# Market and Government Failure in Insuring and Mitigating Natural Catastrophes: How Long-Term Contracts Can Help

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# Market and Government Failure in Insuring and Mitigating Natural Catastrophes: How Long-Term Contracts Can Help

*Howard C. Kunreuther and Erwann O. Michel-Kerjan*[1]

> Insurance plays a vital role in America's economy by helping households and businesses manage risks . . . When insurance prices reflect underlying economic costs they can encourage a more efficient allocation of resources. Efforts to keep premiums for insurance against catastrophe hazards artificially low, whether through regulation or through subsidized government programs, can encourage excessively risky behavior on the part of those who might be affected by future catastrophes.
>
> —*Economic Report of the President,* 2007[2]

Given the hundreds of billions of dollars in economic losses that catastrophes have caused in the United States since 2001, it is difficult to remember that when Hurricane Hugo hit the country in 1989, it was the first catastrophe to inflict more than $1 billion of insured losses. But times have changed: there have been repeated large-scale natural disasters in the United States in the past few years, the terrorism threat worldwide—including the potential for nuclear attacks—has increased, and in addition to the 2008-2009 financial crisis, we face the possibility of international pandemics and world cyberfailure.

These catastrophes differ from one another in obvious ways, but they have two important features in common: uncertainty and wide variance in losses from one year to the next. Experts and decision makers face challenges in assessing the risks associated with these extreme events, developing strategies for reducing future losses following them, and facilitating the recovery process in their aftermath.

To understand these challenges, let us consider some recent natural disasters. The world has experienced large-scale losses and fatalities due to the increasing concentration of population and activities in high-risk coastal regions. In southeast Asia, the tsunami in December 2004 killed more than 280,000 people residing in coastal areas. Cyclone Nargis, which made landfall in Myanmar in May 2008, killed an estimated 140,000 people, making it the deadliest natural disaster in the recorded history of the country. The same month, the Great Sichuan Earthquake is estimated to have killed over 85,000, injured 374,000, and left almost five million homeless

[1] We would like to thank Jeffrey Brown, David Torregrosa, and other participants in "Private Markets and Public Insurance Programs," a conference sponsored by the American Enterprise Institute in January 2009, for helpful comments on a previous version of this paper. This work also benefits from ongoing discussion with Congressional staff on the concept of long-term insurance. We appreciate editorial assistance from Anne Himmelfarb and Carol Heller. We acknowledge support from the Wharton Risk Management and Decision Processes Center (hereafter Wharton Risk Center) and a grant from the Federal Emergency Management Agency, Office of Preparedness Policy, Planning and Analysis, National Preparedness Directorate, U.S. Department of Homeland Security (Grant # 2008-GA-T8-K004). The views and opinions expressed are those of the authors and should not be interpreted as representing the United States Government or FEMA.

[2] See White House Council of Economic Advisors 2007, 122–23. It is quite remarkable that 2007 was the first year that the *Economic Report of the President* devoted a chapter to catastrophic risk insurance.

(Munich Re 2008). Deaths from the Haitian earthquake in January 2010 are estimated at 230,000 (Insurance Journal, 2010).

But even a developed country like the United States, which has extensive experience with natural catastrophes and the resources to adequately prepare for them, may have inadequate loss-reduction measures in place and may lack the emergency-preparedness capacity to deal with large-scale natural disasters, such as occurred during the 2004 and 2005 hurricane seasons. Hurricane Katrina, which hit Louisiana and Mississippi at the end of August 2005, killed 1,300 people and forced 1.5 million people to evacuate the affected area—a historic record for the country. Economic losses caused by Katrina are estimated in the range of $150 to $200 billion.

A series of hurricanes in 2008 caused billions of dollars in direct economic losses along the Caribbean basin and in the United States. Hurricane Ike was the most expensive individual event in 2008, with an estimated privately insured loss of $17.6 billion in addition to $2.4 billion in claims paid by the U.S. national flood insurance program for flood surge resulting from Ike (Swiss Re, 2009). Based on these figures, Hurricane Ike ranks as the third worst weather-related disaster in U.S. history, after Hurricane Katrina and Hurricane Andrew, which hit southeast Florida in August 1992.

These recent catastrophes highlight the challenges of mitigating natural disasters and paying for the damage they cause. The question is not *whether* other large-scale catastrophes will occur, but *when* and *how frequent* they will be, and how extensive the damage—and numerous the fatalities—they will cause.

Now is the time to develop and implement economically sound policies and strategies for managing the risk and consequences of future disasters. To do so it is important to take a long-term view of these issues and avoid the tendency to be myopic and to misperceive risks. A coherent strategy is necessary to ensure sustainable recovery from large-scale disasters and the appropriate future development of hazard-prone areas. But the issues involved in developing such a strategy are complex. They challenge our capacity as a nation to work together despite the different views of stakeholders and legislators about the role and responsibilities of the private and public sectors in dealing with catastrophic risks. But absence of leadership in this area will inevitably lead to unnecessary loss of lives and economic destruction in the devastated regions.

This chapter focuses on the risk of large-scale natural disasters, although we believe that methods for managing these risks have relevance to other types of extreme events, such as terrorism and catastrophic accidents.[3] We begin by discussing the evolution over the past four decades of economic and insured losses due to major catastrophes, as well as the key drivers of this change. We then propose four guiding principles for developing sustainable insurance and mitigation programs. After a discussion of the behavioral biases (notably myopia) that discourage individuals from investing in cost-effective protective measures, we explain how long-term insurance contracts combined with long-term home improvement loans can overcome these biases. We then discuss the National Flood Insurance Program (NFIP), which is due for renewal or changes in the coming months, as a natural candidate for these contracts. The chapter concludes with a brief summary and suggestions for future research.

[3] For a detailed analysis of terrorism insurance, see Kunreuther and Michel-Kerjan (2004), Brown et al. (2004), Wharton Risk Center (2005), Michel-Kerjan and Pedell (2006), and Michel-Kerjan, Raschky, Kunreuther (2009). For a detailed analysis of the question of natural disaster insurance and mitigation in the U.S., see Kunreuther and Michel-Kerjan (2009).

