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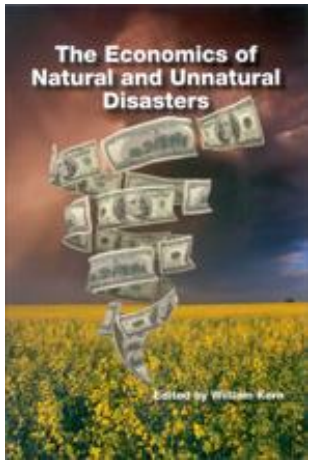

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2
Market and Government Failure in Insuring and Mitigating Natural Catastrophes

How Long-Term Contracts Can Help

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> *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.*
>
> —Council of Economic Advisers (2007)[1]

Given the hundreds of billions of dollars in economic losses due to catastrophes in the United States since 2001, it is difficult to realize that when Hurricane Hugo hit the country in 1989, it was the first catastrophe to inflict more than $1 billion in insured losses. But times have changed because of a series of unprecedented large-scale natural disasters in the United States during the past few years. Times have changed because of the increased terrorism threat worldwide, including the potential for nuclear attacks. Times have changed because of the possibility of international pandemics and world cyber-failure, and because of the financial crises we are currently experiencing. In other words, we have entered a new era of catastrophes.

While all of the above risks are different in character, they share two important features: 1) uncertainty regarding their occurrence and 2) 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, in developing strategies for reducing future losses, and in facilitating the recovery process following a major catastrophe.

As for natural disasters, the world has experienced large-scale losses and fatalities because of 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 country's recorded history. The same month, the Great Sichuan Earthquake in China is estimated to have killed nearly 70,000 people, injured 374,000, and made almost 5 million homeless (Munich Re 2008). Deaths from the Haitian earthquake in January 2010 are estimated at 200,000 (European Commission 2010).

But even in a developed country like the United States, which has both extensive experience with natural catastrophes and the resources to adequately prepare for them, the 2004 and 2005 hurricane seasons demonstrated a lack of adequate loss reduction measures and emergency preparedness capacity to deal with large-scale natural disasters. 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 record number for the country. Economic damages were estimated in the range of $150 billion to $200 billion.

After two relatively quiet hurricane seasons in 2006 and 2007 in the United States, a series of hurricanes made landfall in 2008, causing 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 $16 billion, followed by Hurricane Gustav, with insured losses estimated at $4 billion. Based on these figures, Hurricane Ike ranks as the third most devastating weather-related disaster in U.S. history, after Hurricane Katrina and Hurricane Andrew, which hit southeast Florida in August 1992 (Swiss Re 2008).

These recent catastrophes highlight the challenges of mitigating the effects of natural disasters and financing recovery from them, issues that are now high on the business and policy agendas of many countries. The question is not whether other large-scale catastrophes will occur, but when and how frequently they will strike, and the extent of the damage and 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. It is important for us to take a longer-term view of these issues, given the tendency of individuals to be myopic in their thinking and to misperceive risks. A coherent strategy is necessary to ensure a sustainable recovery from large-scale disasters and the appropriate future development of hazard-prone areas. But these issues are complex. They challenge our capacity as a nation to work together despite different agendas of key stakeholders and legislators regarding the role and responsibilities of the private and public sectors in dealing with catastrophic risks. Absence of leadership in this area will inevitably lead to unnecessary loss of lives and economic destruction in the devastated regions.

