helpful editorial assistance. Support for this research comes from the National Science Foundation (SES-1061882 and SES-1062039); the Center for Risk and Economic Analysis of Terrorism Events (CREATE) at the University of Southern California; CRED at Columbia University; the Travelers Foundation, and the Wharton Risk Management and Decision Processes Center.

Making America More Resilient toward Natural Disasters:

A Call for Action

Howard Kunreuther, Erwann Michel-Kerjan and Mark Pauly

The Wharton School, University of Pennsylvania

March 6, 2013

I. Introduction

Hurricane Sandy caused an estimated $65 billion in economic losses to residences, business owners and infrastructure owners.[1] It is the second most costly natural disaster in recent years in the United States after Hurricane Katrina in 2005, but it is not an outlier; economic and insured losses from devastating natural catastrophes in the United States and worldwide are climbing. According to Munich Re,[2] real-dollar economic losses from natural catastrophes alone increased from $528 billion (1981-1990), $1,197 billion (1991-2000) to $1,23 billion (2001-2010). During the past ten years, the losses were principally due to hurricanes and resulting storm surge occurring in 2004, 2005, and 2008. Figure 1 depicts the evolution of the direct economic losses and the insured portion from great natural disasters over the period 1970-2011.[2]

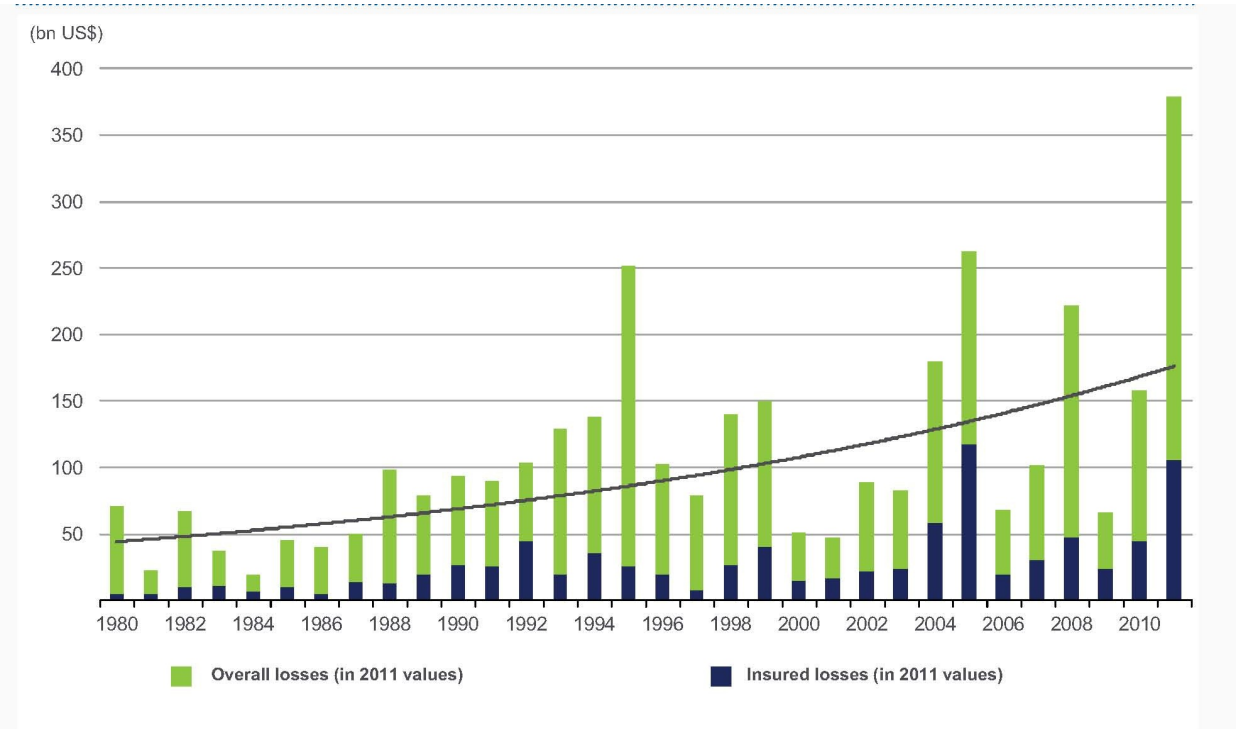

FIGURE 1. NATURAL CATASTROPHES WORLDWIDE 1980-2011. OVERALL AND INSURED LOSSES WITH TREND ($ BILLION)

Sources: Munich Re Geo Risks Research

Extreme events highlight the challenges in encouraging residents in hazard-prone areas to protect themselves against future disaster losses. A 1974 survey of more than 1,000 California homeowners in earthquake-prone areas revealed that only 12 percent of the respondents had adopted any protective measures.[3] Fifteen years later, there was little change despite the increased public awareness of the earthquake hazard. In a 1989 survey of 3,500 homeowners in four California counties at risk from earthquakes, only 5 to 9 percent of the respondents in these areas reported adopting any loss reduction measures.[4] Residents in flood-prone areas have demonstrated a similar reluctance to invest in mitigation measures.[5,6]