## A New Era of Catastrophes

The economic and insured losses from great natural catastrophes such as hurricanes, earthquakes, and floods worldwide have increased significantly in recent years, as shown in figure 4-1 (each vertical bar represents the total economic losses, and the darker zone represents the insured portion of it). A comparison of these economic losses over time reveals a huge increase: $53.6 billion (1950–1959), $93.3 billion (1960–1969), $161.7 billion (1970–1979), $262.9 billion (1980–1989), and $778.3 billion (1990–1999). Between 2000 and 2008, there were $620.6 billion in losses, principally a result of the 2004, 2005, and 2008 hurricane seasons.

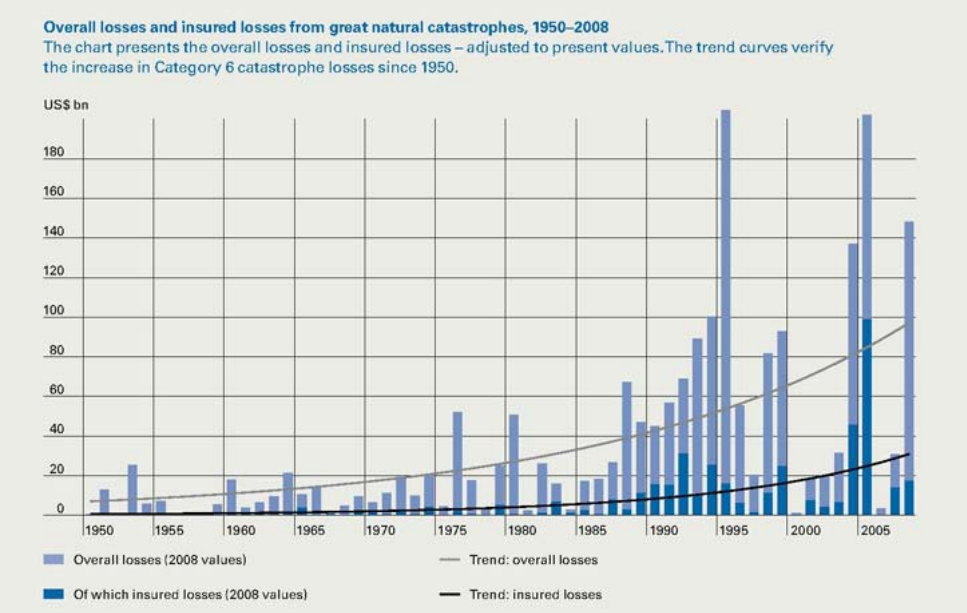


**Figure 4-1. Evolution of Great Natural Catastrophes Worldwide, 1950–2008**

*Sources: Munich Re 2009a*

*Note: Dollar amounts in U.S.$ billion are indexed to 2008.*

Catastrophes have had a more devastating impact on insurers since 1990 than in the entire history of insurance before that time. Figure 4-2, which depicts the upward trend in worldwide insured losses from catastrophes between 1970 and 2008,[4] shows that between 1970 and the mid-1980s, annual insured losses from natural disasters (including forest fires) were in the $3 billion to $4 billion range. The insured losses from Hurricane Hugo, which made landfall in Charleston, South Carolina, in September 1989, exceeded $7.9 billion (2008 dollars). There was a radical increase in insured losses in the early 1990s, with Hurricane Andrew in Florida ($24.6 billion in 2008 dollars) and the Northridge earthquake in California ($20.3 billion in 2008 dollars). The four hurricanes in Florida in 2004 (Charley, Frances, Ivan, and Jeanne) collectively totaled almost $35 billion in insured losses. Hurricane Katrina alone cost insurers and reinsurers an

[4] Munich Re and Swiss Re, the two leading reinsurers in the world, do not use the same definition of catastrophic losses. Natural disasters inflicting insured losses above $38.7 million or total losses above $77.5 million are considered major catastrophes by Swiss Re. Munich Re uses a higher threshold, which explains the differences between figures 4-1 and 4-2. For example, when Munich Re estimated insured loss from natural disasters at about $42 billion in 2004, Swiss Re's estimate was over $52 billion.

estimated $48 billion, with total losses of $87 billion paid by private insurers for major natural catastrophes in 2005.[5]

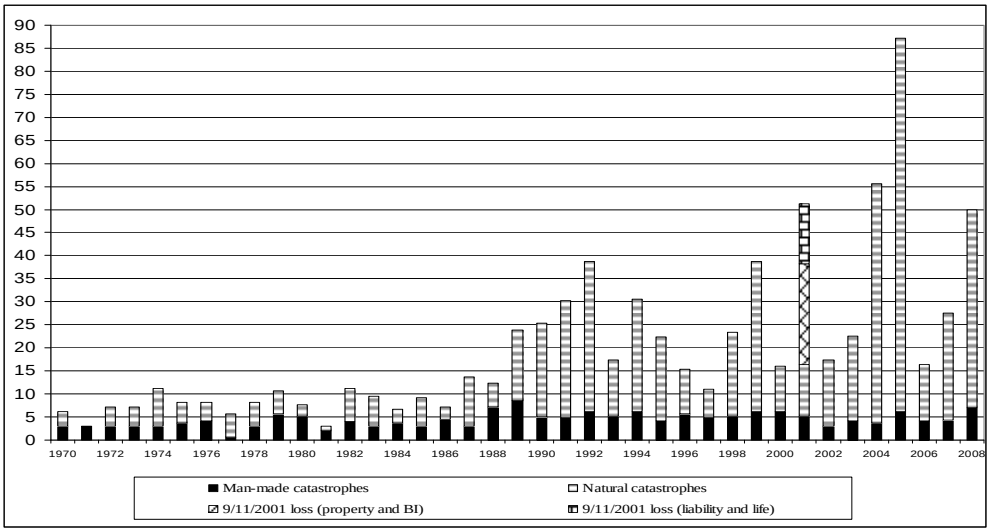


**Figure 4-2. Worldwide Evolution of Catastrophe Insured Losses, 1970–2008**

*Source: Kunreuther and Michel-Kerjan (2009) with data from Swiss Re (2009) and Insurance Information Institute in New York.*
*Notes: All lines, including property and business interruption, in billions of U.S. dollars indexed to 2007, except for 2008, which is current. Man-made catastrophes include major fires and explosions (e.g., in a chemical plant or oil refinery), aviation/rail/shipping-related losses (fires, crashes, collisions), mining accidents, and collapse of infrastructure. BI = business interruption.*