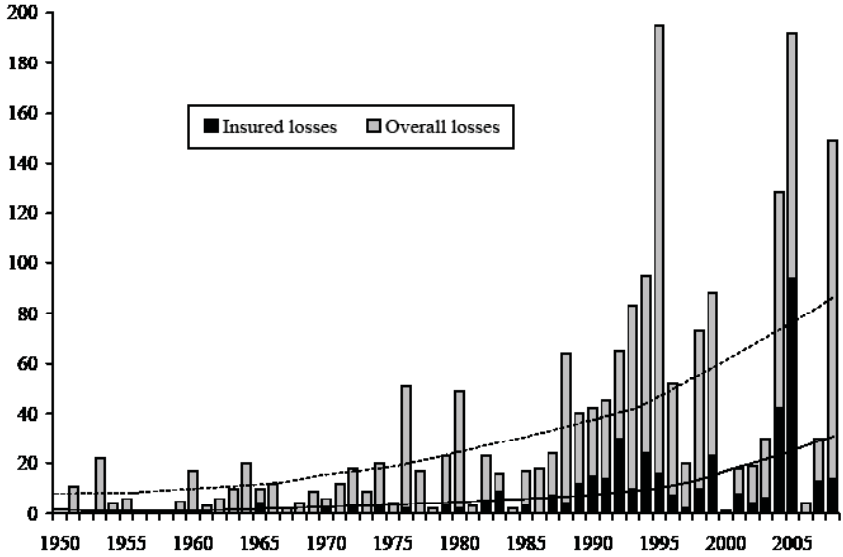
This chapter complements other analyses in this volume by focusing on the risk of large-scale natural disasters, although we believe the concepts and proposals for managing these risks more effectively have relevance to other types of extreme events such as terrorism and catastrophic accidents.[2] The chapter is organized as follows: in the next section we discuss the evolution over the past four decades of economic and insured losses due to major catastrophes and the key drivers of this change. We then propose four guiding principles for developing sustainable insurance and mitigation programs and analyze the behavioral biases, notably myopia, that discourage individuals from investing in cost-effective protective measures. To overcome these biases, we propose long-term insurance contracts combined with long-term loans. We then demonstrate how the National Flood Insurance Program is a natural candidate for these contracts. The chapter concludes with a brief summary and suggestions for future research.

A NEW ERA OF CATASTROPHES

Recent Changes in the Impacts of Extreme Events

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 2.1. (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, losses totaled $620.6 billion, principally as a result of the 2004, 2005, and 2008 hurricane seasons, which wrought historic levels of destruction.

Figure 2.1 Evolution of Great Natural Catastrophes Worldwide, 1950–2008



NOTE: In billions of U.S. dollars, indexed to 2008. Dotted line indicates trend in overall losses. Solid line indicates trend in insured losses.

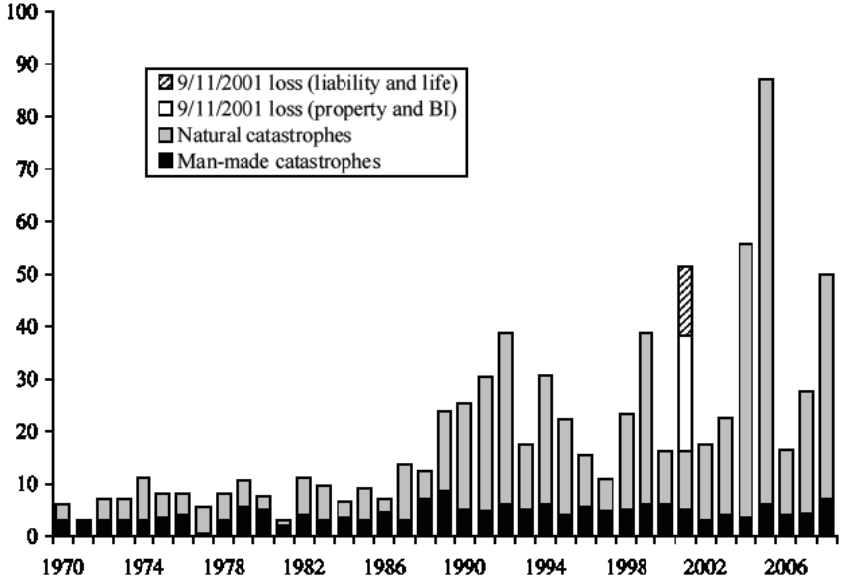
SOURCE: Munich Re (2009a).

Catastrophes have had a more devastating impact on insurers since 1990 than in the entire history of insurance. 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 $4 billion (in 1989 dollars). There was a radical increase in insured losses in the early 1990s, as Hurricane Andrew struck Florida ($23.7 billion in 2007 dollars) and the Northridge earthquake hit California ($19.6 billion in 2007 dollars). The four hurricanes that struck Florida in 2004 (Charley, Frances, Ivan, and Jeanne) collectively totaled almost $33 billion in insured losses. Hurricane Katrina alone cost insurers and reinsurers an estimated $46 billion, and total losses paid by private insurers resulting from major natural catastrophes in 2005 reached $87 billion.[3] Figure 2.2 depicts the upward trend in worldwide insured losses from catastrophes between 1970 and 2008.[4]

