

**Working Paper Series
Congressional Budget Office
Washington, D.C.**

Financing Losses from Catastrophic Risks

Kent Smetters
Wharton School
University of Pennsylvania
Smetters@wharton.upenn.edu

David Torregrosa
Macroeconomic Analysis Division
Congressional Budget Office
David.Torregrosa@cbo.gov

November 2008
CBO Working Paper 2008-09

Congressional Budget Office working papers in this series are preliminary and are circulated to stimulate discussion and critical comment. These papers are not subject to the Congressional Budget Office's formal review and editing processes. The analysis and conclusions expressed in them are those of the authors and should not be interpreted as those of the Congressional Budget Office. References in publications should be cleared with the authors. Papers in this series can be obtained at www.cbo.gov. Select "Publications" and then "Working Papers."

This particular paper is adapted from and expands a version published by the Hamilton Project at the Brookings Institution in June 2008 and available at www.brookings.edu/papers/2008/06_risks_smetters.aspx.

Financing Losses from Catastrophic Risks

Kent Smetters
David Torregrosa
November 2008

Abstract

Catastrophe insurance helps spread risks and increases the ability of policyholders and the economy to recover from both natural disasters and terrorist attacks. Government policies, however, may unintentionally limit the role of the private sector in insuring against catastrophic losses. Several such policies at both the state and the federal level reduce the amount of private capital supplied to insure or hedge against catastrophic risks. One reason is that those policies often become outdated as markets innovate. Policymakers have several different options to increase private risk-bearing capacity and improve the effectiveness of federal involvement. The benefits and potential costs of four options are examined: an optional federal charter for insurers that would preempt states' regulation of rates; regulatory reform of capital markets' risk transfer mechanisms that substitute for reinsurance; changes in the taxation of reserves held by insurers against catastrophic risks; and auctions of federal reinsurance for supercatastrophic risks.

Acknowledgments

The authors thank Jason Bordoff, Nada Eissa, Jason Furman, Robert Litan, Eric Mindich, and Timothy Taylor for their constructive comments on the drafts for the Hamilton Project. In addition, Manasi Deshpande, Pascal Noel, and Paige Shevlin, all of the Hamilton Project, provided useful feedback. Christine Roh provided excellent research assistance. This version of the paper benefited from comments from Robert Dennis, Douglas Hamilton, Joseph Kile, Kim Kowalewski, Robert Shackleton, and Thomas Woodward of CBO. Michael Treadway edited the paper.

Contents

Introduction	1
How Government Intervenes in the Private Market for Catastrophic Risk Protection	5
Four Options to Empower Private Markets to Increase Capacity	16
Can Private Markets Really Insure Against Very Large Losses?	22
Conclusions	25
Appendixes	
A. Current Federal Terrorism Insurance Policy and the Options for Disaster Insurance	27
B. Climate Change and Hurricanes	30
C. State-Sponsored Insurance Funds	32
Boxes	
1. The Recent Increase in Strong Hurricanes Hitting the Southeast: Implications for Insurers	6
2. Accounting Treatment of Alternative Risk Transfer Mechanisms	11
References	35

Introduction

The almost \$37 billion in privately insured losses associated with the terrorist acts on September 11, 2001, and the \$43.6 billion in losses stemming from Hurricane Katrina in August 2005 were large relative to the capital surplus of the insurance industry at the time.¹ The immediate effect was a contraction in the supply of disaster insurance and an accompanying rise in price. A couple of years following Hurricane Katrina, insurance markets for natural disasters had largely recovered on their own, and the market for terrorism insurance continues to recover from September 11 (CBO 2002, 2007a). However, after the events insurers reassessed their risk of losses, and the result was higher prices for both types of risk.

Those disasters increased policymakers' concern about the ability of the private sector to insure against catastrophic losses. That concern goes far beyond the viability of the insurance industry; it extends to maintaining the socially desirable amount of economic activity. The economic and social function of insurance is to diversify risks. Insurance allows individuals and firms to engage in socially efficient and profitable activities that they might not engage in if forced to bear all the associated risks themselves. When optimally provided, insurance raises the private rate of return closer to the social rate of return. If nondiversified firms and households were to lose their ability to recover catastrophic losses through insurance, economic activity might be damaged more than is inevitable in a natural disaster or terrorist attack. People living in those parts of the country most subject to such catastrophes would be forced to absorb very large property risks. The loss of uninsured homes following a catastrophic event could push many people with mortgages into bankruptcy and increase the likelihood that unrepaired homes could slow a neighborhood's or a city's recovery.

Before this decade's major disasters, both federal and state lawmakers had already intervened frequently in insurance markets to ensure that property owners had adequate protection against large losses. At the state level, government involvement has taken several forms: requirements that insurers operating in the state offer catastrophic protection; temporary moratoriums on insurer exit from the state; and controls on premiums to make coverage affordable. Some states have even created their own, taxpayer-financed programs to cover disaster risks: Florida did so after Hurricane Andrew in 1992, and California after the Northridge earthquake in 1994. Together these interventions have mostly achieved their aims; the contraction in the supply of insurance and the concomitant surge in prices that typically follow a major catastrophe are usually limited to the short run.

But those policies have created problems of their own. They have shifted costs to taxpayers and to those policyholders who are less exposed to catastrophic risk. In the long run, those policies drive private insurance firms out of the market if premiums are

¹ Both figures are in 2007 dollars. The Insurance Information Institute's estimate for September 11 losses includes all privately insured losses, including life insurance, and thus is not limited to property and casualty losses. Total privately insured losses from the September 11 attacks and from Hurricane Katrina each totaled about 10 percent of the combined net worth of U.S. property and casualty insurers.

not high enough to cover costs. They also give property owners who no longer bear the full amount of risk less incentive to mitigate risk by, for example, locating in low-risk areas; their riskier behavior then increases losses when a catastrophe occurs. Those two factors—a decline of private supply of insurance, and growth in expected losses—can lead to higher insurance prices, more pressure on state-sponsored programs, and even more calls for federal action.

Federal Initiatives and Legislative Proposals

At the federal level, a terrorism reinsurance backstop—the Terrorism Risk Insurance Act (TRIA)—was passed following the September 2001 attacks, in November 2002.² At the time, policymakers were responding to an apparent shortage of terrorism coverage due to insurers’ uncertainty about the future risk of losses and their impaired ability to bear that risk. Policymakers feared that commercial property owners would be exposed to uninsured risk, causing commercial construction to contract and reducing economic activity in the short run. From a homeland defense perspective, many proponents also argued that the costs of terrorism should be widely shared rather than disproportionately borne by the owners of high-profile potential targets.

Federal taxpayers bear most of the risk from very large terrorism losses under TRIA, which induces private insurers to voluntarily reduce premiums for terrorism insurance. In exchange for the federal government providing reinsurance without charge, TRIA requires insurers to “make available” insurance against acts of terror, although the act does not control the price charged for this added protection. TRIA has likely led to more coverage: the share of companies buying terrorism coverage increased from 27 percent in 2003, shortly after TRIA was first passed into law, to 64 percent in the first half of 2007 (CBO 2007a, 15; Government Accountability Office 2008). However, TRIA’s free reinsurance acts as a subsidy to terrorism insurance. Unpriced risk not only imposes a cost on taxpayers but may also encourage construction in areas at greatest risk, which could eventually increase the total loss to society from a terrorist attack (CBO 2005, 2007a). Congress has twice extended the program, which is now due to expire at the end of 2014. TRIA is discussed in more detail in appendix A to this paper.

Private markets currently provide the bulk of insurance against natural catastrophe. The federal government is also involved, for example through the National Flood and Insurance Program (NFIP). Options now before Congress would expand the federal role. One argument for such expansion is that the federal government can be a stable supplier of catastrophe insurance because, through taxation, it can draw resources from a wide array of sources and people. (Part of the insured losses can also be financed by issuing more debt, shifting the costs to future taxpayers.) By expanding coverage, the government might also reduce uninsured losses, which in the recent past have led to costly supplemental disaster appropriations at the federal level. Another argument is that in a democratic society, government cannot credibly commit to refrain from action after a catastrophe, because catastrophes have high human costs as well as monetary costs. A formal federal insurance role might promote better outcomes than providing

² Reinsurance is insurance provided to insurers, to allow them to diversify their risks, rather than directly to individuals and noninsurance businesses.

supplemental assistance after a disaster for those individuals, firms, and institutions that are either uninsured or underinsured.

Under one set of options, first proposed in the mid-1990s following Hurricane Andrew and the Northridge earthquake, the federal government would auction reinsurance contracts to primary insurance companies (those that write insurance policies directly for individuals and businesses) and state-sponsored insurers. Under another set of options, developed following Hurricane Katrina, the federal government would expand NFIP to cover losses from wind in addition to those from flooding. It has also been proposed that the federal government back the existing state-sponsored programs through either reinsurance or loans. Again, appendix A provides more details.

The insurance industry's trade organizations have argued for federal involvement on the grounds that the private insurance market cannot adequately insure against catastrophic risks for the following reasons:³

- Losses can be so large as to undermine the ability of private insurers to pool risks.
- It is difficult for private insurers to predict these losses.
- Government often contributes to creating these losses through its environmental and other policies.

None of these considerations, however, seem to have undermined other private financial markets, which also must deal with large, unpredictable losses from time to time. To be sure, the roughly \$80 billion in combined losses from the 2001 terrorist attacks and Hurricane Katrina caused large reductions in insurers' capital reserves (Wharton Risk Management and Decision Processes Center 2008, Table 1.1). But these losses, besides being temporary (as noted above), were quite small relative to those commonly suffered in the U.S. capital markets as a whole; the value of the firms in the S&P 500 index, for example, even before the recent market turbulence, the value often fluctuated by \$50 billion or more in a single day. Of course, equity holders in S&P 500 companies are partly compensated for their risk taking in that they gain on the upside as well as lose on the downside, whereas insurers mostly face downside risk. But this one-sided risk is priced into insurance contracts; moreover, noninsurance capital markets routinely take similar bets on risks that are difficult to predict. Credit default swaps are one example: the outstanding notional value of these contracts exceeds \$40 trillion (Bank for International Settlements 2007), or over eighty times the capital reserves of the entire insurance industry worldwide. Finally, insurers' losses are indeed sometimes the result of government actions ranging from stricter environmental standards to war. But capital holders in other private markets regularly make investments in the face of these and other uncertain government policies that place very large sums of capital at risk. Indeed, private insurers themselves have lost hundreds of billions of dollars over the past two decades as a result of changing legal liability standards as well as "unanticipated"

³ See Smetters (2004) for an in-depth discussion of these reasons and others.

environmental liabilities. Yet the ability of most insurers to operate does not seem to have been greatly impaired.