Table 4-1 reveals the twenty-five most costly catastrophes for the insurance sector from 1970 to 2008 (in 2008 dollars). Of these twenty-five major events, fourteen have occurred since 2001, twelve of them in the United States. Hurricane Andrew and the Northridge earthquake were the first two catastrophes that the industry experienced where losses were greater than $10 billion (designated "super-cats") and caused insurers to reflect on whether risks from natural disasters were still insurable. To assist them in making this determination, many firms began using catastrophe models to estimate the likelihood of, and consequences to their insured portfolios from, specific disasters in hazard-prone areas (Grossi and Kunreuther 2005). With the exception of the terrorist attacks on September 11, 2001, all twenty-five of the most costly catastrophes were natural disasters.[6] More than 85 percent of these were weather-related events—hurricanes, typhoons, storms, and floods—with nearly three-quarters of the claims in the United States.

Losses resulting from natural catastrophes and man-made disasters in 2006 were far below the losses in 2004 and 2005. Of the $48 billion in catastrophe-related economic losses, $16 billion was covered by insurance ($11 billion for natural disasters and $5 billion for man-made). During the past twenty years, only 1988 and 1997 had insured losses lower than those in 2006. According to Munich Re, there were 950 natural catastrophes in 2007, the most since 1974. They inflicted nearly $27 billion in insured losses. Swiss Re estimates that insured losses soared to $52.5 billion for the industry in 2008, making it one of the three costliest years ever. Natural catastrophes accounted for $44.7 billion of these losses, with man-made disasters accounting for the remaining $7.8 billion (Kunreuther and Michel-Kerjan, 2009). In 2009,

[5] This figure excludes payment by the U.S. National Flood Insurance Program for damage due to 2005 flooding (over $20 billion in claims).
[6] See the chapter by Jaffee and Russell in this volume for a detailed discussion of terrorism insurance markets.

insured losses due to catastrophes amounted to only $22 billion, due to a very benign North Atlantic hurricane season (Munich Re 2009b).

**Table 4-1. Twenty-Five Most Costly Insured Catastrophes Worldwide, 1970–2008**

| $ BILLION | EVENT | VICTIMS (DEAD OR MISSING) | YEAR | AREA OF PRIMARY DAMAGE |
|---|---|---|---|---|
| 48.1 | Hurricane Katrina | 1,836 | 2005 | USA , Gulf of Mexico, et al. |
| 36.8 | 9/11 Attacks | 3,025 | 2001 | USA |
| 24.6 | Hurricane Andrew | 43 | 1992 | USA, Bahamas |
| 20.3 | Northridge Earthquake | 61 | 1994 | USA |
| 17.6 | Hurricane Ike | 348 | 2008 | USA, Caribbean, et al. |
| 14.6 | Hurricane Ivan | 124 | 2004 | USA, Caribbean, et al. |
| 13.8 | Hurricane Wilma | 35 | 2005 | USA , Gulf of Mexico, et al. |
| 11.1 | Hurricane Rita | 34 | 2005 | USA, Gulf of Mexico, et al. |
| 9.1 | Hurricane Charley | 24 | 2004 | USA, Caribbean, et al. |
| 8.9 | Typhoon Mireille | 51 | 1991 | Japan |
| 7.9 | Hurricane Hugo | 71 | 1989 | Puerto Rico, USA, et al. |
| 7.7 | Winter Storm Daria | 95 | 1990 | France, UK, et al. |
| 7.5 | Winter Storm Lothar | 110 | 1999 | France, Switzerland, et al. |
| 6.3 | Winter Storm Kyrill | 54 | 2007 | Germany, UK, NL, France |
| 5.9 | Storms and floods | 22 | 1987 | France, UK, et al. |
| 5.8 | Hurricane Frances | 38 | 2004 | USA, Bahamas |
| 5.2 | Winter Storm Vivian | 64 | 1990 | Western/Central Europe |
| 5.2 | Typhoon Bart | 26 | 1999 | Japan |
| 5.0 | Hurricane Gustav | 153 | 2008 | USA, Caribbean, et al. |
| 4.7 | Hurricane Georges | 600 | 1998 | USA, Caribbean |
| 4.4 | Tropical Storm Alison | 41 | 2001 | USA |
| 4.4 | Hurricane Jeanne | 3,034 | 2004 | USA, Caribbean, et al. |
| 4.0 | Typhoon Songda | 45 | 2004 | Japan, South Korea |
| 3.7 | Storms | 45 | 2003 | USA |
| 3.6 | Hurricane Floyd | 70 | 1999 | USA, Bahamas, Columbia |

*Sources: Kunreuther and Michel-Kerjan (2009) with data from Swiss Re (2009) and Insurance Information Institute in New York*
*Note: Dollar amounts are indexed to 2008.*

The occurrence of damaging hurricanes is highly variable and uncertain from year to year. However, it is very likely that in the coming years more hurricanes will strike the Atlantic and Gulf coasts. Other parts of the nation will experience severe floods (as occurred in the upper Midwest in 2008) or earthquakes, causing extreme damage to residential and commercial property and infrastructure.

There is a very clear message from these data. Twenty or thirty years ago, large-scale natural disasters were considered to be low-probability events. Today, they not only are causing considerably greater economic losses than in the past but also appear to be occurring at an accelerating pace. In this context, it is important to understand more fully the factors influencing these changes in order to design more effective programs for reducing losses from future disasters.