Table 2.1 reveals the 25 most costly insured catastrophes from 1970 to 2008 (in 2008 dollars). Of these 25 major events, 14 occurred after 2001, and 12 of happened in the United States. Hurricane Andrew and the Northridge earthquake were the first two catastrophes that the industry experienced with losses greater than $10 billion (designated as super-cats), and they 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 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 of the events in the top 25 were natural disasters. More than 80 percent of these were weather-related events—hurricanes and typhoons, storms, and floods—and nearly three-quarters of the claims were made 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 25 years, only 1988 and 1997 had insured losses lower than those in 2006. According to Munich Re (2008), there were 960

Figure 2.2 Worldwide Evolution of Catastrophe-Insured Losses, 1970–2008



NOTE: Man-made catastrophes include major fires and explosions (e.g., in a chemical plant or refinery), aviation/rail/shipping-related losses (fires, crashes, collisions), mining accidents, and collapse of infrastructure. The bar for 2001, because it includes the terrorist attacks of 9/11, is broken down into two additional categories that represent all the various types of insurance, including not only liability and life but also property and business interruption (BI). Losses are shown in billions of U.S. dollars indexed for 2007, except for 2008, which is current.

SOURCE: Wharton Risk Center, with data from Swiss Re and the Insurance Information Institute.

natural catastrophes in 2007, the most since 1974. They inflicted nearly $27 billion in insured losses. Swiss Re estimates that insured losses soared to $50 billion for the industry in 2008, making it one of the three costliest years ever. Natural catastrophes accounted for $43 billion of these losses, with man-made disasters making up the remaining $7 billion (Swiss Re 2008). In 2009, insured losses from catastrophes amounted to $22 billion, a lower figure due to a very benign North Atlantic hurricane season (Munich Re 2009b).

The occurrence of damaging hurricanes is highly variable and uncertain from year to year. However, it is almost certain that in the coming years more catastrophic 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) and earthquakes, causing extreme damage to residential and commercial property and infrastructure.

There is a very clear message from these data. Only 20 or 30 years ago, large-scale natural disasters were considered low-probability events. Today, not only are they causing considerably greater economic losses than in the past, they also appear to be occurring at an accelerating pace. In this context, it is important to understand more fully the factors influencing these changes so as to design more effective programs for reducing losses from future disasters.

The Question of Attribution

At least two principal socioeconomic factors directly influence the level of economic losses due to catastrophic events: 1) degree of urbanization and 2) value at risk. 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 (2004) 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 United States 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 and Atmospheric Administration (NOAA). And the nation's coastal population is expected to increase by more than 12 million by 2015 (Crossett et al. 2004).[5] Yet coastal counties, excluding Alaska, account for only 17 percent of the land area in the United States.

In hazard-prone areas, this urbanization and increase of population also translates into greater concentration of exposure and hence a higher likelihood of catastrophic losses from future disasters. Insurance density is another critical socioeconomic factor to consider when evaluating the evolution of insured loss due to weather-related catastrophes. These factors will continue to have a major impact on the level of insured

Table 2.1 The 25 Most Costly Insured Catastrophes in the World, 1970–2008

Event	$ billions	Victims (dead or missing)	Year	Area of primary damage
Hurricane Katrina	48.1	1,836	2005	U.S., Gulf of Mexico, et al.
9/11 attacks	36.8	3,025	2001	U.S.
Hurricane Andrew	24.6	43	1992	U.S., Bahamas
Northridge earthquake	20.3	61	1994	U.S.
Hurricane Ike	17.6	348	2008	U.S., Caribbean, et al.
Hurricane Ivan	14.6	124	2004	U.S., Caribbean, et al.
Hurricane Wilma	13.8	35	2005	U.S. , Gulf of Mexico, et al.
Hurricane Rita	11.1	34	2005	U.S., Gulf of Mexico, et al.
Hurricane Charley	9.1	24	2004	U.S., Caribbean, et al.
Typhoon Mireille	8.9	51	1991	Japan
Hurricane Hugo	7.9	71	1989	Puerto Rico, U.S., et al.
Winter Storm Daria	7.7	95	1990	France, UK, et al.
Winter Storm Lothar	7.5	110	1999	France, Switzerland, et al.
Winter Storm Kyrill	6.3	54	2007	Germany, UK, the Netherlands, France
Storms and floods	5.9	22	1987	France, UK, et al.