Even after the devastating 2004 and 2005 hurricane seasons, a large number of residents had still not invested in relatively inexpensive loss-reduction measures with respect to their property, nor had they undertaken emergency preparedness measures. A survey of 1,100 adults living along the Atlantic and Gulf Coasts undertaken in May 2006 revealed that 83 percent of the responders had taken no steps to fortify their home, 68 percent had no hurricane survival kit and 60 percent had no family disaster plan.[7]

A survey of nearly 800 residents in coastal counties during Hurricane Irene in 2011 revealed that less than half of storm shutter owners in the state of New York actually installed them to protect their windows before the hurricane came. The others did not because it would have "taken too long." This is an interesting example of mitigation measures being purchased but not utilized.[8]

On the positive side, 89 percent of respondents of this survey in North Carolina and 88 percent in New York indicated doing at least one storm preparation activity (e.g., buying water and food reserves and batteries). But these are short-term preparation actions that required limited effort. Many fewer households undertake protective measures when preparedness requires considerable foresight, effort and capital.

Key decision makers who authorize development of hazard-prone areas after dams or levees are built may unintentionally reinforce this behavior. There is compelling evidence that residents moving into these areas feel completely safe, when in fact, they are still at risk for catastrophes should the dam or levee be breached or overtopped.[9] If a catastrophic disaster occur, the damage is likely to be considerably greater than would have occurred had the lower but still positive level of risk been correctly perceived. This

behavior with its resulting consequences has been termed the *levee effect.* Public officials exacerbate the problem by not enforcing building codes and imposing zoning restrictions. A graphic example highlighting this point is the development of New Orleans following Hurricane Betsy in 1965 after the Corps of Engineers agreed to build massive hurricane protection levees to surround New Orleans and nearby communities. The city planning commission approved new subdivisions between 1967 and 1972 in areas that had been flooded by Betsy.[10]

II. Why Are Those at Risk Reluctant to Invest in Loss Reduction Measures?

Consider the following two illustrative scenarios:

Example 1: The Anderson family recently moved to a community that is subject to flooding, and has been asked by a local company whether they want to invest $1,500 to flood-proof their house so it is less susceptible to water damage. They are told that hydrologists have estimated that the annual chance of a severe flood affecting their home is 1/100 and that should such a disaster occur, flood-proofing their home will reduce their damage from what it would have been by $40,000. The family is not willing to incur this cost because they are not really that worried about the likelihood of flooding, even when offered an opportunity to look at the data.

Example 2: The Benson family has lived in the same community in a house identical to the Andersons for many years. They are concerned about the flood problem, and have looked at the data, but feel they are not in a financial position to incur the $1,500 upfront cost of flood-proofing because of budget constraints. They are postponing this decision "until next year" as they have in previous years.

These examples highlight two key problems in getting people to invest in cost-effective risk-reduction measures:

1. People chose to ignore the chance of future flood damage ("It will not happen to me"), even when they are provided with scientific information on the risk

2. The expected benefits from mitigation over the expected life of the house, do not justify the high upfront cost today, given other pressing demands on the budget.

Decision Making under Risk and Uncertainty

A key challenge in taking steps to reduce losses from natural disasters is to recognize the limitations of public and private decision makers in dealing with risk and uncertainty and then design incentives that help them make more informed and efficient choices.

Many of the biases and simplified decision rules that characterize human judgment and choice under uncertainty reflect automatic, emotional non-analytic thinking.[11] In this regard, risk is often treated as a feeling rather than as a statistical concept.[12] While intuitive perceptions of risk are relatively accurate over a broad range of situations, they can lead to systematic deviations from expert assessments, especially for unfamiliar risks that involve small probabilities and high degrees of uncertainty but do not trigger natural reactions of dread. The risk associated with natural hazards falls into this category.

Logical assessments of risk, such as probability estimation, and Bayesian updating, require considerable time and attention. If the Andersons or Bensons in our examples were to use analytic processes to make better decisions, they would have weighed the upfront investment in flood proofing their home against the expected discounted benefits

over time in the form of reduced losses from future disasters and found the measure to be cost-effective.

This paper suggests ways of addressing and overcoming this challenge: coupling long-term strategies for managing disasters with short-term incentives so that those at risk are willing to undertake the required measures now.

Behavioral Factors Impeding Adoption of Mitigation Measures

There is considerable evidence indicating that individuals do not make efficient tradeoffs between expected costs and benefit.[13] The simplest explanation as to why individuals fail to invest in adaptation and mitigation measures in the face of transparent risks is lack of affordability. If the Bensons have limited disposable income after purchasing necessities, limited credit and no way to borrow at reasonable interest rates, they would choose not to make these investments.