**The Question of Attribution.** Several elements explain this increase in these costs of disasters in recent years. They include a higher degree of urbanization, an increase in the value at risk and insurance density, and the possible impact of a change in climate. In 1950, approximately 30 percent of the world's population lived in cities. In 2000, about 50 percent of the world's population (6 billion) resided in urban areas. Projections by the United Nations (2008) show that by 2025, that figure will have increased to 60 percent based on a world population estimate of 8.3 billion people.

In the U.S. in 2003, 53 percent of the nation's population, or 153 million people, lived in the 673 U.S. coastal counties, an increase of 33 million people since 1980, according to the National Oceanic Atmospheric Administration. And the nation's coastal population is expected to increase by more than 12 million by 2015 (Crossett et al. 2004).[7] Yet coastal counties, excluding Alaska, account for only 17 percent of land area in the United States. In hazard-prone areas, this urbanization and increase in population translate into greater concentration of exposure and hence a higher likelihood of catastrophic losses from future disasters. Given the growing concentration of exposure ~~on~~ the Gulf Coast, another hurricane like Katrina hitting in that area is likely to inflict significant property damage unless strong mitigation measures are put in place.[8]

This new vulnerability is best understood in historical context—that is, compared to the cost of hurricanes in the past. It is possible to calculate the total direct economic cost of the major hurricanes affecting the U.S. in the past century, adjusted for inflation, population, and wealth normalization. Several studies have estimated what previous hurricanes would have cost had they hit today. The most recent one, by Pielke et al. (2008), normalizes to the year 2005 mainland U.S. hurricane damage for the period 1900–2005.

Drawing on data from Pielke et al. (2008), table 4-2 lists the twenty hurricanes that would have been most costly had they occurred in 2005. The estimate for each is a range based on the two approaches to normalizing losses used by the Pielke study. The table provides the year when the hurricane originally occurred, the states that were the most seriously affected, and the hurricane category on the Saffir-Simpson scale. The data reveal that the hurricane that hit Miami

[7] Demographic figures for coastal counties vary depending on the definition of such counties. Under a more restrictive definition (such counties as have a coastline bordering the open ocean or associated sheltered water bodies, or contain V zones as defined by the U.S. National Flood Insurance Program), the proportion of population living in such counties is still 30 percent (Crowell et al. 2007).

[8] For additional data on the economic impact of future catastrophic hurricanes, see Financial Services Roundtable (2007), especially chapter 2.

in 1926 would have been almost twice as costly as Hurricane Katrina had it occurred in 2005, and the Galveston hurricane of 1900 would have had total direct economic costs as high as those from Katrina. This means that independent of any possible change in weather patterns, we are very likely to see even more devastating disasters in the coming years because of the ongoing growth in values located in risk-prone areas.

There is another element to consider in determining how to adequately manage and finance catastrophe risks: the possible impact of a change in climate on future weather-related catastrophes. Between 1970 and 2004, storms and floods were responsible for over *90 percent* of the total economic costs of extreme weather–related events worldwide. Storms (hurricanes in the U.S. region, typhoons in Asia, and windstorms in Europe) contributed to over 75 percent of insured losses. In constant prices (2004), insured losses from weather-related events averaged $3 billion annually between 1970 and 1990 and then increased significantly to $16 billion annually between 1990 and 2004 (Association of British Insurers 2005). In 2005, 99.7 percent of all catastrophic losses worldwide were due to weather-related events (Mills and Lecomte 2006).

**Table 4-2. Twenty Most Costly Hurricanes, 1900–2005 (ranked using 2005 inflation, population, and wealth normalization)**

| Rank | Hurricane | Year | Category | Cost range in 2005 ($ billions) |
|---|---|---|---|---|
| 1 | Miami (Southeast FL/MS/AL) | 1926 | 4 | 140–157 |
| 2 | Katrina (LA/MS) | 2005 | 3 | 81 |
| 3 | North Texas (Galveston) | 1900 | 4 | 72–78 |
| 4 | North Texas (Galveston) | 1915 | 4 | 57–62 |
| 5 | Andrew (Southeast FL and LA) | 1992 | 5-3 | 54–60 |
| 6 | New England (CT/MA/NY/RI) | 1938 | 3 | 37–39 |
| 7 | Southwest Florida | 1944 | 3 | 35–39 |
| 8 | Lake Okeechobee (Southeast Florida) | 1928 | 4 | 32–34 |
| 9 | Donna (FL-NC/NY) | 1960 | 4-3 | 29–32 |
| 10 | Camille (MS/Southeast LA/VA) | 1969 | 5 | 21–24 |
| 11 | Betsy (Southeast FL and LA) | 1965 | 3 | 21–23 |
| 12 | Wilma | 2005 | 3 | 21 |
| 13 | Agnes (FL/CT/NY) | 1972 | 1 | 17–18 |
| 14 | Diane (NC) | 1955 | 1 | 17 |
| 15 | (Southeast FL/LA/AL/MS) | 1947 | 4-3 | 15–17 |
| 16 | Hazel (SC/NC) | 1954 | 4 | 16-23 |
| 17 | Charley (Southwest FL) | 2004 | 4 | 16 |
| 18 | Carol (CT/NY/RI) | 1954 | 3 | 15–16 |
| 19 | Hugo (SC) | 1989 | 4 | 15–16 |
| 20 | Ivan (Northwest FL/AL) | 2004 | 3 | 15 |

Source: Pielke et al. 2008.

There have been numerous discussions and scientific debates as to whether the series of major hurricanes that occurred in 2004 and 2005 might be partially attributable to the impact of a

change in climate.[9] One of the expected effects of global warming will be an increase in hurricane intensity. This increase has been predicted by theory and modeling, and substantiated by empirical data on climate change. Higher ocean temperatures lead to an exponentially higher evaporation rate in the atmosphere, which increases the intensity of cyclones and precipitation. An increase in the number of major hurricanes over a shorter period of time is likely to translate into a greater number hitting the coasts, with a greater likelihood of damage to a residences and commercial buildings today than in the 1940s—a trend that raises issues about the insurability of weather-related catastrophes.