Hurricane Frances	5.8	38	2004	U.S., Bahamas
Winter Storm Vivian	5.2	64	1990	Western/Central Europe
Typhoon Bart	5.2	26	1999	Japan
Hurricane Gustav	5.0	153	2008	U.S., Caribbean, et al.
Hurricane Georges	4.7	600	1998	U.S., Caribbean
Tropical Storm Allison	4.4	41	2001	U.S.
Hurricane Jeanne	4.4	3,034	2004	U.S., Caribbean, et al.
Typhoon Songda	4.0	45	2004	Japan, South Korea
Storms	3.7	45	2003	U.S.
Hurricane Floyd	3.6	70	1999	U.S., Bahamas, Columbia

NOTE: Dollar amounts are indexed to 2008.
SOURCE: Kunreuther and Michel-Kerjan (2009), with data from Swiss Re (2009) and the Insurance Information Institute in New York.

losses from natural catastrophes. Given the growing concentration of exposure on the Gulf Coast, another hurricane like Katrina hitting that area is likely to inflict significant property damage unless strong mitigation measures are put in place.[6]

In order to better understand this new vulnerability, it is possible to calculate the total direct economic cost of the major hurricanes in the United States in the past century, adjusted for inflation, population, and wealth normalization. More specifically, one can estimate what each of these hurricanes would have cost had it hit today. This exercise has been done in several studies. The most recent one, by Pielke et al. (2008), normalizes to the year 2005 mainland U.S. hurricane damage for the period 1900–2005.

Table 2.2 provides estimates for the top 20 most costly hurricanes if they had occurred in 2005, using two approaches for normalizing these losses, each of which gives a cost estimate. The table indicates the range of costs provided by these two estimates, the year the hurricane occurred, the states that were most seriously affected, and the hurricane category on the Saffir-Simpson scale. The data reveal that the hurricane that hit Miami 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 value located in risk-prone areas.

There is another element to consider in determining how to adequately manage and finance catastrophic 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 2.2 Top 20 Hurricane Scenarios, Ranked Using 2005 Inflation, Population, and Wealth Normalization (1900–2005)

Rank	Hurricane	Year	Category	Cost range ($ billion) in 2005
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	4 (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: Data from Pielke et al. (2008).

Numerous discussions and scientific debates have centered on whether the series of major hurricanes in 2004 and 2005 might be partially attributable to the impact of a change in climate.[7] One of the expected effects of global warming is an increase in hurricane intensity. This 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. The results to date raise issues with respect to the insurability of weather-related catastrophes, given that 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 much larger number of residences and commercial buildings today than in the 1940s.

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

GUIDING PRINCIPLES FOR MITIGATING AND INSURING AGAINST CATASTROPHES

To help ascertain the roles the private and public sectors can play in addressing these issues, we propose the following four guiding principles for using the insurance infrastructure to deal more effectively with natural disasters:

Principle 1—Premiums should reflect risk. Insurance premiums should be based on risk in order to provide signals to individuals as to the hazards they face and to encourage them to engage in cost-effective mitigation measures to reduce their vulnerability to catastrophes. Risk-

based premiums should also reflect the cost of capital that insurers need to integrate into their pricing to ensure adequate return to their investors.

The application of Principle 1 provides a clear signal of likely damage to those currently residing in areas subject to natural disasters and those who are considering moving into these regions. Risk-based premiums would also enable insurers to provide discounts to homeowners and businesses that invest in cost-effective loss-reduction mitigation measures. If insurance premiums are not risk-based, insurers have no economic incentive to offer these discounts. In fact, they prefer not to offer coverage to these property owners because it is a losing proposition in the long run.

Principle 2—Deal with equity and affordability issues. Any special treatment given to homeowners currently residing in hazard-prone areas (e.g., low-income uninsured or inadequately insured homeowners) should come from general public funding and not through insurance premium subsidies.

Principle 2 reflects a concern for some residents in high-hazard areas who will be faced with large premium increases if insurers are permitted to 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.