Impediments to Better Risk Sharing

So what really makes the market for insurance against catastrophic losses any different from other financial markets? Specifically,

- What factors currently impede private market insurers from amassing more capital as a reserve against large man-made and natural losses?
- What barriers prevent the broader capital markets from directly participating in the sharing of these large risks?

This paper argues that current government policies themselves unintentionally play a key role in limiting the role of the private sector in insuring against catastrophic losses. In other words, the argument for government intervention is implicitly predicated on the continuation of existing policies that offer short-term benefits but often undermine the role of the private market. Several such policies reduce the amount of capital supplied to insure or hedge against catastrophic risks:

- States routinely limit the premiums that insurers may charge, especially for workers' compensation insurance, where insurers have the largest catastrophic exposure.
- Capital market alternatives to traditional reinsurance face prohibitive regulatory hurdles, even though these alternatives might be much more effective than traditional reinsurance in managing risk.

Federal taxes on insurers' capital reserves force insurers to substantially raise their premiums for catastrophic insurance relative to those for other insurance.

- Courts have created considerable legal uncertainty over whether a given risk is covered under existing insurance contracts; this uncertainty has forced insurers to reduce coverage or raise prices.
- State- and federal-based insurance programs further crowd out private insurance.

Options

To increase private risk-bearing capacity and improve the effectiveness of federal involvement, policymakers have several options, which this paper examines:

- Adopt a federal insurance charter system, in which participation by insurers would be optional, to bypass prohibitive state rules and regulations.
- Change the regulatory accounting treatment of alternative risk transfer arrangements.
- Exempt insurers from tax on the earnings of their catastrophe reserves.

- Auction federal reinsurance contracts for extreme risks.

How Government Intervenes in the Private Market for Catastrophic Risk Protection

Why do traditional insurance markets seem overwhelmed by losses that amount to only a small fraction of the total capital at risk in the U.S. economy? Here we demonstrate that government laws and actions themselves—and generally not private sector “market failures”—make it costly for the private sector to increase capacity. To be sure, insurance regulators have legitimate objectives in many cases: primarily, to ensure that insurers are able to make good on their promises to pay for losses, and to protect consumers, especially homeowners, who are often required to purchase insurance. However, almost all government interventions have their costs, and insurance regulation is no exception.

Rate Suppression and Other Restrictions at the State Level

Insurance is generally regulated at the state rather than the federal level. Analysts agree that capital requirements are important to help protect policyholders against the costs of insurer insolvency. But rate controls have been an issue in some states prone to natural disasters. Many analysts believe that no strong economic rationale exists for regulating the rates charged by insurance companies, because the structure, conduct, and performance of the homeowners’ insurance industry are competitive. There is no clear evidence of firms earning excess profits or exercising other forms of market power (Harrington 2000; Litan and O’Connor 2008; Grace and Klein 2008; Wharton Risk Management and Decision Processes Center 2008). For terrorism insurance, a significant issue has been mandatory coverage, particularly in the workers’ compensation market.

Natural Disasters

Some state regulations have imposed price controls on property and casualty insurers in an attempt to make insurance more affordable. Often that has meant setting rates well below profitable levels. In some cases, regulators believe that the probability of another catastrophic loss is lower than what the market assesses. For example, although rates have risen substantially after the series of hurricanes in 2004 and 2005, Florida has not granted all requested rate increases, particularly in the coastal areas at greatest risk.

At the center of the current disagreement is whether Florida faces a period of heightened losses from hurricanes, which is consistent with recent experience (see box 1). The scientific community is divided about the reasons behind the increase in activity since 1995 but is largely united in the view that this high level of activity will persist for at least another ten to fifteen years (see appendix B). However, Florida regulators continue to require that loss estimates be based on a historical baseline, which may significantly

Box 1. The Recent Increase in Strong Hurricanes Hitting the Southeast: Implications for Insurers

Intense hurricanes have been hitting the Atlantic and Gulf Coasts with increasing frequency. One researcher estimates that the average power of hurricanes in the Atlantic has doubled in the past thirty years, as both the peak wind speed and the duration of the storms have increased (Emanuel 2005). The percentage of storms rated as category 4 or 5 on the Saffir-Simpson scale has increased by 25 to 40 percent. There has been some upswing in the total number of hurricanes in the North Atlantic since 1995, but that may be due to natural climate cycles (see Emanuel 2006 and Webster et al. 2005).

Researchers have raised the possibility that the trend toward more-intense hurricanes is due at least in part to global warming resulting from human activities (Elsner, Kossin, and Jagger 2008). The primary link posited between warming and hurricanes has to do with rising sea surface temperatures in the North Atlantic during the hurricane season. Hurricanes arise only when those temperatures rise above a trigger level, and rising sea surface temperatures could provide more energy for storms to propagate. By one expert estimate, the warming expected from a doubling of atmospheric concentrations of carbon dioxide-equivalent would roughly double expected hurricane losses, which would rise by about 0.06 percent of GDP (\$8 billion in 2005 dollars) (Nordhaus 2006). However, the processes that drive hurricane development are sufficiently complex that the effects of climate change on the frequency and intensity of hurricanes—historically and in the future—are currently highly uncertain (see appendix B).

Whatever their cause, more hurricanes of greater intensity mean greater insured losses, particularly since development in coastal areas has boomed in recent decades. Insurers were surprised when four major hurricanes—Charley, Frances, Ivan, and Jeanne—hit in 2004, resulting in about \$25 billion in losses. Privately insured losses from Hurricane Katrina, which hit the Gulf coast in August 2005, reached \$43.6 billion. Losses from Hurricanes Rita and Wilma, which also struck in 2005, were an additional \$16.5 billion, making 2005 the costliest year ever for insurers. (All figures in this paragraph are in 2007 dollars and were provided by the Insurance Information Institute.) Following those losses, insurers reassessed their risks of losses from hurricanes. Risk Management Solutions, one of the leading catastrophe risk modeling firms, raised its estimate of expected annual losses by close to 50 percent in the Gulf, Florida, and the Southeast (Risk Management Solutions 2006). The other two leading modeling firms—AIR Worldwide and EQECAT—also revised their loss estimates upward, but by smaller amounts (Kunreuther and Michel-Kerjan 2007; AIR Worldwide 2006).

underestimate the current risk (Wharton Risk Management and Decision Processes Center 2008; Risk Management Solutions 2006).⁴

⁴ Catastrophe risk modeling firms have significantly revised their expectations of losses to reflect the recent increase in the number and severity of storms, which is attributed to natural long-term cycles or global warming or both.

One of the unintended consequences is to constrain the long-run supply of private insurance. The lack of pricing flexibility, combined with heavy losses, has been an inducement for firms to cut back their exposure to the Florida market. For example, Allstate dramatically reduced the number of its homeowners' policies in force statewide, from 576,000 in 2004 to 241,000 at the end of 2007, after its requests for rate increases ranging between 28 and 42 percent were denied (McQueen 2008; Grace and Klein 2007).⁵ Many former policyholders are turning instead to the state-sponsored insurance company for coverage. Meanwhile the implicit subsidy to insurance purchasers encourages development in high-risk areas, increasing expected costs even more. Removing these price controls could substantially increase the supply of catastrophe insurance.

Moreover, although rate controls may hold down average premiums in the short run, studies of auto insurance markets suggest that regulations do not lower premiums in the long run (Litan and O'Connor 2008). One reason is that claims may rise in the long run because regulations reduce incentives for policyholders to mitigate risks.

Workers' Compensation and Terrorism Insurance

Insurance companies are especially concerned about the potentially large losses stemming from workers' compensation claims caused by a terrorist act or an earthquake that injures hundreds or thousands of workers on the job.⁶ Workers' compensation claims exceeded \$2.1 billion (in 2007 dollars) after the September 11 attacks; nearly all were for death benefits. Ongoing treatment of a worker's permanent injuries is usually much more costly to an insurer than a one-time death benefit. Workers' compensation insurance provides wage replacement at levels set by state law, as well as unlimited medical benefits to employees injured on the job, including those injured by a terrorist attack or an earthquake. This comprehensive protection was originally designed to avoid costly labor disputes.

Virtually every aspect of the workers' compensation market, however, is controlled by regulation. Benefit levels are set by statute rather than by negotiation between insurers and insured. All states except Texas require employers to provide this type of insurance to workers, and premiums are heavily regulated.⁷ Such regulation naturally limits the supply of workers' compensation insurance and increases the use of "involuntary placements," whereby employers deemed at high risk of incurring workers' compensation claims are denied coverage by private insurers at prevailing rates and forced instead into the involuntary or "residual" market for coverage. States generally

⁵ The state insurance commission has blocked Allstate from writing new automobile insurance policies in the state (Florida Office of Insurance Regulation 2008). Regulators generally have resisted large cutbacks by insurers and have in the past temporarily blocked nonrenewals or cancellations, as they did in Florida after Hurricane Andrew in 1992 and Hurricane Charley in 2004.

⁶ In general, hurricanes should not result in large workers' compensation claims because most businesses shut down ahead of the storm. In contrast, there may be little advance warning of an earthquake or terrorist attack.

⁷ In some circumstances, employers may have the right to self-insure. In what are called "monopolistic" states, coverage is provided directly by a state-run insurer.

require insurers to participate in the residual market, which means they are unable to control their exposures.