The combination of increasing urbanization, concentration of value in high-risk areas, and the potential impact of a change in weather-patterns raises questions for the insurance industry about how they will provide protection against catastrophic risks in the future. Conventional insurance relies on geographical *and* time diversification, both of which are somewhat compromised by these recent trends. Determining the appropriate roles and responsibilities of the private and public sectors (as a source of financial support or as market regulator) is critical in this regard.

## Guiding Principles for Mitigating and Insuring against Catastrophes

The following four guiding principles clarify how the private and public sectors can use the insurance infrastructure to deal more effectively with natural disasters.[10]

**Principle 1: Premiums should reflect risk.** Insurance premiums should be based on risk in order to provide signals to individuals about the hazards they face and to encourage them to engage in cost-effective mitigation measures that reduce their vulnerability to catastrophes. Risk-based premiums should also reflect the cost of capital that insurers must integrate into their pricing in order to assure adequate return to their investors.

The application of principle 1 provides a clear signal of likely damage to those currently residing in hazard-prone areas as well as those considering locating there. Risk-based premiums would also enable insurers to provide discounts to homeowners and businesses that invest in cost-effective mitigation measures. If insurance premiums are not risk based, insurers are unlikely to offer any premium discounts for those who adopt mitigation measures. In fact, they prefer not to offer coverage to these property owners because it will be a losing proposition in the long run.

**Principle 2: Equity and affordability issues should be addressed.** Specifically, any special treatment given to homeowners currently residing in hazard-prone areas (e.g., low-income uninsured or inadequately insured homeowners) should be funded through general public funding and not through insurance premium subsidies. This principle reflects a concern for some residents in high-hazard areas who will be faced with large premium increases if insurers adhere to principle 1. As discussed in the next section, regulations imposed by state insurance commissioners keep premiums in many regions subject to hurricane damage artificially lower than the risk-based level.

[9] For more details on the scientific evidence regarding climate change and its impact, see Stern Review (2006).
[10] The first two principles are taken from Kunreuther and Michel-Kerjan (2009).

Note that principle 2 applies only to individuals who *currently reside* in a hazard-prone area. Those who decide to move to the area in the future should be charged premiums that reflect the risk. If they were provided with financial assistance from public sources to purchase insurance, the resulting public policy would directly encourage development in hazard-prone areas and exacerbate the potential for catastrophic losses from future disasters.

**Principle 3: There should be sufficient demand for coverage.** The demand by individuals and firms for insurance coverage with risk-based premiums should be sufficiently high so that insurers can cover the fixed costs of introducing a program that provides coverage and that spreads the risk broadly throughout their portfolios. High demand for insurance would also reduce the level of state and federal relief to uninsured or underinsured homeowners in the aftermath of the next disaster.

**Principle 4: The likelihood of (re-)insurers' insolvency should be minimized.** Insurers and reinsurers should determine how much coverage to offer and what premium to charge against the risk so that the chances of insolvency are below some predefined acceptable threshold. Insurance regulators should play an important role here in assuring that insurers providing coverage in high-risk areas have a solid financial basis for doing so.

## The Behavioral Challenges: The Demand for Insurance and Mitigation

What is the effectiveness of mitigation in reducing exposure to future disaster? In our recent book, we shed some light on this question by analyzing the impact that mitigation would have on reducing losses from hurricanes in four states: Florida, New York, South Carolina, and Texas. (Kunreuther and Michel-Kerjan 2009). In our analysis of the impact of mitigation, we consider two extreme cases: one in which no one has invested in mitigation, the other in which everyone has invested in predefined mitigation measures. From the U.S. hurricane model developed by the catastrophe modeling firm Risk Management Solutions (RMS), losses were calculated assuming an appropriate mitigation measure across the insured portfolio. The mitigation measures were based on various assumptions for the different regions. Thus in Florida, the requirements were those defined by the "Fortified . . . for Safer Living" program of the Institute for Business and Home Safety's (IBHS). In New York, South Carolina, and Texas, mitigation means the application of the latest building codes to the residential structures.[11]

Table 4-3 indicates the differences in losses and savings from adopting mitigation measures for hurricanes with return periods of 100, 250, and 500 years for each of the four states.

[11] We are assuming that because these measures are incorporated in building codes they are cost-effective. In other words, the discounted long-term expected benefits from the mitigation measure over the projected life of the building are greater than its upfront costs. By obtaining detailed cost estimates for specific mitigation measures incorporated in building codes or Florida's "Fortified . . . for Safer Living" program, one could rank their relative cost-effectiveness.

**Table 4-3. Money Saved in Reduced Losses from Full Mitigation for Different Return Periods**

| | *100-Year Event* | | | *250-Year Event* | | | *500-Year Event* | | |
|---|---|---|---|---|---|---|---|---|---|
| **State** | **Unmitigated Losses** | **Savings in Reduced Losses from Mitigation ($)** | **Savings in Reduced Losses from Mitigation (%)** | **Unmitigated Losses** | **Savings in Reduced Losses from Mitigation ($)** | **Savings in Reduced Losses from Mitigation (%)** | **Unmitigated Losses** | **Savings in Reduced Losses from Mitigation ($)** | **Savings in Reduced Losses from Mitigation (%)** |
| FL | $84 billion | $51 billion | 61% | $126 billion | $69 billion | 55% | $160 billion | $83 billion | 52% |
| NY | $6 billion | $2 billion | 39% | $13 billion | $5 billion | 37% | $19 billion | $7 billion | 35% |
| SC | $4 Billion | $2 billion | 44% | $7 billion | $3 billion | 41% | $9 billion | $4 billion | 39% |
| TX | $17 billion | $6 billion | 34% | $27 billion | $9 billion | 32% | $37 billion | $12 billion | 31% |

*Source: Kunreuther and Michel-Kerjan (2009).*

The analyses reveal that mitigation has the potential to significantly reduce losses from future hurricanes. The reductions range from 61 percent in Florida for a hundred-year return-period loss to 31 percent in Texas for a five-hundred-year return-period loss. In Florida alone, mitigation reduces losses by $51 billion for a hundred-year event and $83 billion for a five-hundred-year event. These findings are important given the costly capital needed to cover the tail of the distribution of extreme events. Adoption of mitigation measures on residential structures significantly reduces this tail in each of these four states.