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—Have sufficient demand for coverage. The demand by individuals and firms for insurance coverage with risk-based premiums should be sufficiently high that insurers can cover the fixed costs of introducing a program for providing coverage and spreading 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—Minimize likelihood of insolvency. 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 level.

Insurance regulators should play an important role in ensuring 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

How effective can mitigation be in reducing exposure to future disaster? To shed some light on this question, we undertook an analysis of 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 we consider two extreme cases: one in which no one has invested in mitigation, and one in which everyone has invested in predefined mitigation measures. From the U.S. Hurricane Model developed by the catastrophe modeling firm Risk Management Solutions, losses were calculated on a ground-up and gross basis, assuming an appropriate mitigation measure across the insured portfolio. The mitigation measures were selected based on various assumptions for the different regions. For example, in Florida, the requirements were those defined by the Institute for Business and Home Safety's "Fortified . . . for safer living" program. As this program is only for new construction, when we describe an analysis using these recommendations, it is the retrofit techniques that are aligned with the features of the Fortified program. In New York, South Carolina, and Texas, mitigation means the application of the latest building codes to the residential structures.[8]

Table 2.3 indicates the differences in losses and savings from adoption of mitigation measures for hurricanes with return periods of 100,

Table 2.3 Money Saved in Reduced Losses from Full Mitigation for Different Return Periods

	100-year event			250-year event			500-year event		
State	Unmitigated losses ($ billions)	Savings in reduced losses from mitigation ($ billions)	Savings in reduced losses from mitigation (%)	Unmitigated losses ($ billions)	Savings in reduced losses from mitigation ($ billions)	Savings in reduced losses from mitigation (%)	Unmitigated losses ($ billions)	Savings in reduced losses from mitigation ($ billions)	Savings in reduced losses from mitigation (%)
FL	84	51	61	126	69	55	160	83	52
NY	6	2	39	13	5	37	19	7	35
SC	4	2	44	7	3	41	9	4	39
TX	17	6	34	27	9	32	37	12	31

SOURCE: Kunreuther and Michel-Kerjan (2009).

250, and 500 years for each of the four states we are studying when these loss-reduction measures are in place. The analyses reveal that mitigation has the potential to reduce losses from future hurricanes by amounts ranging from 61 percent in Florida for a 100-year return period loss, to 31 percent in the state of Texas for a 500-year return period loss. In Florida alone, the use of mitigation leads to a $51 billion reduction in losses for a 100-year event and $83 billion for a 500-year event. These findings are important given the cost of capital needed to cover the tail of the distribution of extreme events. Adoption of mitigation measures on residential structures significantly reduces, if not eliminates, this tail in each of these four states.

The challenge, however, lies in making sure residents in hazard-prone areas invest in these mitigation measures. Indeed, recent extreme events have highlighted the challenges associated with reducing losses from hurricanes and other natural hazards due to what one of us has termed the natural disaster syndrome (Kunreuther 1996). Many homeowners, private businesses, and public sector organizations in hazard-prone areas do not voluntarily adopt cost-effective loss-reduction measures, making these areas highly vulnerable and unprepared should a severe hurricane or other natural disaster occur. 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 had no intention of doing so. This combination of underinvestment in protection prior to the catastrophic event and partial financing of the recovery by the general taxpayer can be critiqued on both efficiency and equity grounds.

A range of informal mechanisms explain this natural disaster syndrome. One relates to framing the problem imperfectly: experts focus on the likelihood and consequences as two key elements of the risk. Several studies show, however, that individuals rarely seek out probability estimates in making their decisions. When these data are given to them, decision makers often do not use the information. In one study, researchers found that only 22 percent of subjects sought out probability information when evaluating several risky managerial decisions. People have particular difficulty dealing with probabilistic information for small-likelihood events. They need a context in which to evaluate the likelihood of an event occurring. 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 a chemical plant that had an annual chance of experiencing a catastrophic accident that 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 won't happen to me." As a result, they do not feel the need to invest voluntarily in protective measures, such as strengthening their houses or buying insurance. It is only after the disaster occurs that these same individuals express remorse that they didn't undertake protective measures.