Although the structure of the workers' compensation market varies from state to state, some general observations are possible:

- Virtually no exclusions are allowed. Workers' compensation must include coverage against acts of terrorism, including nuclear, biological, chemical, and radiological attacks. Analysts have identified possible scenarios involving weapons of mass destruction under which insured losses could exceed TRIA's \$100 billion cap on total federal payouts (Dixon et al. 2007).
- Insurers may not adjust the terrorism insurance surcharge to take account of either an insured party's location within a state or the concentration of exposure. Those charges, which feed into rates in most states, are generally a uniform fraction of payroll—typically \$0.01 per \$100.⁸ Insurers in the District of Columbia, which has a high risk of terrorist attack, filed in 2002 for a terrorism loss cost of \$0.07 per \$100 of payroll, but regulators approved rates of just \$0.05 per \$100, according to the National Council on Compensation Insurance. Regulatory constraints can result in rate suppression and cross-subsidization of higher-risk by lower-risk activities (Danzon and Harrington 2001), and the insured firms face reduced financial incentives to mitigate losses.
- Most states—New York being the notable exception—require that an employer purchase workers' compensation insurance from a single insurer. This reduces opportunities for insurers to diversify their risk.
- As noted above, unattractive risks are insured in the residual market. State regulation may unintentionally enlarge the residual market by denying firms the flexibility to set risk-based rates. Residual markets act as insurers of last resort and are established by law rather than as a result of market forces. In many states, firms that write policies in the voluntary market are required to participate in the residual market. Rates are higher in residual markets—typically, the allowable loss cost is 50 percent higher for terrorism risk than in the voluntary market. These markets grew sharply after the September 2001 attacks; their growth continues under TRIA but at a reduced rate (National Council on Compensation Insurance 2006).

⁸ According to the National Council on Compensation Insurance (personal communication from NCCI staff to the authors, August 1, 2008), the loss cost filings are higher in the following states: \$0.02 per \$100 in Florida, and \$0.03 per \$100 in Illinois, Virginia, and Maryland. Actual rates will include markups for administrative expenses and profits. New York and California are not members of NCCI; however, New York recently passed a law that will allow insurance companies to file their own terrorism insurance rate. Loss costs will be allowed to vary by carrier and by class but will average about \$0.04 per \$100 of payroll. In addition, New York, like other states, has a separate charge for natural catastrophes and catastrophic industrial accidents; that charge is less than \$0.01 per \$100.

Accounting and Legal Regulation

The current regulatory environment has not kept up with innovation in the capital markets. State regulations constrain the amount of capital available to hedge catastrophic losses. Those regulations implicitly or explicitly follow the guidance put forward by the National Association of Insurance Commissioners (NAIC) unless the NAIC rules are clearly inconsistent with the state's laws (General Accounting Office 2002).

Regulations covering “admitted” insurers (those allowed to do business in the state) mainly focus on the insurer's ability to make good on its contractual obligations when its policyholders suffer losses. When a primary insurer buys reinsurance, it increases its underwriting capacity, which it then gets to record on its books. This accounting treatment recognizes that reinsurance improves the primary insurer's ability to meet its contractual obligations.

The accounting and legal treatment of products that are economically similar to reinsurance is less favorable. Nevertheless, recent years have witnessed an increase in the use of alternatives to traditional reinsurance, in the form of direct capital market instruments for sharing catastrophic risks. These new instruments have taken many forms, including catastrophe (“cat”) bonds, “sidecars,” contingent capital, industry loss warranties (ILWs), and some exchange-traded contracts (Michel-Kerjan and Morlaye 2008).⁹ These risk transfer mechanisms were formerly used only occasionally by primary insurers to make reinsurance more “contestable,” that is, to create substitutes for traditional reinsurance in order to increase competition. But the catastrophic losses suffered by the insurance industry in 2004 and 2005 created a \$142 billion capital shortfall, followed by sharp increases in reinsurance prices (Guy Carpenter Securities 2008, 13). Primary insurers needed a cheaper alternative to traditional reinsurance and increasingly turned to these instruments.

Publicly disclosed cat bond transactions, in particular, increased dramatically in 2007. Total outstanding risk capital covered by cat bonds totaled \$13.8 billion by the end of 2007, with almost \$7 billion coming from new issues in that year alone. Total capital at risk was up 49 percent from 2006 and 251 percent from 2005. Risk premiums (the “rate on lines” above short-term Treasury yields) relative to expected losses in the cat bond

⁹ Catastrophe bonds offer high-layer excess-of-loss protection over several years. For example, a catastrophe bond might pay 80 percent of an insurer's losses in the layer between \$1 billion and \$2 billion. In the event of a specified catastrophe, the interest and principal owed by the issuer (generally an insurer) would diminish in part or in full. Sidecars are a mechanism through which outside investors choose specific insurance risks to assume in partnership with a reinsurance firm for a specified period of time, typically one to three years. Contingent capital allows an insurer to issue debt or equity at a specified rate or price following a disaster, when the insurer's financial condition might otherwise preclude such a sale. (If no disaster occurs, no securities are issued.) ILWs are similar to catastrophe bonds. For example, they effectively allow hedge funds to act as reinsurers for catastrophic events by reimbursing an insurer a set amount if total losses to the insurance industry from a specified disaster exceed a given amount. Catastrophe derivatives are traded on organized exchanges and over the counter. For example, the WINDX contract pays a specified amount based on measured wind speeds at various locations. Contract holders in effect are purchasing protection from capital market investors against the risk of hurricane damage.

offerings narrowed between 2006 and 2007, suggesting increased competition.¹⁰ Lane and Beckwith (2007) estimate that ILW activity adds another \$5 billion to \$10 billion of capacity (total capital at risk). Sidecar activity in 2007 totaled \$947 million in capital at risk,¹¹ and exchange-traded derivative activity across the major underlying exchanges stood at \$25 million in capital at risk.¹²

A primary insurer that purchases an alternative risk transfer contract containing basis risk is generally not allowed to count this holding as an asset or as a reduction in its liability for underwriting purposes (see box 2).¹³ (Basis risk is the difference between the insurer's actual loss and its reimbursement from the payoff of one of these securities.) This prohibition holds even if the *totality* of the primary insurer's risk transfer arrangement contains less basis risk and less credit risk than a standard unsecured reinsurance contract with large deductibles and other forms of loss retention. This regulatory hurdle partly undermines the viability of some of the best "pure plays" under which capital market participants would want to supply capital to those seeking to hedge catastrophic risk.¹⁴

Almost a decade ago, a working group of the NAIC was examining whether to allow primary insurers to recognize pure plays as a recoverable asset for underwriting purposes, provided that the instruments supplied an adequate amount of "hedge effectiveness" (that is, a low enough basis risk). That matter was evidently dropped, but in 2003, NAIC considered proposals to allow reinsurance-like accounting treatment for catastrophe bonds that provided highly effective hedges for insurers' losses (General Accounting Office 2003a).

¹⁰ A recent \$200 million offering from the Chubb Group that was underwritten by Goldman Sachs illustrates the size of the spreads over expected losses for different tranches. The A tranche has an expected loss of 1.65 percent and a spread over the London interbank offer rate of 625 basis points (6.25 percentage points); the B tranche has an expected loss of 2.04 percent and a spread of 725 basis points; and the C tranche an expected loss of 6.13 percent and a spread of 1,460 basis points. These spreads are roughly comparable to those of traditional reinsurance (personal correspondence with Goldman Sachs staff, April 9, 2008).

¹¹ Guy Carpenter Securities (2008, 4, 5, 29, 44). Estimates from Goldman Sachs tell a similar story, with sidecar activity dropping from \$4.4 billion in 2006 to \$1.8 billion in 2007 (from a listing of all natural catastrophe bond transactions provided by Goldman Sachs).

¹² Lane and Beckwith (2007, 2). The major exchanges include the New York Mercantile Exchange and the Chicago Mercantile Exchange.

¹³ Alternative assets with basis risk can typically count on the "investment" side of the insurer's balance sheet like any other asset holding, but not in a manner that materially improves the insurer's ability to underwrite additional risk. More recently, hybrid or dual-trigger contracts with indemnity-based triggers are being counted as reinsurance, provided that the cedant's losses exceeds the contract's payoff. This innovation reduces the regulatory hurdle somewhat but then requires suppliers of capital to make firm-specific bets. (Under dual-trigger contracts, payouts would be made following an event only if the industry-wide loss threshold, or a parametric trigger, were exceeded and an insurer's own loss exceeded a specified amount; Cummins 2006. In practice, the insurer often needs to show that its net loss is greater than or equal to its collections under the catastrophe bond.) This accounting approach falls short of comprehensive reform and may have unintended consequences. A dual-trigger contract may contain more basis risk than a single-trigger parametric contract; at a minimum, the market would greatly benefit from clearer accounting rules. Rating agencies are starting to allow dual-trigger contracts as well, but only if they make up a fairly small portion of the cedant's overall reinsurance program.

¹⁴ Not all analysts agree that the regulatory and accounting treatment of catastrophe bonds has been a significant impediment to their greater use (Cummins 2008).

Box 2. Accounting Treatment of Alternative Risk Transfer Mechanisms

Basis risk is a major factor in the accounting treatment of alternative risk transfer mechanisms. The National Association of Insurance Commissioners' rules allow the underwriting risk of a primary insurer (the "cedant") to be transferred to the capital market using these alternative securities if the capital at risk is "fully hedged" by the security, that is, if there is no "basis risk." Many alternative risk contract designs, however, pay off according to parametric (for example, Richter scale) indexes or total industry losses in a geographic region, not the cedant's actual losses. These contracts allow capital suppliers to make a "pure play" on a broad risk rather than worry about each cedant's individual portfolio.

The conventional wisdom is that traditional reinsurance contracts have no basis risk, because they indemnify the cedant's actual losses, whereas capital market-friendly "pure-play" contracts do produce basis risk, because they pay off according to metrics that are only correlated with, not identical to, the actual loss. But this picture is incomplete. Losses in traditional reinsurance contracts are subject to moral hazard: the cedant may increase its level of reinsured riskiness by reducing its own underwriting efforts and loss adjustment controls and costs. Traditional reinsurance contracts therefore require that the cedant absorb a substantial fraction of its own direct losses through deductibles and coinsurance provisions; this considerable unhedged exposure amounts to basis risk. In contrast, pure-play contracts do not create moral hazard since there is almost nothing that a cedant can do to increase its *own* payoff, which is based on factors outside of its direct control. As a result, a cedant could obtain significant protection from alternative contracts that would involve less basis risk than traditional reinsurance. (We are thankful to Neil Doherty of The Wharton School for this point.)

Not only would an alternative risk management program involve less basis risk than traditional reinsurance; it could also contain less credit risk. Credit risk stems from the potential inability of the counterparty that is contractually obligated to bear the risk (in this case, the reinsurer) to make good on its obligation after a loss. Traditional reinsurance is subject to counterparty credit risk because reinsurers do not set aside capital reserves equal to their total potential losses. Instead, much like banks in a fractional reserve banking system, reinsurers rely on the low probability that the policies they write will *all* produce losses at the same time, which would be the equivalent of a bank run. Rating agencies are then employed to determine the creditworthiness of reinsurers. But as the recent subprime mortgage crisis has shown, rating agencies often guess wrong—potentially very wrong. In contrast, many of the pure-play contracts, including cat bonds, are fully collateralized by money set aside in special-purpose vehicles (essentially a "lockbox") containing enough capital to cover the maximum possible underlying risk. Catastrophe bonds are generally fully collateralized with Treasury securities. Because the bonds cover a specific layer of risk, their maximum payouts are well defined.