The Benson's decision to avoid making this investment is reinforced by their focusing on the upfront costs of risk reduction measures relative to the delayed benefits of suffering less damage from floods that *might* occur in the future. [14,15] Even before making this tradeoff, individuals residing in harm's way may decide not to undertake mitigation measures if the likelihood of the disaster is below their threshold level of concern. In a laboratory experiment on purchasing insurance, many individuals bid zero for insurance coverage against low probability events, apparently viewing the probability of a loss as sufficiently small that they were not interested in protecting themselves against it.[16] This may explain why the Anderson family did not invest in loss mitigation measures..

III. The Role of Insurance in Incentivizing Mitigation

Insurance, as a risk sharing mechanism, can play an important role in linking mitigation with financial protection should a disaster occur. People often buy insurance that makes good economic sense. They buy property insurance on their homes. They buy collision insurance on their new cars. They buy life insurance if they have dependents. But insurance against extreme events, such as floods and earthquakes, poses problems because these events are rarely experienced. People tend to ignore them or be unaware of their consequences until it is too late.

Yet insurance, if priced properly, delivers the greatest value precisely in cases of relatively rare events that can cause large losses: high benefits in the form of claim payments in return for relatively low premiums paid over time. The insurance premium itself can act as a powerful signal as to the likelihood of a loss in the face of individual attempts to ignore the risk. Insurance also has the potential to encourage investment in loss reduction measures through premium discounts reflecting expected reduced claims following a disaster.[17]

Guiding Principles for Insurance

For insurance to play these important roles we propose the following three guiding principles.

Principle 1: Premium reflecting risk. Insurance premiums should reflect risk to signal to individuals how safe they are and what preventive or protective measures will reduce their vulnerability to property losses. Risk-based premiums should also reflect the cost of

capital that insurers need to integrate into their pricing to assure adequate competitive returns to their investors.

Principle 1 provides a clear signal of the expected damage cost to those currently residing in areas subject to natural disasters and those considering moving into these regions. Insurers will also have an economic incentive to reduce premiums to homeowners and businesses investing in cost-effective loss-reduction measures, and those at risk will have an economic incentive to implement those measures.

On the other hand, if insurance is poorly designed and premiums are unrelated to risk or to changes in risk, individuals are likely to underinvest in loss reduction measures. For example, if high risk premiums are heavily subsidized, this will lead to an underinvestment in mitigation because the premium reduction for undertaking this investment would be smaller than it should be or even zero.

Insurance commissioners in several states have constrained premiums in hurricane-prone coastal regions by either suppressing the rates private insurers may charge and/or by providing coverage at distorted premiums through state organizations. The most extreme example is Florida. Through its state-operated insurance company, Citizens Property Insurance Corporation, homeowners residing in hurricane-prone areas pay highly subsidized rates that undercut private insurers' premiums. Over the past eight years, Citizens has ballooned to become the state's largest insurer, with about 1.4 million policies at the beginning of 2013.[18]

If Principle 1 is applied in hazard-prone areas where premiums are currently subsidized, some residents will be faced with large price increases. This concern leads to the second guiding principle.

Principle 2: Dealing with equity and affordability issues. Any special treatment given to consumers at risk should come from means-tested, tax-financed insurance vouchers and not through cross-subsidized insurance premiums.

Principle 2 is important if individuals residing in hazard-prone areas find that their premiums increase considerably when rates become risk-based. For some homeowners, higher premiums will impose an unexpected financial burden should they purchase a policy voluntarily or be required to do so. For these reasons, insurance vouchers financed by general taxation (not by higher premiums paid by lower risk individuals), may be the best way to make the risk-based rates equitable. Note that Principle 2 applies only to those individuals who currently reside in hazard-prone areas. Those who decide to locate in the area should be charged premiums that reflect the risk.

Principle 3: Multi-year insurance. To overcome myopia and encourage investment in preventive and protective measures, insurers should design multi-year contracts with fixed annual premiums.

Today, property insurance contracts are issued on an annual basis which discourages long-term thinking. Multi-year insurance contracts would benefit homeowners by assuring them coverage at reasonable premiums following a catastrophe. With annual contracts, insurers may discontinue coverage for some policyholders in high-hazard areas

following catastrophic losses, particularly if state regulators do not allow them to increase premiums. An advantage of multi-year contracts for insurers is a decrease in their marketing costs as they do not have to concern themselves with renewal of policies. It also reduces the variance with respect to claims payments since insurers are now diversifying their risk across time as well as across policyholders.

Multi-year insurance can be implemented only if insurers are permitted to charge prices that reflect long-term risk, and to adjust these premiums over time if risk changes. Today indeed, insurance premiums in many states are restricted to be artificially low in hazard-prone areas, contributing to the non-marketability of multi-year insurance for protecting homeowners' properties against losses from large-scale natural disasters. In addition, uncertainty regarding costs of capital and changes in risk over time deters insurers from extending their contracts beyond a single year.

Encouraging Investment in Loss Reduction Measures

The above three insurance principles should make it financially attractive for those at risk to invest in mitigation measures, particularly if the insurance policy is coupled with a home improvement loan so that the upfront costs of the loss-reduction investment is spread over a few years.