The challenge, however, lies in making sure that residents in hazard-prone areas invest in these mitigation measures. Indeed, recent extreme events have highlighted this challenge, and have led one of us to identify the *natural disaster syndrome* as a common phenomenon (Kunreuther 1996). The phenomenon has the following features: homeowners, private businesses, and public-sector organizations fail to voluntarily adopt cost-effective loss-reduction measures. Thus they are highly vulnerable and unprepared should a severe hurricane or other natural disaster occur. But the magnitude of the destruction following a catastrophe often leads governmental agencies to provide disaster relief to victims—even if prior to the event the government claimed that it would not do so. This combination of underinvestment in protection prior to the catastrophic event, together with taxpayer financing of part of the recovery following it, can be critiqued on both efficiency and equity grounds.

There are a range of informal mechanisms that explain this natural disaster syndrome. One relates to framing the problem imperfectly: while experts focus on an event's likelihood and consequences in determining risk, several studies show that individuals rarely seek out probability estimates in making decisions. When these data are given to decision makers, they are often not taken into account. In one study, researchers found that only 22 percent of subjects sought out probability information when evaluating several risky managerial decisions. (Huber et al 1997). People have particular difficulty dealing with probabilistic information for small-likelihood events and generally need a context in which to evaluate the likelihood of an event occurring. For example, they have a hard time gauging how concerned to feel about a 1 in 100,000 probability of death without some comparison points. Most people just do not know whether 1 in 100,000 is a large risk or a small risk. In one study, individuals could not distinguish the relative safety of chemical plants whose annual chance of experiencing a catastrophic accident varied from 1 in 10,000 to 1 in 1 million (Kunreuther, Novemsky, and Kahneman 2001).

There is also evidence that firms and residents tend to ignore risks whose subjective odds are seen as falling below some threshold. Prior to a disaster, many individuals perceive its

likelihood as sufficiently low that they contend *it will not happen to me* (probability neglect). As a result, they do not feel the need to invest voluntarily in protective measures, such as strengthening their house or buying insurance. After the disaster occurs, however, these same individuals express remorse that they didn't undertake protective measures.

Another reason that individuals do not invest in protective measures is that they are highly myopic and tend to focus only on short-term returns—that is, only on those that occur over the next couple of years. In addition, there is extensive experimental evidence showing that temporal discounting tends to be hyperbolic, so that events in the distant future are disproportionately discounted relative to immediate ones. As an example, people are willing to pay more to hasten the receipt of a cash prize from tomorrow to today than from two days from now to tomorrow (Loewenstein and Prelec 1991). The implication of hyperbolic discounting for mitigation decisions is that residents will be reluctant to invest a tangible fixed sum now to achieve a future benefit: that benefit is instinctively undervalued—and is one that no one hopes ever to see at all. The effect of placing too much weight on immediate considerations is that the upfront costs of mitigation will loom disproportionately large relative to the delayed expected benefits in losses over time.[12]

There is extensive evidence that residents in hazard-prone areas do not undertake loss-prevention measures voluntarily. A 1974 survey of more than a thousand California homeowners in earthquake-prone areas revealed that only 12 percent of the respondents had adopted any protective measure (Kunreuther et al. 1978). Fifteen years later, there was little change despite 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 reported adopting any loss reduction measures (Palm et al., 1990). Burby et al. (1988) and Laska (1991) found similar reluctance by residents in flood-prone areas to invest in mitigation measures.

In the case of flood damage, Burby (2006) provides compelling evidence that actions taken by the federal government, such as constructing levees, tend to give residents a false sense of security, since they would still be in harm's way should the levee be breached or overtopped. This problem is intensified by local public officials who do not enforce building codes or who fail to restrict development in high-hazard areas. If developers do not design homes resistant to disasters, and individuals do not voluntarily adopt mitigation measures, one can expect large-scale losses following a catastrophic event, as evidenced by the property damage to New Orleans caused by Hurricane Katrina.

Even after the devastating 2004 and 2005 hurricane seasons, a large number of residents in high-risk areas had still not invested in relatively inexpensive loss-reduction measures, 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 had taken no steps to fortify their home, 68 percent had no hurricane survival kit, and 60 percent had no family disaster plan. (Goodnough 2006). The failure of many homeowners to voluntarily invest in cost-effective mitigation measures or purchase adequate insurance coverage should not simply be considered irrational. As we just discussed, people might have their own reasons for not taking these actions until after the next disaster occurs. The way in which our proposal –the development of long-term insurance contracts– could address these issues is explored below.

## A New Concept: The Development of Long-Term Insurance Contracts

[12] For a more detailed discussion of the reasons why individuals do not invest in cost-effective mitigation measures see Kunreuther, Meyer and Michel-Kerjan (in press).

To overcome some of the behavioral tendencies described above it is important to develop an incentive system so individuals will want to invest in risk reduction measures. We propose a move from the standard one-year insurance contracts (for homeowners' insurance and flood insurance for residential properties) to long-term insurance (LTI) as a way of dealing with individuals' tendency to be myopic in their thinking.[13] Doing so would be in the interest of homeowners as well as the country as whole. Because some insurers have recently restricted the sale of new homeowners' policies (which cover wind damage, but not flood losses) in hurricane-prone areas, policyholders cannot help but worry that their existing coverage might be subject to unexpected cancellation or very significant premium increases, particularly if there is severe hurricane damage in the near future.

**Need for Long-Term Insurance.** Short-term insurance policies foster significant social costs. Evidence from recent disasters reveals that consumers who fail to adequately protect their homes and/or even insure them, create a welfare cost to themselves and a possible cost to all taxpayers in the form of government disaster assistance. Under the current U.S. system, the governor of the affected state(s) can request that the president declare a "major disaster" and offer special assistance if the damage is severe enough. The number of presidential disaster declarations has dramatically increased over the past fifty years: there were 162 over the period 1955–1965, 282 over 1966–1975, 319 over 1986–1995, and 545 over 1996–2005 (Michel-Kerjan 2008).