Federal Tax Treatment

Taxes by their nature distort some types of business decisions, but these distortions are especially severe when it comes to providing catastrophic insurance. The federal tax code currently taxes as income the earnings of an insurer that are temporarily inflated when disaster losses are low. Insurers may not count additions made to their reserves against low-probability risks as expenses for tax purposes. Instead they may expense the cost of reserves only for losses that have been reported by policyholders but that remain unsettled, as well as losses that are believed to have already occurred but for which claims have not yet been reported (Bradford and Logue 1997). Taxes therefore lead insurers to raise less capital for catastrophic protection than they would otherwise.

In fact, federal taxes alone can significantly raise the price of *catastrophic* insurance, while having only a negligible impact on *noncatastrophic* insurance. This difference can be seen in a simplified example of two hypothetical corporate insurers: one that provides catastrophic hurricane coverage and one that insures against standard fire risk.¹⁵

Suppose that each insurer's portfolio of policies issued has the same *expected* annual average loss of \$10 million, but that the hurricane insurer faces a single \$1 billion loss with certainty once every 100 years, whereas losses to the fire insurer alternate between \$8 million and \$12 million each year. Annual premiums of \$10 million would cover the expected costs of each. But to ensure its ability to pay claims every year, the fire insurer needs to hold only about \$2 million in capital reserves, for those years in which losses are \$12 million. It can take advantage of the law of large numbers (since the underlying risks are not highly correlated) and collect just enough in premiums so that annual premium income plus its capital reserves cover its expected annual payments plus a small amount of variation. In contrast, the hurricane insurer cannot rely on the law of large numbers but must instead be prepared at all times for the "big one." So it needs to hold capital of \$990 million for the \$1 billion loss that will occur once every 100 years on average.

The capital reserves of insurers are often held in the form of bonds, the interest on which is subject to corporate income tax, which reduces the net earnings to each insurer's shareholders (Harrington and Niehaus 2001b). Since the shareholders could have invested instead in a mutual fund that pays no corporate tax, each insurer in our example must charge more in premiums to cover its tax liability so as to remain competitive in the capital market. If taxes absorb about one-fourth of investment income, then, for example, an 8 percent after-tax return on an insurer's investments is reduced to 6 percent. Because shareholders could instead invest directly in a mutual fund that returned 8 percent, each insurer needs to collect an additional 2 percentage points in premiums. But the situations of the two insurers now dramatically diverge. The hurricane insurer has to charge \$19.8 million in additional premiums (2 percent of its \$990 million capital reserve) to cover its taxes, beyond the \$10 million to cover its expected loss, for a total of almost \$30 million, or almost three times its expected loss. In contrast, the fire insurer needs only to collect \$40,000 (2 percent of its \$2 million capital reserve) in additional premiums to cover its taxes. In other words, the hurricane insurer must charge almost fifty times as much in

¹⁵ This example is based on one presented in Musulin (1997, 2-5).

additional premiums as the fire insurer, and almost three times as much in total premiums, even though both portfolios have the same expected overall loss.

This simplified example overstates the tax distortion because it fails to capture all the relevant attributes of the tax system. The effect is first reduced by the fact that the income generated by the mutual fund would be fully taxed at the individual level at current rates for ordinary income, whereas the dividends and capital gains from the stock in the insurance company would be taxed at the currently lower rates for those types of income. Second, the insurer would be able to deduct the catastrophic losses when they occur. Deductions in a given year are limited to the amount of taxable income in that year, but with carryforwards and carrybacks, much if not most of the loss would eventually be deducted. Consequently, the effective corporate tax is not really 25 percent on income from the portfolio, but only the cost of deferring the deduction (plus any amount that cannot be carried over). Nevertheless, the basic point still holds: the inability to set aside tax-free reserves significantly raises the cost of providing catastrophe coverage.

In practice, insurers operating nationally have some ability to pool catastrophic risks and make more efficient use of capital. (They also use reinsurance, most of which is purchased from international reinsurers, as discussed further below.) Thus, catastrophe insurance prices are lower than in the example above but still high relative to expected claims. Losses from an event are generally concentrated regionally, so that operating in many states provides some diversification. Similarly, losses from earthquakes and hurricanes are not correlated, so there are benefits to insuring multiple catastrophic risks. Rating agencies, however, traditionally have given high ratings only to insurers that held enough capital to pay off at least a once-in-100-years loss from a hurricane or a once-in-250-years loss from an earthquake (net of reinsurance). After the series of catastrophes in recent years, the rating agencies have increased their capital standards and now generally require that high-rated insurers be able to withstand two such catastrophic events within a year (Wharton Risk Management and Decision Processes Center 2008).

The tax wedge is more important to primary insurers than to reinsurers.¹⁶ Most reinsurers avoid this tax wedge by establishing headquarters outside the United States. For example, most new reinsurance firms are based in Bermuda. If the interactions between primary insurers and reinsurers were frictionless, this tax wedge would be of little importance. But informational asymmetries and counterparty risks are just two reasons to believe that frictions matter.

Legal Environment

All insurers also face the risk that courts might reinterpret their contract provisions in a way that favors larger payouts to policyholders.¹⁷ That risk was realized after Hurricane Katrina. Multiple lawsuits were filed in Louisiana, Mississippi, and Texas over whether

¹⁶ In equilibrium, investors in insurance funds should earn the same after-tax returns (on a risk-adjusted basis) as other investors. The higher prices for catastrophic coverage should compensate for the tax wedge.

¹⁷ For example, see Wilson (2007); Liam Plevin and Peter Lattman, "Rulings Bolster Insurers: Landscape Is Changing As Katrina Cases Move Through Higher Courts," *Wall Street Journal*, December 7, 2007, C1; Harbin (2006).

losses suffered from the storm should be attributable to wind or to flooding. That determination is important because most homeowners' policies exclude all losses from flood. (Policyholders may purchase federal flood insurance separately.) Some lawsuits argued that although much of the damage was from flooding due to storm surges, those storm surges were driven by the winds, and thus the losses were covered. Also, Mississippi's attorney general sought to ban the flood exclusion provision retroactively. Insurers lost some of these cases in the lower courts, and several companies, including State Farm, paid sizable settlements in others. However, the federal district court upheld the flood exclusion clause in Mississippi, as did a Louisiana state judge. Still, insurers have responded by cutting back coverage: State Farm, for example, will not write new homeowners' policies in Mississippi because of the added risk.

Some insurers in California are also worried that they would face either public pressure or lawsuits, or both, forcing them to expand coverage to pay most claims following an earthquake irrespective of the terms of the insurance policy (Grossi and Muir-Woods 2006). Depending on the circumstances, determining whether losses should be attributable to quake damage (which is excluded under many policies) or to the fires following the quake (which are not) might be difficult. This distinction is important because only about one in eight residences in California carries earthquake insurance.

Crowding Out: State Insurance

As discussed earlier, some states limit the premiums that insurers may charge. This makes some potential policyholders uninsurable because they are too high a risk at the maximum allowable premiums. As a consequence, these states often end up providing insurance themselves to these otherwise uninsurable customers. But these state-based policies also typically compete at the margins with traditional private insurance, and political pressure sometimes leads to expansion of these programs beyond just the privately uninsurable. These cheap programs therefore crowd out the private sector, leaving taxpayers and the less risky policyholders to foot the bill.

State-sponsored programs provide natural disaster insurance at lower prices, and with minimal underwriting, to policyholders at the greatest risk. Many coastal states operate "beach plans," which are risk-sharing pools specifically designed to insure high-risk (and often highly valued) properties against hurricane damage.¹⁸ Florida operates the largest such plan and separately offers mandatory catastrophe reinsurance to all property insurers operating in the state. (See appendix C for details.) California has a state-sponsored plan for earthquakes. Eligibility rules vary, but only in some cases are the programs restricted to insuring only those at the highest risk. Rates in such state programs are typically subsidized by taxpayers and by participating insurance companies.

Although these public programs provide affordable insurance coverage and fill the temporary gap caused by the sharp contraction of supply after megacatastrophes, they also have major disadvantages. First, their ability to offer low-cost insurance is largely illusory; most of the risk is simply shifted to other policyholders and to taxpayers. Major catastrophes have resulted in deficits for the Florida plans that have been funded through

¹⁸ For an analysis of selected state plans, see Government Accountability Office (2007, 55-78).

“assessments,” which are in effect taxes on all policyholders in the state, and through legislative appropriations. The programs also take advantage of their tax-preferred status by accumulating reserves on a tax-free basis and by issuing municipal debt, which is cheap to the issuer since the interest on it is tax-free, to cover losses after a disaster. Second, the low premiums charged by the state programs discourage those at risk from undertaking preventive measures that would reduce losses in the future. A negative feedback loop is thus created: the subsidized rates produce an even larger wedge between expected losses and the premiums collected. Third, because each insurer’s postdisaster assessment is based on its market share, private insurers are discouraged from issuing more policies. Fourth, losses incurred by the state programs lead to efforts to shift risks to federal taxpayers through federal emergency declarations.

In these circumstances a reduction in regulation can lead to an increase in coverage. California, for example, has a large and well-functioning private market for *commercial* earthquake insurance that is lightly regulated, especially with regard to price. Coverage in the commercial marketplace is several times that in the residential market. This difference is surprising since the diversified shareholders of commercial policyholders should be less concerned about earthquake risk (which is typically uncorrelated with risks in the rest of the economy) than nondiversified homeowners. Some analysts attribute this difference to the lack of mandated coverage in the commercial marketplace.¹⁹ Commercial insurers are free to choose their customers and thus avoid excessive concentrations of risk. They also use global reinsurance markets to limit exposure to catastrophic losses.