Suppose the Anderson family and the Benson family are required to buy an insurance policy as a condition for their mortgage. Assume also that the premiums reflect risk (*Principle 1)*. The policy is a 5-year contract with annual premiums stable over this period (*Principle 3)*. The two families are now each offered a 5-year home improvement

loan for flood-proofing their homes at an interest rate of ten percent. Each family now has to decide whether or not to undertake the measure.

Recall that both families were reluctant to invest in mitigation measures for different reasons. The Andersons perceived the risk to be below their threshold level of concern; the Bensons faced budget constraints. If flood insurance were required as a condition for a mortgage, then a home improvement loan could encourage each family to invest in mitigation.

Suppose the Anderson and Benson families are told that if they invest in mitigation, their annual premium over the next five years will be lowered due to the reduction in expected annual claims that the insurer pays each family – in this case $400 [i.e. 1/100 ($40,000)].[i] If each family takes a 5-year home improvement loan to cover the $1,200 mitigation cost at an interest rate of 7.5%, the annual loan cost will be $290. Thus there is a net saving to them of $110 (i.e., $400 - $290) for each of the next five years. From a financial viewpoint, this package should be attractive to both families. The key innovation would be to market the insurance and the home improvement loan as a package, with the combination paid off in annual premiums.

If the new flood insurance premiums are now higher than before, an insurance voucher could be offered to current lower-income homeowners to reflect the unexpected increase (*Principle 2)*. Over time, vouchers would eventually disappear as homes were re-sold except for those original families who retained ownership. The voucher would not preclude families from receiving a premium discount reflecting the reduced losses from future disasters due to investments in loss reduction measures.

Reframing the Problem of Risk

Another complementary way to make people want to invest in protection today is to reframe the problem of risk so that people believe potential future disasters are *above* their threshold level of concern.

Research shows that simply adjusting the time frame can have a significant impact on the perception of the risk. For example, people were more willing to buckle their seat belts when they are told they had a one-in-three chance of an accident over a 50-year lifetime of driving, rather than a .00001 chance each trip.[19] Similarly, property owners in a flood prone area are far more likely to take flood risk seriously if instead of being told the chance of a flood is 1 in 100 in any given year, that it has a greater than 1 in 5 chance of happening in the next 25 years.[20] Such reframed risk information could be provided by insurers, realtors, and/or local, state and federal organizations concerned with reducing losses from disasters to encourage investments in risk reduction measures.

Calling attention to the benefits of investing in mitigation measures by focusing on the reduction in losses from a specific storm such as Sandy or Katrina might attract more interest than a general message framed in terms of reducing damage from future hurricanes. Even before 9/11, controlled experiments revealed that consumers are willing to pay more for insurance against a plane crash caused by terrorists than for flight insurance due to any cause, a counterintuitive finding since by definition "any cause" includes a terrorist attack.[21]

IV. Encouraging Resilience through Other Initiatives

Insurance can be complemented by several other initiatives that should lead families to better protect themselves.

Well-Enforced Building Codes

Building codes are another key component in ensuring that those residing in hazard-prone areas adopt cost-effective loss reduction measures. Following Hurricane Andrew in 1992, Florida reevaluated its building code standards and in 1995, coastal areas of the state began to enforce high-wind design provisions for residential housing. The Florida Building Code 2001 edition, adopted in mid-2002, was accompanied by an extensive education and training program that included a requirement that all licensed engineers, architects, and contractors take a course on the new code.[ii]

Hurricane Charley in 2004 demonstrated the effectiveness of the new statewide building code. One insurance company provided the Institute for Business and Home Safety (IBHS) with data on 5,636 policies in Charlotte County at the time this hurricane made landfall on August 13, 2004. There were 2,102 reported claims from the hurricane (37 percent of all the homeowners' insurance policies in Charlotte County for this insurer). Figure 2 reveals that homes that met the wind-resistant standards enforced in 1996 had a claim frequency that was 60 percent *less* than those that were built prior to 1996.

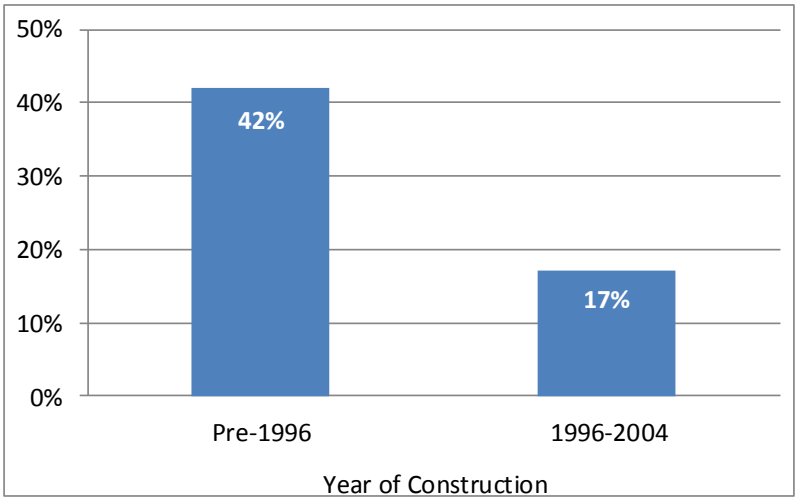

FIGURE 2. AVERAGE CLAIM FREQUENCY BY BUILDING CODE CATEGORY FROM HURRICANE CHARLEY

Source: Data from the Institute for Business & Home Safety (IBHS)