The development of LTI should encourage individuals to invest in cost-effective mitigation measures. As pointed out above, many homeowners are unwilling to incur the high upfront cost associated with these investments relative to the small premium discount—reflecting the expected reduction in annual insured losses—that they would receive the following year. If an LTI policy were coupled with a long-term home-improvement loan tied to the mortgage, the reduction in insurance premiums would exceed the annual loan payment. The social welfare benefits of LTI coupled with long-term mitigation loans over $N$ years could be significant: there will be less damage to property, lower costs to insurers for protecting against catastrophic losses, more secure mortgages, and lower costs to the government for disaster assistance.

**Why a Market for Long-Term Insurance Does Not Exist Today.** In his seminal work on uncertainty and welfare economics, Kenneth Arrow defined "the absence of marketability for an action which is identifiable, technologically possible and capable of influencing some individuals' welfare . . . as a failure of the existing market to provide a means whereby the services can be both offered and demanded upon the payment of a price" (Arrow 1963, p.945). Here we shall discuss several factors which have contributed to the nonmarketability of LTI for protecting homeowners against losses from fire, theft, and large-scale natural disasters. We discuss elements which affect both the supply and demand sides.

*Supply Side.* Today, political pressure frequently causes insurance rates to be artificially low in hazard-prone areas. The result is that the risks most subject to catastrophic losses also become the most unattractive for insurers to market. A second stumbling block, derived from premium regulation, is that insurers are unclear about how much they will be allowed to charge in the future. Uncertainty regarding costs of capital and changes in risk over time may also deter

[13] This section draws heavily on Jaffee, Kunreuther, and Michel-Kerjan (2008).

insurers from providing long-term insurance. In principle, of course, insurers could add a component in their premiums to account for the costs created by these factors. The problem is that the insurance regulator, presumed to be representing consumers' interests, may not allow these costs to be embedded in the approved premiums. A new and less intrusive format for government regulation of insurance markets may be required if the private sector is to be successful in dealing with time-varying risks and capital costs.

Insurers might also be concerned about possible changes in the level of risk over time. For example, global warming could trigger more intense weather-related disasters, and/or local environmental degradation might change the risk landscape in the next several decades. One way to address this concern would be to have renegotiable contracts on a regular basis (e.g., every five years) based on new information validated by the scientific community in much the same way that there are renegotiable loans with adjustable rates.

*Demand Side.* Some homeowners, particularly those contemplating an LTI contract, may worry about the financial solvency of their insurer over a long period. Consumers might also fear being overcharged if insurers set premiums that reflect the uncertainty associated with long-term risks. Thus those who have not suffered a loss for ten years but have a twenty-five-year LTI may feel that the premiums are unfairly priced. It is therefore essential that the design of an LTI contract anticipate these concerns and be transparent to the policyholder.

**Developing an LTI Policy.** To compare the expected benefits of annual vs. LTI contracts, Jaffee, Kunreuther, and Michel-Kerjan (2008) have developed a simple two-period model in a competitive market setting where premiums reflect risk. The authors show that an LTI policy reduces the marketing costs for insurers compared with one-period policies, and also reduces the search costs to consumers if their insurer decides to cancel the policy at the end of period 1. If the policyholder is permitted to cancel an LTI policy at the end of period 1 on learning that the cost of a one-period policy is low enough to justify paying a cancellation cost ($C$), then it is always optimal for the insurer to offer an LTI policy, and for a consumer to purchase one. The insurer will set $C$ at a level which enables it to break even on those policies that are canceled before the maturity date.

We should note that in developing any type of LTI policy to be marketed by the private sector, premiums need to reflect risk (principle 1). Permitting insurers to charge prices that enable them to break even will give them incentives to develop new products. Under the current state-regulated arrangements, where many insurance commissioners have limited insurers' ability to charge risk-based premiums in hazard-prone areas, no insurance company would even entertain the possibility of marketing an LTI policy. Insurers would be concerned about the regulator clamping down on them now or in the future regarding what price they could charge, so that a long-term contract would be infeasible from a financial point of view.

## A Natural Candidate for Long-Term Insurance: Flood Insurance through the National Flood Insurance Program

Given the existing tension between state insurance regulators and the insurance industry, we feel that it would be best politically to introduce LTI by focusing on flood insurance, which is provided by the federal government in the United States.[14] The National Flood Insurance

[14] For more details on the National Flood Insurance Program, see the chapter by Mark Browne and Martin Halek in this volume.

Program (NFIP) was created in 1968 because insurers viewed flood risk as uninsurable and refused to cover it. As of December 2008, the NFIP sold over 5.5 million policies (compared to 2.5 million in 1992) and covered nearly $1.2 trillion in assets (compared to only $237 billion in 1992; nominal) (Michel-Kerjan and Kousky, 2009). Given that the NFIP is up for renewal in Congress, there may be a window for change in the coming months.

It would be useful to consider whether one could make flood insurance policies long-term by tying them to mortgages. Such a program would connect insurance directly to the property, rather than to the homeowner. If a homeowner moved to another location, the flood insurance policy would remain with the property. One might also consider *requiring* everyone in flood-prone areas to take out the insurance, just as those who own a car are required to take out automobile insurance.

**Why Have a Long-Term Flood Insurance Policy?** A long-term flood insurance program would offer homeowners currently residing in flood-prone areas a fixed rate for a fixed period of time (e.g. five, ten, or twenty years), or an adjustable rate based on a risk index re-evaluated regularly. If the homeowner moved away from the area before the end of the policy period, then the insurance policy would automatically be transferred to the new property owner at the same rate. For those homeowners who were being charged subsidized premiums because their homes were constructed before their community joined the NFIP, these prices would be maintained for the length of the policy period. For homeowners living in houses constructed after their community joined the program, premiums would be actuarially based.

From the perspective of the relevant stakeholders—homeowners, FEMA, banks and other financial institutions, and the taxpayer—there are a number of reasons why such long-term flood insurance policies would be a great improvement over the current annual policies. Flood insurance premiums set at a fixed price would provide homeowners with financial stability.