Crowding Out: Federal Insurance

In addition to the subsidy for terrorism insurance provided under TRIA, discussed previously, the federal government provides various forms of implicit insurance against natural catastrophe. Following such a disaster, Congress generally provides extensive federal assistance to individuals, small businesses, and state and local governments to help cover uninsured losses and assist in economic recovery, with the Federal Emergency Management Agency (FEMA) serving as the lead agency. The federal government typically pays at least 75 percent of the cost of infrastructure repairs. The Small Business Administration also helps individuals pay for temporary housing and offers direct lending and loan guarantees to businesses. The Department of Housing and Urban Development frequently assists individuals in their transition from emergency shelters to permanent housing. Although all these types of assistance reduce financial hardship and help stimulate the economy after a disaster, they also discourage individuals and businesses from taking steps to mitigate future losses and from seeking private market solutions for financing those losses.²⁰

¹⁹ Personal communication from Richard Roth, Jr., consulting actuary and former assistant insurance commissioner in California, February 21, 2008. See also Grossi and Muir-Woods (2006) and CBO (2002, 39-41).

²⁰ Some studies have not found a strong link between the decision to forgo insurance coverage and policyholders’ expectations of postdisaster assistance. For a review of those studies, see Wharton Risk Management and Decision Processes Center (2008, 134). However, the widespread attention devoted to the federal assistance following Hurricane Katrina may have a stronger influence on insurance decisions (Kunreuther 2006).

According to estimates by the CBO, additional federal spending for hurricane-related disaster assistance—including the \$43.6 billion (in 2007 dollars) in insured losses for Hurricane Katrina—together with various forms of disaster-related tax relief, will add about \$125 billion to the federal budget deficit over 2006-10.²¹ About \$26 billion of this relief will go to homeowners and renters who were uninsured or underinsured, according to the Government Accountability Office (2007, 6).

Even when most businesses and individuals have insurance, federal assistance can still be substantial. Federal disaster assistance to individuals, businesses, and state and local governments following the 2001 terrorist attacks totaled somewhere between \$25 billion and \$33 billion, and possibly more, depending on which outlays are assumed to be directly related to the attacks (CBO 2005, 25–26; General Accounting Office 2003b; Dixon and Stern 2004). Just over \$20 billion of the aid was targeted to the New York City area, another \$7 billion was paid to victims or their families from the September 11th Victim Compensation Fund, and \$5 billion went to U.S. airlines. Between two-thirds and three-quarters of retail businesses in lower Manhattan had insurance that covered losses from the attacks, but small businesses in the area generally did not carry enough business interruption coverage (which replaces business income lost because of physical disruption). Although the federal government assisted small businesses that had not purchased insurance, such aid covered only a modest portion of their uninsured losses. Many of these interventions would not be needed if the private market were encouraged to insure these losses in the first place.

Four Options to Empower Private Markets to Increase Capacity

We now examine four potential reforms that would increase private market participation in insuring catastrophic risk and could make federal interventions more effective.

An Optional Federal Charter for Insurers

Insurance companies operate nationally but are regulated at the state level (Grace and Klein 2008). This treatment distinguishes them from banks and securities firms and was most recently reaffirmed by the Gramm-Leach-Bliley Act in 1999. A federal insurance charter system in which participation by insurers is optional would give insurers the same choice over regulatory regime that banks currently have (Rust and Killinger 2007; Shadow Financial Regulatory Committee 2006). Although the specifics of the various proposals differ, an optional federal charter could preempt state regulation, encourage innovation, and reduce the administrative burden on insurers, who today must deal with different state regulations. It also might increase competition among insurers, banks, and security firms. Competition between the federal charter and the existing state charters for

²¹ CBO (2007a, 11). Five supplemental spending bills provided direct assistance to individuals and public assistance to state and local governments to cover the costs of repairing and replacing damaged infrastructure. For an analysis of federal disaster relief, see Holtz-Eakin (2005). In addition to authorizing direct assistance, Congress increased the borrowing authority of the flood insurance program to \$20.8 billion, of which a total of \$17.5 billion has been used, primarily to pay off hurricane-related claims.

insurers could also result in regulatory reform at the state level. Under most proposals, insurers holding an optional federal charter would still participate in state mandatory residual risk pools and guarantee funds and pay state taxes on premiums. This participation would eliminate the need for a federally run guarantee system (U.S. Department of the Treasury 2008).

Current optional federal charter proposals would generally prohibit rate regulation at the federal level. State regulation of premiums is a major impediment to insuring catastrophic risks. Under one charter proposal, the proposed National Insurance Act of 2007, the new federal charter would have freed property and casualty insurers from both premium regulation and “form” regulation (the latter covers what a policy may include or exclude; see Webel 2007, 2008). In the few states where rates are not highly regulated, such as Illinois, the evidence has shown that competition has held down auto insurance premiums. Similarly, where states have reduced premium regulation, more firms have entered the market, and the residual pool (see above) has shrunk (Wallison 2006). Moreover, risk-based rates would provide policyholders with stronger incentives to mitigate risks and to consider risks more carefully when choosing locations for new development. In the long run, studies of auto insurance markets suggest that rate deregulation should not harm the average consumer; average rates might even fall as a result of lower claims (Litan and O’Connor 2008).

Premium deregulation may raise concerns about affordability, particularly for low-income policyholders in the short run. States or the federal government could choose to provide policyholders with insurance vouchers to make insurance more affordable (Wharton Risk Management and Decision Process Center 2008). Vouchers would allow government subsidies to better target lower-income policyholders; today the implicit subsidies delivered through premium regulation are greatest for those with the biggest homes and properties. Because these subsidies would now result in explicit budget outlays, their costs would be transparent to taxpayers.

Preemption of state regulation is not without risk, and not without disadvantages. State insurance regulators might have better information about local market conditions and stronger incentives to be responsive to residents. If a federal regulator proved lax in enforcing its safety and soundness regulations or provided weaker consumer protections, some policyholders could be made worse off. Some consumer advocates also fear that a dual system could result in a “race to the bottom,” in which state and federal regulators compete to give insurers more-favorable treatment and thus secure greater power and bigger budgets. Conversely, another possibility is that a federal regulator might impose stronger rate regulation in the future. In addition, the banking regulatory model is not without problems. For example, recent events have revealed significant gaps in the oversight of mortgage originations, which have led to various reform proposals (U.S. Department of the Treasury 2008).

Moreover, the creation of an optional federal charter would require that a new regulatory structure be created, possibly within the Treasury and likely modeled along the lines of the Office of the Comptroller of the Currency, which oversees national banks (U.S.

Department of the Treasury 2008). The new office would have to handle chartering, licensing, and supervision of insurers. It would also be in charge of safety and soundness regulation and new product approval. New regulations would be required for each of those activities. Because regulation of insurance companies is now largely a state function, the federal government lacks experience in this area. How the federal government would perform in this role is uncertain. Some important questions include the following (Grace and Scott 2008):

- Should the McCarran-Ferguson Act (1945), which generally exempts the business of insurance from most federal antitrust law, be kept in force?
- What capital requirements should be set to ensure insurance companies' solvency, and how far should capital be allowed to fall before triggering prompt corrective action?²²
- Would requiring insurers to participate in state residual risk pools and guaranty funds (which pay claims if an insurer fails) lead to consistent regulation of federally chartered insurers? Might a federal guaranty system be necessary?
- What consumer protections should exist for deceptive advertising, unfair policy terms, and discriminatory treatment, and how would the large volume of likely consumer complaints and policy inquiries be addressed?

Regulatory Improvement of Risk Transfer Mechanisms with Basis Risk

Another avenue for increasing insurance capacity would be to allow primary insurers to tap the capital markets more directly, through pure-play contracts that contain some basis risk. Capital market participants could then base their decisions about whether to supply capital on their best forecasts of average industry losses in a geographic region or some other broad metric. In particular, they would no longer need detailed knowledge of a particular primary insurer's idiosyncratic characteristics, including its own loss portfolio and individual underwriting and loss adjustment practices. With pure-play contracts, these idiosyncratic risks largely cancel out in the aggregate.

As explained above, the usefulness of current NAIC rules is suspect, because they prohibit transactions that potentially have greater "hedge effectiveness" (less basis risk) and less credit risk than traditional reinsurance programs. These rules effectively protect the "franchise value" of reinsurers that have accumulated detailed customer knowledge over the years. But the rules are likely counterproductive and may actually reduce total hedge effectiveness and increase exposure to credit risk. Catastrophic insurance premiums are typically several times higher than the underlying expected losses. Expanding the scope for capital market participation would likely greatly reduce the cost of catastrophic risk insurance by allowing insurers to more broadly diversify their exposure using pure-play contracts available in the capital markets.

²² "Prompt corrective action" is a term borrowed from banking regulation. It sets the requirements for regulatory intervention when institutions fail to meet prescribed capital tests.

To be sure, it would be inefficient for regulators to allow any sort of alternative security to count as a substitute for reinsurance if the hedge effectiveness thereby provided is too low (that is, if basis risk is too high). For example, a primary insurer with considerable hurricane exposure in Florida would obtain very little hedging from an instrument whose payoff is correlated with earthquake risk in Tokyo. But regulators could establish a minimum hedge effectiveness ratio that any security could satisfy for regulatory purposes. If the NAIC does not revisit this issue in a timely manner, an optional federal charter could be established that preempts traditional state-level regulations.

Tax Reform

Changes in the taxation of income on capital reserves of insurers against expected catastrophic losses could expand the availability of catastrophic risk coverage while lowering its cost (CBO 2002; Harrington and Niehaus 2001b). As discussed above, the taxation of income on capital reserves increases the premiums that insurers must charge for catastrophe insurance (Harrington and Niehaus 2001a). Taxation of portfolio income is not unique to catastrophe insurance, of course; it is a basic feature of the corporate income tax. But, as explained above, catastrophe insurance is distinguished from other types of insurance, such as auto, life, and health insurance, by its necessarily high ratio of capital reserves to expected losses, and therefore by its high ratio of taxable investment income to expected losses.

Under one potential reform, the government would allow insurers to put money aside tax-free to cover expected losses (Rust and Killinger 2007). State-sponsored plans generally may already do so, and so avoid paying taxes on investment income. Similarly, private mortgage guaranty insurers are permitted to hold 50 percent of their premiums in a tax-deductible reserve for ten years. (The reserve must be invested in special non-interest-bearing Treasury bonds.) Many European countries also allow reserves to be set aside tax-free for catastrophic losses.

Another possibility is to allow insurers to carry back catastrophe losses for, say, ten or twenty years, instead of the current two years, and to recover federal taxes paid in past years.²³ A precedent for this alternative already exists: product liability insurers may carry back losses for ten years.