Moreover, this insurer's average claim for pre-1996 homes was $24 per square foot, compared to $14 per square foot for those constructed between 1996 and 2004, as shown in Figure 3. For a home of 2,000 square feet, the average damage before and after the new building code was implemented would be $48,000 and $28,000, respectively. In other words, the average reduction in claims from Hurricane Charley to **each** damaged home in Charlotte County built according to the newer code was approximately $20,000.[22]

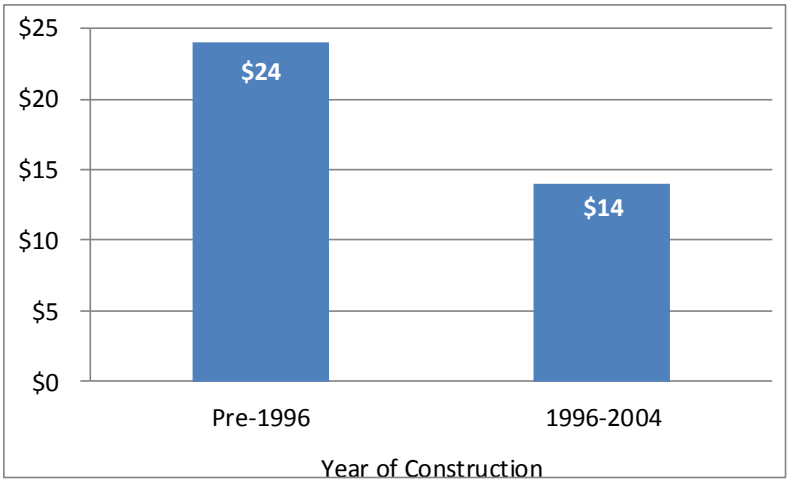

FIGURE 3. AVERAGE CLAIM SEVERITY BY BUILDING CODE CATEGORY FROM HURRICANE CHARLEY

Source: Data from the Institute for Business & Home Safety (IBHS)

IBHS released a new report in 2012 that provided an analysis of residential building codes in the 18 hurricane-prone coastal states along the Gulf of Mexico and the Atlantic Coast. While Florida scored 98 out of 100, other highly exposed states have a long way to go: Louisiana scored 73, New York 60, Alabama 18, Texas 18, and Mississippi 4.[23]

Providing Mitigation Seals of Approval

Homeowners who adopt cost-effective mitigation measures could receive a seal of approval from a certified inspector that the structure meets or exceeds building code standards. This requirement could either be legislated or imposed by the existing government sponsored enterprises (GSEs) (Fannie Mae, Freddie Mac, and Ginnie Mae) as a condition for obtaining a mortgage. Homeowners may want to seek such a seal of approval if they knew that insurers would provide a premium discount (similar to the

discounts that insurers now make available for smoke detectors or burglar alarms), and if home improvement loans were available for this purpose.

A seal of approval could increase the property value of the home by informing potential buyers that damage from future disasters is likely to be reduced because the mitigation measure is in place. There are other direct financial benefits from having a seal of approval. Under the *Fortified…for safer living* program of the Institute for Business & Home Safety, an independent inspector, trained by IBHS, verifies that disaster resistance features have been built into the home that exceed the minimum requirement of building codes and may enable the property owner to receive homeowners' insurance credits in some states.[22] The success of such a program requires the support of the building industry and a sufficient number of qualified inspectors to provide accurate information as to whether existing codes and standards are being met or exceeded. Such a certification program can be very useful to insurers who may choose to provide coverage only to those structures that are given a certificate of disaster resistance.

Evidence from a July 1994 telephone survey of 1,241 residents in six hurricane-prone areas on the Atlantic and Gulf Coasts provides supporting evidence for some type of seal of approval. Over 90 percent of the respondents felt that local home builders should be required to adhere to building codes, and 85 percent considered it very important that local building departments conduct inspections of new residential construction.[24]

Providing Local, State and Federal Tax Incentives

Communities and cities should design their taxation systems to encourage residents to pursue cost-effective mitigation measures. In practice, communities often create a

monetary disincentive to invest in mitigation – those who improve their home by making it safer are likely to have their property reassessed at a higher value based on the amount invested in the improvements and, hence, be required to pay higher taxes. California has recognized this problem, and in 1990, voters passed Proposition 127, which exempts seismic rehabilitation improvements to buildings from reassessments that would increase property taxes.