Long-term flood insurance would also assure the spread of risk within the program, since most homeowners in flood-prone areas would be covered. If flood insurance were required for all homeowners residing in hazard-prone areas, then there would be even a larger spread of risk. This type of requirement would provide much-needed financial revenue for the program over time because it would create a much larger policy base than is currently available.

Long-term policies would prevent another practice among homeowners in high-flood-risk areas, the cancellation of policies after a long period without a flood. This practice occurs even where individuals are required to purchase the policy as a condition for obtaining a federally insured mortgage: banks and financial institutions have often failed to enforce this requirement, first because few of them are ever fined, and second because the mortgages are often transferred to banks in non-flood-prone regions of the country, where there is less awareness of either the flood risk or the requirement that homeowners may have to purchase this coverage. Consider the flood in August 1998 that damaged property in northern Vermont. Of the 1549 victims of this disaster, FEMA found that 84 percent of the homeowners in Special Flood Hazard Areas (SFHAs) did not have insurance, even though 45 percent of these individuals were required to purchase this coverage (Tobin and Calfee 2005).

If long-term loans for mitigation were offered by banks, then individuals with long-term flood insurance policies would have a financial incentive to invest in cost-effective risk-reduction measures. To highlight this point, consider the following simple example. Suppose a property owner could invest $1,500 to floodproof his home so as to reduce by $30,000 the water damage from a future flood or hurricane with an annual probability of 1 in 100. The NFIP should

be willing to reduce the annual premium by $300 (i.e., 1/100 x $30,000) to reflect the lower expected losses that would occur if a flood or hurricane hit the area in which the policyholder was residing. If the house was expected to last for ten or more years, the net present value of the expected benefit of investing in this measure would exceed the upfront cost at an annual discount rate as high as 15 percent.

Today, many property owners would be reluctant to incur the $1,500 expenditure. If they focused on short-term benefits and underweighted the future, as so many tend to do, they would see that the expected discounted benefits—$300 dollars off the policy next year—are less than the $1,500 upfront costs. In addition, budget constraints could discourage them from investing in the mitigation measure, as could uncertainty about how long they will reside in the house and/or whether their premium will be reduced when they renew their policy. There may also be a failure to appreciate the structural interdependencies associated with floods, earthquakes, and other disasters—specifically, the fact that mitigation measures not only reduce the potential losses to one's own property but may alleviate damage to neighboring structures.

If a twenty-year flood insurance policy were tied to the property, then the homeowner could take out a twenty-year home-improvement loan of $1,500 linked to the mortgage at an annual interest rate of 10 percent, resulting in payments of $145 per year. If the insurance premium was reduced by $300, the annual savings to the homeowner would be $155.[15] A bank would have a financial incentive to provide this type of loan, which would help to protect it against a catastrophic loss to the property. The NFIP would have an incentive to offer LTI contracts, which would reduce its potential losses from a major disaster by balancing its portfolio over time. The general public would approve an LTI policy since it would be less likely that large amounts of their tax dollars would be needed for disaster relief. These new financial products thus benefit everyone involved.

## Conclusion

Since the 1990s, we have witnessed a series of large-scale catastrophes that have inflicted historic economic and insured losses. Fourteen of the twenty five most costly insured catastrophes worldwide between 1970 and 2008 occurred after 2001, and all were natural disasters except for the 9/11 terrorist attacks. The U.S. has been particularly challenged because twelve of these disasters occurred in this country. The growing concentration of population and structures in high-risk areas, combined with the potential consequences of global warming, are likely to lead to even more devastating catastrophes in the coming years unless cost-effective risk-reduction measures are put in place.

The challenge facing the United States, and many other countries, is how to prevent the natural disaster syndrome. The government must encourage residents and businesses to invest in loss-reduction measures and insurance before a disaster so that the government can avoid large-scale disaster relief afterwards. The fact remains that even when risk-reduction measures are available and are cost-effective, many people still do not invest in them. In the aftermath of Hurricane Katrina, many victims suffered severe losses from flooding because they had not undertaken loss mitigation and did not have flood insurance to cover the resulting damage to their home. As a result, an unprecedented level of federal disaster assistance was provided to these victims and the affected communities.

[15] Alternatively, this loan could be incorporated into the mortgage at even a lower interest rate than 10 percent.

There are many reasons why those in harm's way do not undertake protective measures in advance of disaster. Many individuals believe that the event will not happen to them. In the case of New Orleans, some residents may have felt that they were fully protected by flood-control measures such as the levees.[16] This mistaken belief has led to increased development in hazard-prone areas without appropriate land-use regulations and well-enforced building codes. In addition, budget constraints and short time horizons may limit people's ability and willingness to invest in hazard-mitigation measures and to purchase insurance. Such a dynamic has been observed in many countries around the world.

We propose a new initiative that could address these issues: long-term insurance contracts coupled with long-term home improvement loans that would incentivize homeowners to adopt cost-effective mitigation measures and provide them with stable financial protection over time. Given the potential difficulties of implementing such a program today because insurance regulators in many states do not allow insurers to set premiums that reflect risk, we believe that the federally-run flood insurance would be a natural first candidate for such a long-term program. With the NFIP up for renewal in the coming months, there may be political will to develop more effective solutions that involve long-term insurance contracts and long-term loans for mitigation.

The quote from the 2007 Economic Report of the President introducing this chapter that argues for premiums that reflect underlying economic costs so as to encourage a more efficient allocation of resources. We support this key concept by advocating that premiums should reflect risk (Principle 1) but also feel that one has to address equity issues by providing grants from the public sector to those deserving special treatment who currently reside in hazard-prone areas (Principle 2). There is an opportunity for the Obama administration and the U.S. Congress to heed these two principles and take steps now to reduce losses resulting from catastrophic events so we more effectively manage large-scale risks in a new era of catastrophes.

[16] FEMA clearly thought that the levees would provide this protection. Otherwise they would have designated the Lower Ninth Ward as a flood -prone area, and residents would have been eligible to purchase insurance under the NFIP.

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