Tax reform could also have a large impact on the alternative risk transfer mechanisms that serve as a substitute for traditional reinsurance. In particular, almost all catastrophe bonds are now, for tax reasons, issued through offshore special-purpose vehicles (SPVs).²⁴ If cat bonds were issued through an onshore SPV, they would be treated like equity for tax purposes because of the contingent nature of the interest payments. From a practical standpoint, this means that an onshore SPV cannot deduct such payments as can

²³ Insurers and other corporations may already carry back losses two years and carry forward losses twenty years, which helps smooth out their cash flow following a disaster.

²⁴ One concern with special-purpose vehicles is how their sponsor should account for those entities. Most are not reported on a firm's balance sheet and are instead disclosed in the notes to the financial statements, raising issues of transparency. However, this issue is not limited to the issuance of catastrophe bonds and other insurance-linked securities but is common to a range of financial transactions and is beyond the scope of this paper.

the holder of a regular bond, which makes the onshore arrangement tax inefficient. Giving onshore SPVs tax treatment similar to other bond issuers could bring this securitization on shore, which means that negotiations over these contracts would not have to be held off shore.

Changes to the tax code, however, do not come for free; all have various costs and drawbacks. First, the above changes would result in a loss of federal revenue. Second, such changes could lead to substantial distortions in the allocation of capital, especially between insurers and other financial institutions not subject to the same tax treatment. For example, in the case of onshore SPVs, similar tax treatment for other financial instruments with contingent payments might be necessary, reducing government revenue even more. (Because of concerns about transparent disclosure by all types of firms, some analysts are also generally skeptical about proposals that would encourage greater use of off-balance-sheet SPVs.) Third, without adequate oversight, insurers could abuse the option to set aside tax-free reserves: by deliberately overestimating expected losses, they could shelter additional capital income from taxation (Litan 1990). Fourth, such changes would require highly complicated revisions to the corporate tax code. (An analysis of tax code changes is beyond the scope of this paper.)

Federal Reinsurance for Catastrophic Risks

The federal government is today the implicit insurer of last resort for natural catastrophes, and it provides, through TRIA, explicit free reinsurance for terrorism risks. Until the impediments to private insurance of catastrophic risks can be reduced, some analysts favor a limited yet formal role for the government in selling reinsurance for such risks (Litan 2006; see also Kunreuther and Pauly 2006). This reinsurance would be sold only for the very highest “layers” of risk, to reduce crowding out of private coverage (Cummins 2006). Government provision could increase the availability and decrease the price of insurance for the largest catastrophes (CBO 2002). Unlike private insurers, the federal government would not need to hold explicit capital reserves to pay off claims and avoid insolvency, and it could potentially diversify risks better than private insurers, according to proponents. Some analysts, however, challenge the notion that the government has a cost advantage in bearing risk and reinsuring catastrophes. They note that the premiums charged by the federal government would not compensate taxpayers for the burden of supplying the capital (or “market risk”) and that losses might simply be shifted across generations (Priest 1996; Braun, Todd, and Wallace 1998).

More important, using risk-based premiums to cover expected losses could actually reduce the expected costs to taxpayers relative to the current approach, where the federal government implicitly assumes the role of guarantor of last resort. In theory, the use of risk-based premiums would also strengthen the financial incentives for firms and households to mitigate risks, including through the location and design of new construction and retrofitting of existing structures.

Government policies, however, can fail or have unintended consequences in practice (CBO 2002; Stiglitz 2006). First, federal programs seldom tailor premiums to risks, and as a result, federal insurance programs can be undermined by moral hazard and by

adverse selection (whereby those at higher risk are more likely to buy insurance in the first place). The government faces less pressure than private firms to control for adverse selection and moral hazard. Second, federal reinsurance could crowd out private suppliers and deter innovative private market solutions. Capital market products, including catastrophe bonds, would be at a competitive disadvantage. Third, a federal program that nationalized disaster risk might reduce the diversification gains from international risk sharing. Extensive diversification of risk contributed to the ability of insurers and reinsurers to remain in business following the attacks on the World Trade Center. Global reinsurers bore much of those losses.

Rather than set prices administratively, the federal government could therefore auction reinsurance to insurers and state-sponsored programs (Lewis and Murdock 1996, 1999), and for only those losses in excess of a large deductible. An auction approach could elicit new information and allow the private market to determine the appropriate risk-adjusted premiums, provided that bidding was significantly competitive. These auctions could

- require minimum prices based on actuarially expected losses plus an additional amount for risk load (to cover uncertainty surrounding the estimates) and administrative costs;
- set a large minimum level, or “retention level,” of insured losses that policyholders must sustain before the federal government will pay;
- limit the federal government’s maximum liability by controlling the number of contracts sold; and
- demand that states participating in the auctions increase their efforts to mitigate risk.

The reinsurance contracts would be similar to the catastrophe options that once traded on the Chicago Board of Trade. They would cover specific “layers” of loss and be divisible and tradable, paying a fixed amount per billion dollars in losses stemming from a disaster.

Because a federal reinsurance program could be designed to cover only the highest levels of losses, insurers would have to sustain large losses before the federal contracts paid out any money. Specifying the contracts in terms of aggregate losses would simplify the program’s administration, maintain incentives to underwrite policies and adjust claims, and facilitate trading of the securities in the secondary market. To be sure, setting the minimum bid would require some careful analysis, as well as determining the appropriate risk load to compensate for the uncertainty surrounding the available loss estimates, so there is no guarantee that taxpayers would be fully protected against losses (CBO 1997, 1998, 2000). If the contracts were well designed and there was no collusion, the bidding could exceed this minimum.

Still, the effectiveness of federal reinsurance contracts would depend on their design and on the competitiveness of the auction process. Most legislative proposals to auction

federal reinsurance contracts would leave a great deal of discretion with the secretary of the Treasury in designing the auction and setting the terms of the contracts. The design of a federal reinsurance contract and the format for the auctions would in part determine the viability of the policy and the potential cost to taxpayers (CBO 2002). Proposals typically require that separate auctions cover different geographic regions. Some bills have even proposed separate auctions for Florida and California; others carve out special provisions for state-sponsored programs. Proposals also typically include a risk load, which is often 100 to 200 percent of the expected loss. The goal is to get bidders to reveal their market-based values, but that will only happen if the contracts are limited in number and attract sufficient demand. Some of the key trade-offs and concerns are the following:

- Using an aggregate loss trigger (that is, tying retention levels and contract payouts to aggregate losses rather than to losses suffered by individual insurance companies) simplifies administration, facilitates trading in the secondary market, and limits moral hazard. But such a trigger also means that any particular insurer's losses may or may not match the contract's payout. This approach, rather than a conventional indemnity approach, may be much better suited to natural disaster risks than to terrorism risks, which are more site specific.
- Estimates of expected losses from the catastrophic risks covered by the contracts would be subject to great uncertainty. For example, modelers vary responses to climate change for their estimates of hurricane risk. Thus, significant discretion is likely to be needed in setting the retention levels and identifying the appropriate risk loads. The federal government has weaker incentives than the private sector to overcome that uncertainty and set prices at a budget-neutral level. (This is particularly true when the greatest risks are from infrequent events that pose remote likelihoods of loss in any particular year. Such events make it harder to detect underpricing.) If bidding is robust, how the retention levels and risk loads are set may not matter, but if the contracts are awarded at or near their reservation prices (minimum bids), taxpayers may be at greater risk.

If separate auctions are established for state-sponsored programs, the risk of losses being transferred to taxpayers is greater. (Some bills would allow the secretary of the Treasury to lower the loss threshold for state-sponsored programs.) The danger is of greater political pressure to set low reservation prices and avoid competitive bidding. In addition, special provisions might unintentionally create incentives for states to introduce state-sponsored plans, which would crowd out private reinsurance.

Can Private Markets Really Insure Against Very Large Losses?

Can private markets really be expected to shoulder more catastrophic risk? Two commonly stated motivations for government intervention are that more insurance against catastrophes is always good and that private insurance markets are unable to deal with ambiguity and uncertainty, particularly for very large risks. Some analysts question the validity of those motivations.

First, asset diversification is an alternative to insurance. However, individuals generally are less able than firms to diversify risks. Personal lines of insurance (for example, home, auto, and life insurance) help individuals mitigate a risk that is otherwise nondiversifiable. Most personal lines, however, cover losses from acts of terror; as argued earlier, coverage for natural catastrophes would also likely be available if the private market were not hampered in numerous ways. So the real question is whether large property owners should really be purchasing catastrophic protection.

Some firms and commercial properties may not need insurance against catastrophic risks, because their owners can effectively diversify risk. Large properties that are affected by government policies such as TRIA are typically owned by shareholders who are well diversified and have access to capital markets even after a loss (Cummins 2006; Doherty and Tinic 1981). Firms' demand for insurance, therefore, is typically much lower than that by nondiversified individuals. Firms owned by diversified shareholders optimally buy insurance only if the benefits from lowering informational asymmetries and other capital market costs exceed the underwriting costs. That condition is unlikely to hold in the case of catastrophic losses, where the capital market can easily identify the nature of the loss (Smetters 2004). Forgoing insurance and instead raising capital after a loss occurs is likely preferable for many companies to buying insurance. This suggests that the current take-up rate under the TRIA program may be inefficiently high because of the low price.²⁵

Second, are private insurers really incapable of dealing with ambiguity and uncertainty? U.S. capital markets other than those for insurance—those in equities, fixed income, and derivatives—routinely gain or lose \$100 billion on a daily basis, and often several trillion dollars in a single month. Much of this risk can be traced to new companies that have very little history or few close substitutes that investors can look to in order to accurately assess future earnings. Nonetheless, investors provide enormous amounts of liquidity to U.S. firms, producing one of the most efficient mechanisms for financing risky activity that has ever existed in the history of the world. It is unclear why private insurers should act any differently.

To be sure, supply in private insurance markets often contracts following a major disaster. For example, after September 11, 2001, terrorism exclusions in property-casualty policies began to be routinely enforced in 2002 for larger and more obvious targets, although major insurers of small and medium-size risks with annual premiums below \$1 million, including Travelers, still typically did not write such exclusions into policies for nonlandmark properties (A.M. Best Co. 2002). An anonymous survey by the Real Estate Roundtable, a proponent of TRIA, claimed that \$15.5 billion in real estate transactions had been delayed or canceled as of September 2002 because of concerns about terrorism insurance (Real Estate Roundtable 2002a, 2002b). It is likely that many of the postponed projects were on the verge of being delayed anyway, given the sharp cyclical reduction in commercial fixed investment before September 11 (Bureau of

²⁵ Of course, firms are sometimes required to purchase insurance in order to simplify the ratings process (CBO 2005, 10).