The city of Berkeley in California has taken an additional step to encourage home buyers to retrofit newly purchased homes by instituting a transfer tax rebate. The city has a 1.5 percent tax levied on property transfer transactions; up to one-third of this amount can be applied to seismic upgrades during the sale of property. Qualifying upgrades include foundation repairs or replacement, wall bracing in basements, shear wall installation, water heater anchoring, and securing of chimneys. These measures have an additional external benefit to neighbors by their not being subject to damage from a collapsing house next door.

South Carolina established Catastrophe Savings Accounts in 2007 that allow residents to set money aside, state income tax-free, to pay for qualified catastrophe expenses. The amount placed in the account reduces the taxpayer's South Carolina taxable income and, as a consequence, reduces the state income tax that the homeowner has to pay. A homeowner may deduct contributions to a Catastrophe Savings Account to cover losses to their legal residence against hurricane, rising floodwaters, or other catastrophic windstorm event damages.[iii]

South Carolina also offers tax credits for retrofitting, allowing individuals to take state income tax credits for costs to retrofit homes. In order to qualify for the tax credit, costs must not include ordinary repair or replacement of existing items. The homeowner may take a credit in any taxable year for costs associated with specific fortification measures as defined by the Director of Insurance. In addition to obtaining tax credits for retrofitting properties in the mitigation process, consumers will also receive tax credits on the mitigation materials they buy. (For more details on this program see http://www.doi.sc.gov/faqs/CatSavingsAcct.htm.)

Encouraging or Mandating Better Zoning

After major catastrophes, there is often pressure at the local level to permit rebuilding to restore economic activity and tax revenue. In additional residents have emotional ties to their community. Local authorities should consider adopting zoning policies that do not permit rebuilding in damaged areas if the likelihood of another disaster is sufficiently high to merit these measures. If rebuilding is permitted, it should be conditional only upon effective mitigation and purchase of insurance with a premium set high enough to cover the expected costs of damages. Insurance premiums that reflect high risk might be sufficient to deter inefficient rebuilding.

The federal government could encourage state governments to undertake cost-effective mitigation and reconstruction measures by denying or limiting the availability of post-disaster financial assistance to communities that fail to adopt and enforce such zoning policies.[iv] This might be difficult in the aftermath of a disaster when media coverage and political pressure for rebuilding damage communities is high, as politicians may focus on

short-term rewards.[25] Making such policies explicit by law should help them in resisting such pressure.

National Flood Insurance as a Prototype

The National Flood Insurance Program (NFIP) was created in 1968 to provide flood insurance to homeowners and small businesses given the absence of private insurance. As of December 2012 it sold over 5.5 million policies and provided over $1.28 trillion in coverage. But it had to borrow a total of nearly $27 billion from the U.S. Treasury to meet its claims obligations in the aftermath of the 2004, 2005, 2008 and 2012 hurricane seasons.[26,27]

An in-depth analysis of the entire portfolio of the NFIP revealed that the median tenure of flood insurance was between two and four years while the average length of time in a residence was seven years. As depicted in Table 1, of the 841,000 new policies purchased in 2001, only 73 percent were still in force one year later. By 2009 (eight years after 2001), only 20 percent of them were still in place.[28]

Table 1: Duration of New NFIP Policies by Year after First Purchase -- 2001-2008

New Business Year	2001	2002	2003	2004	2005	2006	2007	2008
Housing Units	841,000	876,000	1,186,000	986,000	849,000	1,299,000	974,000	894,000
1 year	**73%**	**67%**	**77%**	**78%**	**76%**	**73%**	**74%**	**73%**
2 years	**49%**	**52%**	**65%**	**65%**	**63%**	**59%**	**58%**	
3 years	**39%**	**44%**	**57%**	**55%**	**53%**	**48%**		
4 years	**33%**	**38%**	**50%**	**48%**	**44%**			
5 years	**29%**	**33%**	**44%**	**38%**				
6 years	**25%**	**30%**	**33%**					
7 years	**22%**	**26%**						
8 years	**20%**							

Sources: Michel-Kerjan et al, 2012.

Surprisingly, homeowners allow their flood insurance to lapse even when they are required to have flood insurance as a condition for a federally insured mortgage. Some banks and financial institutions have not enforced this regulation for at least two reasons: few banks have been fined and/or the mortgages are transferred to financial institutions in non-flood-prone regions of the country that have not focused on either the flood hazard risk or the requirement that homeowners may have to purchase this coverage. Only half of those residing in flood prone areas have flood insurance[29,30].

Introducing multi-year flood insurance tied to the structure rather than to the homeowner would ensure that exposed properties are covered over time. Should the homeowner move to another location, the flood insurance policy would remain with the property. Flood insurance should be required on all residences in flood-prone areas to avoid

disaster relief following the next major flood or hurricane. Ideally the cost of insurance would be included in the property tax bill so that this requirement is enforced.