Individuals also do not invest in protective measures because they are highly myopic and tend to focus on the returns for only the next couple of years. In addition, there is extensive experimental evidence showing that human 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 have the timing of the receipt of a cash prize accelerated from tomorrow to today than from the day after tomorrow to tomorrow (Loewenstein and Prelec 1991). The implication of hyperbolic discounting for mitigation decisions is that residents are expected to invest a tangible fixed sum now to achieve a future benefit that they instinctively undervalue—and that, paradoxically, they hope never 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 from loss mitigation over time.

Extensive evidence indicates that residents in hazard-prone areas do not undertake loss-prevention measures voluntarily. 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 measure (Kunreuther et al. 1978). 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 (Palm et al. 1990). Burby et al. (1988) and Laska (1991) have found a 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, make residents feel safe, when in fact they are still in harm's way should the levee be breached or overtopped. This problem is reinforced by local public officials who fail to enforce building codes or to impose land-use regulations to restrict development in high-hazard areas. If developers do not design homes to be 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 had still not invested in relatively inexpensive loss-reduction measures for their property, nor had they undertaken emergency preparedness measures. A survey of 1,100 adults living along the Atlantic and Gulf coasts conducted in May 2006 revealed that 83 percent of the responders had taken no steps to fortify their homes, 68 percent had no hurricane survival kit, and 60 percent had no family disaster plan (Goodnough 2006). As noted above, homeowners' failure to invest in cost-effective mitigation measures or to purchase adequate insurance coverage if not required to do so stems from behavioral and psychological biases. As a means to address these issues, we suggest the use of long-term contracts.

A NEW CONCEPT: THE DEVELOPMENT OF LONG-TERM INSURANCE CONTRACTS

We propose moving from the standard one-year insurance contracts for homeowners and flood insurance for residential properties to long-term insurance (LTI) to encourage property owners to invest in cost-effective mitigation measures.[9] In the case of homeowners coverage (which includes protection against the effects of wind damage, but

not flood losses), some insurers have recently restricted the sale of new homeowners policies 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 severe hurricane damage occurs 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 or even insure at all 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 a stricken state 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 50 years: there were 162 during the period 1955–1965, 282 during 1966–1975, 319 during 1986–1995, and 545 during 1996–2005 (Michel-Kerjan 2006).

The development of LTI should also encourage individuals to invest in cost-effective mitigation measures. As previously pointed out, many homeowners do not invest in such measures due to myopia and budget constraints. They are unwilling to incur the high upfront cost associated with these investments relative to the small premium discount they would receive the following year reflecting the expected reduction in annual insured losses (Kunreuther, Meyer, and Michel-Kerjan, forthcoming). If an LTI policy was coupled with a long-term home improvement loan tied to the mortgage, the reduction in insurance premiums would exceed the annual loan payment. LTI coupled with long-term mitigation loans over a number of years could yield significant social welfare benefits: less damage to property, reduction in costs of protection against catastrophic losses by insurers, more secure mortgages, and lower costs to the government for disaster assistance.

Why Does a Market for Long-Term Insurance 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). Here we shall discuss several factors that have contributed to the nonmarketability of LTI for protecting homeowners' property against losses from fire, theft, and large-scale natural disasters. We discuss elements that affect both the supply and demand sides.

Supply side

Today, due to political pressure, insurance rates are frequently restricted to be artificially low in hazard-prone areas, as illustrated by Florida's actions in recent years. As a result, the risks most subject to catastrophic losses also become the most unattractive for insurers. This premium regulation also results in a second stumbling block: insurers are uncertain 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 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. However, insurance regulators, presumed to be representing consumers' interests, may not allow these costs to be embedded in the approved premiums. Furthermore, it is unclear what the voluntary demand for coverage will be, given the resulting premiums. In a real sense, 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, or local environmental degradation might change the risk landscape in the next several decades. One way to address this concern would be to make contracts renegotiable at a specified interval based on new information validated by the scientific community, much like renegotiable loans with adjustable rates (e.g., every five years).

Demand side

Some homeowners may worry about the financial solvency of their insurers over a long period, particularly if they are concerned about being locked into an LTI contract. Consumers might also fear being overcharged if insurers set premiums that reflect the uncertainty associated with long-term risks. Furthermore, those who have not suffered a loss for 10 years but have a 25-year LTI may feel that the premiums are unfairly priced. It is thus essential that the design of an LTI contract anticipate these concerns and be transparent to the policyholder.