Economic Analysis 2001, Table 1). Moreover, even if this suspension of activity was mostly due to terrorism concerns, it constituted only a small fraction of the over \$600 billion in combined annual commercial and residential construction in 2001. Still, commercial construction activity had already started to shrink before September 11, and so the terrorist attacks clearly made things worse.

Private insurance markets, however, soon begin to add capital after a disaster. Moreover, the speed with which insurers resume adding capital after a major disaster has in general increased rapidly over time. It took several years for insurers to replace the capacity lost after Hurricane Andrew. Yet just a decade later, in the wake of September 11, insurers increased capital reserves by \$21 billion in just three months (Morgan Stanley 2001). The appearance of general agreement on a government backstop in late 2001 likely slowed the entry of even more capital into the insurance industry. However, many industry analysts argued that because of the uncertainty surrounding terrorism risk, most of the new capital was not backing the underwriting of such risk. Nonetheless, by September 2002 premiums had dropped by as much as 75 percent per unit of coverage from the beginning of the year. Limits, or the maximum amounts that can be paid out on a policy, as high as \$1 billion became available and were increasing over time (Shadow Financial Regulatory Committee 2002). At least ten start-up insurers were formed, and other insurers continued to add capital (Guy Carpenter Securities 2003). Two months before TRIA went into force, insurers already had added \$30 billion of capital, with another \$10 billion in new issues pending. Even the Building Owners and Managers Association, also a proponent of TRIA, acknowledged that three-quarters of owners of larger commercial and residential buildings had secured terrorism coverage.²⁶ The Shadow Financial Regulatory Committee (2002, 2), an independent group of leading academic scholars and experts, concluded, “Private insurance, reinsurance, and lending markets have made and are continuing to make substantial progress in adjusting to the post-September 11 world.” By September 20, 2007, insurer capital stood at \$522 billion, compared with \$290 billion at the end of 2001 (Hartwig 2007). A.M. Best Co. (2008) projected that insurers would realize record net earnings of more than \$59 billion in 2007. As the financial strength of the insurance industry improves, so, too, does its ability to bear catastrophic risks. Cyclical fluctuations, however, will remain a problem.

Alternative risk transfer products have also grown over time. Cat bonds, for example, hardly existed a decade ago but now account for about 8 percent of global property insurance limits, and ILWs for about another 4 percent. (The remaining 88 percent of global property limits are largely covered by traditional reinsurance.) These alternatives together accounted for less than 1 percent of risk limits a decade ago (Guy Carpenter Securities 2008, 5).

A 12 percent market penetration for alternative risk transfer mechanisms might appear at first glance to represent considerable growth, but in fact these mechanisms are still well short of their potential. As argued earlier, it is likely that prohibitive government regulation and existing tax rules severely limit the growth of alternative risk transfer

²⁶ See “Terrorism Insurance Survey Reveals Disturbing Trends,” PR Newswire, September 20, 2002.

classes, despite their superior ability to deal with basis risk and preferred creditworthiness.

Indeed, even the current figures might overstate the growth of these alternative securities, since many are actually fairly traditional in nature. Five of the twenty-seven cat bonds issued in 2007—accounting for \$2.3 billion of the \$7 billion in new issuance—used indemnity-based triggers, just as standard reinsurance does (Guy Carpenter Securities 2008, 23). These contracts have the look and feel of a traditional reinsurance policy, but the payoff after a loss takes the form of forgiving bond repayments from the primary insurer rather than a direct payment from the reinsurance company. Their main advantage over traditional reinsurance stems from having no credit risk. Moreover, another eight of the cat bonds issued in 2007—accounting for another \$1.7 billion of the \$7 billion in new issuance—used a combination of indemnity-based and another sort of trigger; these instruments, called “hybrid” or “modeled” contracts, therefore also require investors to have fairly detailed knowledge of the specific risks being insured. Almost all ILWs also embed some form of indemnity-based trigger (usually along with some other trigger).²⁷

Indemnity contracts are generally much less transparent and fail to provide capital market investors with a clean “pure play” in the general sources of catastrophic risk. Indemnity contracts also create moral hazard, which must be estimated, mitigated, and priced.²⁸ From a portfolio perspective, insuring catastrophic risk is mostly a pure “alpha play,” where returns are largely uncorrelated with the rest of the economy. So the supply side of capital for pure-play contracts should be fairly strong. However, the demand side appears to be fairly weak, probably because these contracts cannot count as a recoverable asset in most states.

Conclusions

Enabling capital markets to more easily finance catastrophic losses in a diversified manner is substantially more efficient than forcing nondiversified property owners to bear the losses without recoupment, which could lead to large ripple effects throughout the economy. This paper has examined how existing government policies play key roles in unintentionally limiting the amount of capital available to finance the nation’s catastrophic losses. Although government policies are typically motivated by clear and reasonable objectives when initially implemented, they often become outdated as markets innovate. Not surprisingly, policymakers routinely revise government policies and regulations in the face of changing conditions. This paper has examined several different

²⁷ The relevance of the indemnity trigger in ILWs depends on the threshold of the trigger. For example, if the indemnity trigger were set to \$1, then only the parametric trigger would be meaningful. ILWs have not received much regulatory scrutiny, presumably because they are not a large part of many issuers’ reinsurance programs.

²⁸ Some investors prefer indemnity contracts for reasons other than pure regulatory and accounting reasons. For example, some may be more comfortable with a specific insurer’s underwriting than having payouts determined by an index of industry-wide losses.

options to deal with today's changed conditions, including their benefits and potential costs.

Appendix A

Current Federal Terrorism Insurance Policy and the Options for Disaster Insurance

A federal financial backstop to private terrorism insurance coverage is in place through 2014. Lawmakers are also considering options for a more formal federal role in natural disaster insurance.

The Terrorism Risk Insurance Act

Before the attacks of September 11, 2001, insurers and reinsurers typically covered conventional acts of terrorism. Insured losses of all types from the September 2001 attacks reached nearly \$37 billion and were largely unanticipated.²⁹ The majority of those losses were borne by global reinsurers, many of which subsequently exited the market. In several states, including New York and California, primary insurers were required to continue to provide terrorism coverage, so they could not exit the market.

In response to fears that a shortage of terrorism insurance would slow economic growth, Congress passed the Terrorism Risk Insurance Act in November 2002. TRIA was intended as a temporary measure, designed to help insurers recover from the economic shock of covering the catastrophic losses of September 11 and to give the industry time to develop more accurate ways of modeling terrorism risk. The program was extended in subsequent legislation and was scheduled to expire on December 31, 2007, but was reauthorized.

Under TRIA, property and casualty insurance companies are required to offer commercial terrorism coverage. That coverage is subsidized by the federal government, which in 2008 agrees to pay 85 percent of an insurer's losses, above a deductible, in the event of attack by foreign terrorists. The insurer pays the deductible (20 percent of premiums in the previous year) and the 15 percent of losses not paid by the government, up to a total limit for the program of \$100 billion. The government does not charge for this coverage but would be required to recoup some of its costs after an attack by taxing all policyholders.

Although the capital lost to the insurance market after September 11 has since been restored, the private reinsurance market remains limited, with less than \$10 billion of coverage issued for the risks retained by the private insurers. Most industry analysts argue that the supply of reinsurance will remain constrained as long as estimates of expected losses from terrorism remain highly uncertain. Other analysts argue that federal reinsurance crowds out private reinsurance.

Congress considered two proposals to extend TRIA beyond 2007. The first, which was debated in the House of Representatives but ultimately rejected, would have extended the

²⁹ That estimate includes all insured losses, including group life and aviation, and is expressed in 2007 dollars. See Hartwig (2006).

program for fifteen years, lowered deductibles, added group life insurance, and required insurers to offer coverage for risks posed by weapons of mass destruction involving nuclear, biological, chemical, and radioactive (NBCR) materials.³⁰ Proponents of adding coverage for weapons of mass destruction argued that the government is likely to end up covering much of the losses from their use in any case, even without an explicit commitment to do so. Making the commitment explicit, but doing so through existing insurance, would have the advantage of using private insurers to underwrite risks, bear some of the losses, and adjust claims. Private insurers have largely excluded NBCR risks from their insurance policies because of their greater magnitude and uncertainty relative to conventional terrorism risks.³¹

In the end, Congress approved the Senate version of the TRIA reauthorization, which extends the program for seven years, maintains current deductibles, and covers attacks by domestic as well as by foreign terrorists.³² Covering domestic terrorism reduces the ambiguity of current law, particularly for cases in which domestic groups are acting in sympathy with, but not necessarily under the direction of, international terrorists. The bill did not require the offer of coverage for weapons of mass destruction. To satisfy budget scoring rules, the final version of the reauthorization required insurers as a group to reimburse the federal government for any outlays after an attack that are covered under TRIA. Those repayments would occur over time through assessments on commercial policyholders, including those that decline terrorism coverage. As before, insurers do not pay any premiums for the federal coverage.

Legislative Proposals Concerning Natural Disasters

Hurricane Katrina demonstrated that many homeowners were inadequately insured, because traditional homeowners' policies do not provide integrated multiperil coverage. Although most homeowners are insured against wind damage, including that from hurricanes, private insurance does not cover flood losses, which is provided separately through the federal government. Consequently, disputes arise over whether losses are covered under the contracts and who should pay. Disputes over whether losses should be attributed to wind or flooding ended up in the courts. Many insurers found themselves paying claims that they thought fell outside the policies, and many homeowners were left with uninsured flood losses.

A proposal before the House would allow FEMA to offer multiperil insurance for floods and windstorms (CBO 2007c). Currently the federal government insures only flood losses (up to a \$250,000 ceiling for residential properties and another \$100,000 for contents) and had to borrow \$17.5 billion to cover the claims from Hurricanes Katrina and Rita that the NFIP could not pay out of its reserves. Under the proposal, the federal government would insure against damages from flood or hurricane up to a maximum of \$650,000 per residence for structure, contents, and additional living expenses. Multiperil coverage would avoid the ambiguity of whether the losses were due to wind or flooding and so

³⁰ For more details see CBO (2007b).