Premiums would be risk-based to reduce taxpayer subsidies, and fixed for a prespecified time period (e.g., 5 years) based on updated flood maps. Low-income homeowners currently residing in flood-prone areas whose premiums increased would be given a means-tested insurance voucher to reflect the difference. Homeowners who invested in mitigation measures would be given a premium discount to reflect the reduction in expected losses from floods whether or not they had an insurance voucher. Home improvement loans would encourage investments in cost-effective mitigation measures. Well-enforced cost-effective building codes and seals of approval would provide an additional rationale for undertaking these loss reduction measures.

The reform of the National Flood Insurance Program in July 2012 (Biggert-Waters Act) provides a starting point for implementing multi-year insurance programs coupled with the other initiatives described above. The legislation authorized studies by FEMA and the National Academy of Sciences to examine ways of incorporating risk-based premiums (*Principle 1)* and the feasibility of means-tested insurance vouchers *(Principle 2).*

FEMA is also developing more accurate flood maps to set risk-based rates. The Biggert-Waters Act authorizes $400 million per year for this purpose over fiscal years 2013-2017. For instance, prior to Hurricane Sandy, FEMA was restudying areas of the New Jersey and New York coastlines in order to update Flood Insurance Rate Maps (FIRMs). Because existing FIRMs for these areas were developed more than 25 years ago, and updated FIRMs are not finalized, FEMA determined it is vital to provide near-

term Advisory Base Flood Elevations (ABFEs) to support reconstruction efforts. Home and business owners suffering damage from Sandy in communities adopting these ABFEs will be required to build higher and safer structures. This also means lower flood insurance premiums due to the reduced risk of water damage from future hurricanes.[v]

V. Moving Forward

Additional research is needed to design multi-year alternative risk transfer instruments for protection against catastrophic losses. Studies are also need to integrate insurance with other policy tools such as well-enforced building codes, zoning regulations, tax incentives and seals of approval to encourage investment in mitigation measures.

One also needs to take into account the impact that climate change will have on future damage from flooding due to potential sea level rise and more intense hurricanes. Repetto and Easton[31] have provided evidence that Federal agencies and other bodies have underestimated the risks of damage from extreme weather events due to climate change. Kunreuther, Michel-Kerjan and Ranger[32] show that enforcing building codes for all residences in Florida could reduce by nearly half the expected price of insurance under climate change projections, as they are likely to affect hurricane damage and the risk-based price of insurance in Florida in 2020 and 2040.

Based on these data, the case for making communities more resilient to natural disasters by investing in loss reduction measures now is an obvious one. Today, the general public is aware that we will face severe disasters in the future. The challenge facing the country is how to take advantage of the damage from Hurricane Sandy and the momentum created by the five-year renewal of the NFIP to take positive steps today rather than

regretting our inaction after the next hurricane or flood wreaks havoc. This will also reduce how much each of us as taxpayers will be asked to pay for disaster relief.[33]

REFERENCES

1. Aon Benfield 2013. *Annual Global Climate and Catastrophe Report: 2012*.
2. Munich Re 2011. Topics geo. Natural catastrophes 2010, Report, Munich: Munich Re.
3. H. Kunreuther et al. *Disaster Insurance Protection: Public Policy Lessons*. (New York: Wiley, 1978).
4. R. Palm, M. Hodgson R. D. Blanchard and D. Lyons, *Earthquake Insurance in California: Environmental Policy and Individual Decision Making*. (Boulder, CO.: Westview Press, 1990).
5. R. J. Burby, S. Bollens, E. J. Kaise, D. Mullan and J. R. Sheaffer, *Cities under Water: A Comparative Evaluation of Ten Cities' Efforts to Manage Floodplain Land Use*. (Boulder, CO.: Institute of Behavioral Science, University of Colorado, 1988).
6. S. B. Laska, "Floodproof Retrofitting: Homeowner Self-Protective Behavior," Boulder: Institute of Behavioral Science, University of Colorado, 1991.
7. A. Goodnough, "As Hurricane Season Looms, State Aim to Scare," *New York Times*, May 31, 2006.
8. E. J. Baker, J. Czajkowski and R. Meyer, "Modeling the Real-Time Decision to Evacuate from a Hurricane," Working Paper, Wharton Risk Management Center, The Wharton School, Philadelphia, PA, 2012.
9. R. Burby, "Hurricane Katrina and the Paradoxes of Government Disaster Policy: Bringing About Wise Governmental Decisions for Hazardous Areas," *Annals of the American Academy of Political and Social Science* 604 (2006): 171–191.
10. C. Colten and A. Giancario, "Losing Resilience on the Gulf Coast: Hurricanes and Social Memory," *Environment* 53 (2011):4, 6-19.
11. D. Kahneman, *Thinking, Fast and Slow.* (New York: Farrar, Straus and Giroux, 2011).
12. G. F. Loewenstein, E. U. Weber, C. K. Hsee and N. Welch, "Risk as Feelings," *Psychological Bulletin* 127 (2001): 267–286.

13. H. Kunreuther, R. Meyer and E. Michel-Kerjan, "Overcoming Decision Biases to Reduce Losses from Natural Catastrophes," in E. Shafir, ed., *Behavioral Foundations of Policy*, (Princeton University Press, 2013).