Developing an LTI Policy

Jaffee, Kunreuther, and Michel-Kerjan (2008) have developed a simple two-period model in a competitive market setting, where premiums reflect risk, to compare the expected benefits of annual contracts versus LTI. The authors show that an LTI policy reduces the marketing costs for insurers compared with single-period policies, and also reduces the search costs to consumers if their insurer decides to cancel its policy at the end of period 1. If an LTI policyholder can cancel at the end of period 1 on learning that the cost of a 1-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 the consumer to purchase one. The insurer will set C at a level that enables it to break even on those policies that are canceled before the maturity date. We should note that if one is going to develop any type of LTI policy that would be marketed by the private sector, then premiums need to reflect risk (Principle 1). If insurers can charge prices that enable them to break even, they will have incentives to develop new products. Under the current state regulatory 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 that the regulator would clamp 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 NFIP

Given the existing tension between state insurance regulators and the insurance industry, we feel that it is best politically to introduce LTI by focusing on flood insurance, since this coverage is provided by the federal government here in the United States. The National Flood Insurance Program (NFIP) was created in 1968 as a result of insurers' refusal to cover this risk because they viewed it as uninsurable. In 2007, the NFIP sold over 5.5 million policies (compared to 2.5 million in 1992) and covered over $1.1 trillion in assets (compared to only $237 billion in 1992). These figures were stable in 2008 (Michel-Kerjan and Kousky, forthcoming).

It would be useful to consider whether one could make flood insurance policies long-term by tying them to mortgages. This practice would connect insurance directly to the property, rather than to the homeowner. 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 today whether or not they are financing the purchase of their car. If a homeowner moved to another location, the flood insurance policy would remain with the property.

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., 5, 10, or 20 years). 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 being charged subsidized rates because their homes were constructed before their community joined the NFIP, these rates would be maintained for the length of the policy period. For homeowners who constructed homes after their community joined the program, rates would be actuarially based.

For a number of reasons, such a long-term flood insurance policy would be a great improvement over the current annual policies from the perspective of the relevant stakeholders: homeowners, the Federal

Emergency Management Agency (FEMA), banks and financial institutions, and the general taxpayer. Assigning a fixed rate to flood insurance would provide financial stability to homeowners. They would also know that they are protected against water damage from floods and hurricanes. This would reduce the legal problems that have stemmed from recent hurricanes (such as the Florida hurricanes of 2004, Katrina, and Ike).

Long-term flood insurance would also ensure the spread of risk within the program, since most homeowners in flood-prone areas would be covered. Requiring flood insurance for all homeowners residing in hazard-prone areas would provide an even larger spread of risk. This larger policy base would provide much-needed financial revenue for the program over time.

Long-term policies would prevent individuals from canceling their policies after they have not experienced a flood for several years. Some individuals currently do this even if they are required to hold the policy as a condition for a federally insured mortgage. The banks and financial institutions have often not enforced this regulation because few of them have been fined or because the mortgages are transferred to banks 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. Consider the flood in August 1998 that damaged property in northern Vermont. Of the 1,549 victims of this disaster, FEMA found 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 banks offered long-term loans for mitigation, individuals with long-term flood insurance policies would be encouraged to invest in cost-effective risk reduction measures. To highlight this point, consider the following simple example. Suppose a property owner's investment of $1,500 in floodproofing would 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 × $30,000) to reflect the lower expected losses that would occur if a flood or hurricane hit the area. If the house was expected to last for 10 or more years, the net present value of the expected benefit of invest-

ing in this measure would exceed the upfront cost at an annual discount rate as high as 15 percent.

In the current system, many property owners would hesitate to make the $1,500 expenditure, because they would get only $300 back next year and might consider the benefits over only the next few years when making their decisions. If they underweight the future, the expected discounted benefits would likely be less than the $1,500 upfront cost. In addition, budget constraints could discourage them from investing in the mitigation measure. Other considerations that could play a role in the decision not to invest in these measures include uncertainty as to how long the family will reside in the house and whether their insurer would reward them again when their policy is renewed. There may also be a failure to appreciate the interdependencies associated with floods, earthquakes, and other disasters. That is, investing in mitigation measures can reduce not only the potential losses to one's own property but the damage to neighboring structures.