14. G. Loewenstein and D. Prelec, "Anomalies in intertemporal choice: Evidence and an interpretation," *Quarterly Journal of Economics.* 107, no. 2, (1992):573-597.

15. D. Laibson. "Golden eggs and hyperbolic discounting," *Quarterly Journal of Economics* 112 (1997): 443-478.

16. G. McClelland, W. Schulze and D. Coursey, "Insurance for Low-Probability Hazards: A Bimodal Response to Unlikely Events," *Journal of Risk and Uncertainty* 7 (1993): 95-116.

17. H. C. Kunreuther, M. V. Pauly and S. McMorrow, *Insurance and Behavioral Economics: Improving Decisions in the Most Misunderstood Industry,* (New York: Cambridge University Press, 2013).

18. H. Kunreuther and E. Michel-Kerjan, *At War with the Weather.* (Cambridge, MA: MIT Press, 2011).

19. P. Slovic, B. Fischhoff and S. Lichtenstein, "Accident Probabilities and Seat Belt Usage: A Psychological Perspective," *Accident Analysis and Prevention* 10 (1978): 281:285.

20. N. Weinstein, K. Kolb and B. Goldstein, "Using Time intervals Between Expected Events to Communicate Risk Magnitudes," *Risk Analysis* 16 (1996): 305-308.

21. E. Johnson, J. Hershey, J. Meszaros and H. Kunreuther, "Framing, probability distortions, and insurance decisions," *Journal of Risk and Uncertainty, 7* (1993) 35–51.

22. Institute for Business and Home Safety (IBHS), "The Benefits of Modern Wind Resistant Building Codes on Hurricane Claim Frequency and Severity—A Summary Report," Institute for Business and Home Safety. Tampa, FL, 2007.

23. Institute for Business and Home Safety (IBHS), *Rating the States: An Assessment of Residential Building Codes and Enforcement Systems for Life Safety and Property Protection in Hurricane Prone Regions.* Tampa FL, 012.

24. Insurance Institute for Property Loss Reduction, *Homes and Hurricanes: Public Opinion Concerning Various Issues Relating to Home Builders, Building Codes and Damage Mitigation.* Boston, MA: IIPLR, 1995.

25. E. Michel-Kerjan and J. Volkman Wise, "The Risk of Ever-Growing Disaster Relief Expectations." Paper presented at the annual NBER Insurance Group conference, Cambridge, MA, September 2011. Accessible at: http://nber.org/confer/2011/INSf11/Michel-Kerjan_Volkman_Wise.pdf.

26. E. Michel-Kerjan, "Catastrophe Economics: The National Flood Insurance program," *Journal of Economic Perspectives*, 24, no. 4 (2010): 165-86.

27. R. King, (2013) "The National Flood Insurance Program: Status and Remaining Issues for Congress," Congressional Research Service, 7-5700, R42850 (p. 6) http://www.fas.org/sgp/crs/misc/R42850.pdf

28. E. Michel-Kerjan, S. Lemoyne de Forges and H. Kunreuther, "Policy Tenure under the U.S. National Flood Insurance Program," *Risk Analysis*, 32, no. 4 (2012): 644-658.

29. W. Kriesel and C. Landry, "Participation in the National Flood Insurance Program: An Empirical Analysis for Coastal Properties," *Journal of Risk and Insurance* 71, no. 3 (2004): 405–420.

30. L. Dixon, N. Clancy, S. A. Seabury and A. Overton, "The National Flood Insurance Program's Market Penetration Rate: Estimates and Policy Implications," Santa Monica, CA: RAND, 2006.

31. R. Repetto and R. Easton, "Climate Change and Damage from Extreme Weather Events," *Environment* 52 (2012): 2, 22-33.

32. H. Kunreuther E. Michel-Kerjan and N. Ranger, "Insuring against Future Climate Catastrophes," *Climatic Change* (in press).

33. E. Michel-Kerjan and H. Kunreuther, "Paying for Future Catastrophes," *New York Times Sunday Review*, November 27, 2012.

[i] To keep the example simple we are assuming that insurance provides full coverage against future losses. In reality there will be a deductible so that the property owner will pay for some of the losses. We also assume reconstruction costs to be stable over time.

[ii] More recent building codes were established in 2004, then in 2007. See www.FloridaBuilding.org.

[iii] Tax incentive programs such as this one should encourage homeowners to take out a larger deductible on their insurance policy and contribute more to the Catastrophe Savings Account. In the process they pay lower insurance premiums and lower taxes at the same time. The insurer benefits by having lower claims following a disaster. If many homeowners take advantage of this program by raising their deductible, the insurer's catastrophic exposure could be significantly reduced.

[iv] Under the Stafford Act, the federal government covers 75 percent of the losses to public infrastructure.

[v] More details on FEMA's Advisory Base Flood Elevations (ABFE) program can be found in http://www.region2coastal.com/faqs/advisory-bfe-faq