If a 20-year flood insurance policy was tied to the property, then the homeowner could take out a 20-year, $1,500 home improvement loan 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 savings to the homeowner each year would be $155. Alternatively, this loan could be incorporated as part of the mortgage at an even lower interest rate than 10 percent.

Long-term insurance and mitigation loans would constitute new financial products. A bank would have a financial incentive to provide this type of loan, since it would be better protected against a catastrophic loss to the property, and the NFIP would know that its potential loss from a major disaster had been reduced. Moreover, this scenario would reduce the likelihood of large tax-dollar expenditures for disaster relief. Indeed, prior to the 2005 hurricane season, which inflicted nearly $18 billion in flood claims, the NFIP had a cumulative deficit of about $3 billion after 37 years of operation (Michel-Kerjan and Kousky, forthcoming). LTI thus offers a win-win situation for all.

CONCLUSION

Since the 1990s, a series of large-scale catastrophes have inflicted historic economic and insured losses. More than half of the 25 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 United States has been particularly challenged, since 12 of these 25 disasters for insurance 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 ascertaining how to encourage residents and businesses to invest in loss-reduction measures and insurance in advance of a disaster so as to avoid the need for large-scale governmental disaster relief after a catastrophe occurs. Indeed, even when risk reduction measures are available and are cost-effective, many people are still not investing in them. Following a disaster, government agencies provide assistance to the area. We term this the natural disaster syndrome.

Several instances of the natural disaster syndrome have occurred in recent years. In the aftermath of Hurricane Katrina, many victims suffered severe losses from flooding because they had not used mitigation measures in their homes and did not have flood insurance to cover the resulting damage. The affected individuals and communities consequently received an unprecedented level of federal disaster assistance. There are many reasons why those in harm's way have not undertaken 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 believed that they were fully protected by flood control measures such as the levees.[10] Such beliefs have led to increased development in hazard-prone areas without appropriate land-use regulations or properly enforced building codes. In addition, budget constraints and short time horizons may limit people's ability and desire 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 loans to encourage the adoption of cost-effective mitigation measures and provide stability to homeowners. Given the benefits and potential difficulties of implementing such a program, we conclude that flood insurance would be a natural candidate for such a long-term program. Given, too, that the NFIP is up for renewal in 2010, there may be the political will to develop more effective solutions.

There is an opportunity for the Obama administration and Congress to take steps now to reduce these losses and protect the nation against extreme events in a more systematic way than the government has to date. We need a more coherent national strategy for managing these risks in a new era of catastrophes.

Notes

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1. It is quite remarkable that 2007 was the first year that the *Economic Report of the President* devoted a chapter to catastrophic risk insurance.
2. For a detailed analysis on terrorism insurance by the authors, see Kunreuther and Michel-Kerjan (2004), Wharton Risk Center (2005), Michel-Kerjan and Pedell (2006), and Michel-Kerjan, Raschky, and Kunreuther (2010). For a detailed analysis of the question of natural disaster insurance and mitigation in the United States, see Kunreuther and Michel-Kerjan (2009).
3. This figure excludes payment by the U.S. National Flood Insurance Program (NFIP) for damage due to 2005 flooding (over $20 billion in claims).
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 difference between Figure 2.1 and Figure 2.2. 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.

5. These numbers vary depending on the definition of "coastal counties" one considers. The less restrictive definition, the one used for the figures in the text and applying to 53 percent of the U.S. population, includes lakes. Taking a more restrictive definition (i.e., any county that has a coastline bordering the open ocean or associated sheltered water bodies or a county that contains V zones—velocity flood zones, or areas likely to have floodwaters of great velocity—as defined by the National Flood Insurance Program), one still finds that the proportion of the population living in such counties is 30 percent (Crowell et al. 2007).
6. For additional data on the economic impact of future catastrophic hurricanes, see Rust and Killinger (2006), sec. 1:13–1:26.
7. For more details on the scientific evidence regarding climate change and its impact, see Stern (2007).
8. We are assuming that because these measures are incorporated in building codes they are cost-effective. In other words, the discounted long-term expected benefit from the mitigation measure over the projected life of the house is 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.
9. This section draws heavily on Jaffee, Kunreuther, and Michel-Kerjan (2008).
10. FEMA clearly thought that the levees would provide this protection. Otherwise it would have designated the Lower Ninth Ward as a hazard-prone area and residents would have been eligible for flood insurance.

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