³¹ Insurers do provide NBCR coverage in the workers' compensation line, because states mandate that there be no exclusions in that line.

³² For more details see CBO (2007d).

would likely reduce litigation. The government is supposed to charge actuarial rates for such coverage. However, some analysts contend that while the private sector may have strong incentives to overcharge, governments have strong incentives to undercharge (Stiglitz 2006). In particular, relative to private insurers, the government may find it harder to charge high rates for properties that pose the greatest risks. Consequently, the government might base rates on the average risks and suffer as a result from adverse selection.

The proposal as currently drafted thus does not provide sustainable long-term multiperil insurance, because it does not guarantee indefinite borrowing authority. If the multiperil program were to incur losses, additional borrowing authority would be needed to pay the claims. The costs to taxpayers would be recorded only when such borrowing occurred. The legislation would prohibit FEMA from renewing multiperil policies until such borrowing is repaid.

Congress is considering other approaches to increase the supply of catastrophe insurance and lower the premiums paid by policyholders. The House of Representatives passed the Homeowners' Defense Act of 2007 (H.R. 3355), which would create two federal direct loan programs for state reinsurance and insurance funds—one for liquidity purposes and one to cover catastrophic losses (CBO 2007e). The Florida Hurricane Catastrophe Fund and the California Earthquake Authority, as well as other existing state programs, would likely be participants. The loans, which would only be available following a disaster, would be backed by the full faith and credit of the state, and the terms would vary. If the state insurance funds are unable to access other sources of funds at reasonable rates, the federal government may extend liquidity loans at rates 3 percentage points above comparable rates for five- to ten-year terms. Loans may also be extended if the reinsurance program suffers insured losses greater than 150 percent of the property and casualty premiums written in the state over the preceding year. Demand for catastrophe loans is uncertain, because state reinsurance programs are not responsible for losses above their ceiling coverage level.

As amended, the proposal would also allow the establishment of a federal reinsurance plan for state reinsurance programs for losses of a magnitude expected to occur only once every 200 years, whether triggered by a single event or by multiple events. The federal government would cover 90 percent of losses above that amount and charge rates that, on an expected value basis, would be sufficient to cover the costs of claims.

Reinsurance coverage for natural catastrophes is available in the private market. The root problem is that because state programs charge below-market premiums (see appendix C), purchasing private reinsurance is an unattractive option. Because the federal reinsurance would be available with no markups above expected losses, which are highly uncertain for once-in-200-years events, private reinsurers would be unable to compete successfully for this business. Federal taxpayers would be at risk if the federal reinsurance contracts were underpriced.

Appendix B. Climate Change and Hurricanes

The recent increase in the frequency and intensity of Atlantic and Gulf Coast hurricanes may be due in part to human-induced warming. Evidence suggests that human activities are changing the global climate, and that the resulting warming is influencing patterns of sea-level rise, rainfall, and hurricane intensity around the world (Intergovernmental Panel on Climate Change 2007). Changes in those patterns could increase the risk of catastrophic damage in the United States from Atlantic and Gulf hurricanes.

However, it remains uncertain how large any contribution of warming to hurricane frequency and intensity might be, compared with the natural variability in hurricane intensities and the resulting increase in damages associated with continued development of the nation's coastal regions (CBO forthcoming). Several factors affect the development, frequency, and intensity of hurricanes, making them difficult to predict. The processes that drive hurricane development are sufficiently complex that the effects of climate change on the frequency and intensity of hurricanes are currently highly uncertain. To complicate matters, the factors that influence the frequency of hurricanes appear to be quite different from the factors that influence their intensity (Emanuel 2006a). Moreover, the net effect of warming on the frequency and intensity of hurricanes that strike the United States may differ from its effect in other parts of the world. As a result, no single catastrophe or even a single season of multiple catastrophes can be attributed solely or even primarily to human-induced changes in climate (Pilke et al. 2005).

Other things being equal, increases in ocean temperatures from global warming will raise the potential intensity of a hurricane: theory predicts that hurricane wind speeds should increase about 5 percent for every 1 degree Celsius (1.8 degrees Fahrenheit) increase in average sea surface temperature, and the destructive power of hurricanes rises with the cube of the wind speed. Consequently, even modestly more intense hurricanes could cause considerably greater damage. Researchers estimate that temperatures in the North Atlantic, where hurricanes striking the Atlantic and Gulf Coasts form, have risen about 0.67 degree Celsius since 1906, with just over 40 percent of the increase attributable to global warming (Holland and Webster forthcoming). Most global climate models project further increases in sea surface temperatures. Patterns of strong decrease of air temperature with altitude also contribute to hurricane formation, while patterns of high wind tend to reduce peak winds and thus retard hurricane formation.

However, research suggests that warming may also contribute to factors that tend to neutralize the formation and duration of hurricanes. The most important such factor is wind shear—horizontal winds that blow in different directions and speeds at different altitudes at a given location—which can disrupt the circular flow of hurricanes and break them apart.

The influence of wind shear on the development and intensity of storms remains rather poorly understood, but even modest amounts of vertical wind shear can prevent weak

disturbances from intensifying into hurricanes and may limit the intensity of storms that have already formed. It appears possible that climate change could lead to larger changes in wind shear than in potential intensity, tending to inhibit the development of hurricanes in spite of their increasing potential intensity. One recent study concludes that increasing wind shear caused by climate change could moderate any increase in both the intensity and frequency of hurricanes reaching the Atlantic and Gulf Coasts (Vecchi and Soden 2007). Moreover, recent studies that use proxy data to analyze the historical intensity and frequency of hurricanes conclude that variability in wind shear (rather than sea surface temperature) has been the dominant factor affecting major hurricane activity over the past few centuries to millennia (Donnelly and Woodruff 2007; Elsner 2007; Nyber et al. 2007).

Hurricanes are also influenced by quasi-periodic, multidecadal shifts in climate that affect hurricanes by heating or cooling the seas, and by changing regional patterns of wind shear (Goldenberg et al. 2001; Bengtsson 2001; CBO forthcoming). In the Atlantic those shifts include El Niño, the West African monsoon, and probably the Atlantic Multi-decadal Oscillation (Dailery and Zuba 2007; Donnelly and Woodruff 2007). Climate change therefore may ultimately affect hurricanes through its as-yet-uncertain effects on such multidecadal cycles.

At present, there is little evidence of a long-term trend in the number of tropical storms and hurricanes worldwide. There has been some upswing in the number of hurricanes in the North Atlantic after 1995, but the relative contributions of human-induced warming and other causes is unclear (Emanuel 2006b; Webster et al. 2005). Under the influence of the Atlantic Multi-decadal Oscillation, the Atlantic was unusually cool from the late 1800s to about 1930, warmer than its long-term average from the 1930s to the 1960s, cooler from about 1970 until 1995, and warmer than average again after 1995 (Dailery and Zuba 2007). Observed increases in hurricane intensity in the North Atlantic may also be due to multidecadal variability rather than climate change (Mann and Emanuel 2006).

A recently developed analytic technique, applied to results from climate models, indicates that global warming could reduce the global frequency of hurricanes but increase their frequency off the southeastern coast of the United States (Emanuel, Sundararajan, and Williams 2008). The study also found that the intensity of hurricanes may increase in some locations, including the North Atlantic.

Appendix C. State-Sponsored Insurance Funds

Proposals that the federal government extend loans to state-sponsored insurance funds or offer those funds reinsurance are partly motivated by the recent losses sustained by the Florida funds. Rather than being borne by the policyholders in the residual funds (those who cannot find willing insurers at the maximum allowable rates), the losses are largely shifted to all insured policyholders in the state through “assessments” or taxes on insurance policies. Analysts also recognize that none of the funds could pay for a supercatastrophe.

The Florida Hurricane Catastrophe Fund

The Florida Hurricane Catastrophe Fund was established in 1993, after Hurricane Andrew, to provide a cheap source of reinsurance. Florida requires that all residential property insurers operating in the state, including the Citizens Property Insurance Corporation, the state’s residual pool, purchase reinsurance from the fund. Premiums are a quarter to a third the rates charged by private reinsurers, according to some estimates, and even lower by others’ accounts.³³ The fund charges no risk loads to cover uncertainty surrounding either the timing or the amounts of the payments. After the losses experienced in 2005-06, a 25 percent rapid cash buildup factor was added to premiums in 2006, but the Florida legislature repealed that provision the next year. The fund’s maximum statutory payout is less than \$30 billion, so claims might not be paid in full after a major event (see State Board of Administration of Florida 2006, 2008; see also Florida Hurricane Catastrophe Fund 2007).

To pay claims of \$3.95 billion arising from the 2004 hurricanes (Charley, Frances, Ivan, and Jeanne) and claims of \$4.5 billion from the 2005 hurricanes (Katrina, Rita, and Wilma), the fund issued \$1.35 billion in municipal revenue bonds. The bonds are backed by a 1 percent emergency assessment beginning January 1, 2007, on all property and casualty lines (excluding workers’ compensation and, for a limited time, medical malpractice). The state’s assessment base for the taxes is about \$35 billion; the tax will apply to all homeowners’ policies and to auto insurance policies for the next six years. The state does not explicitly back any of the bonds issued by the catastrophe fund.

Florida’s Citizens Property Insurance Corporation

The Citizens Property Insurance Corporation is the largest property insurer in Florida, collecting over \$3.3 billion in premiums annually, with almost 1.4 million policies in effect as of October 21, 2007, including over 400,000 in high-risk areas that almost exclusively cover losses from wind.³⁴ The number of policies increased by nearly 500,000 between 2005 and 2006 following rate hikes in the private market. One of Citizens’ goals is to be able to cover a once-in-130-years event for the high-risk accounts. To pay claims in these accounts, however, assessments and policyholder surcharges would be triggered

³³ Government Accountability Office (2007, 20). The fund estimates that its rates are just one-fourth to one-fifth the price of private reinsurance. See also Florida Hurricane Catastrophe Fund (2007, 3).

³⁴ In August 2007 Citizens began offering a multiperil policy in the high-risk account that had previously covered only windstorm damage (Citizens Property Insurance Corporation 2007).

at a much lower level—after just a one-in-six-years event (Citizens Property Insurance Corporation 2007, slide 9).

Recent legislative changes have made Citizens a more attractive option for policyholders, making it more of an alternative market than a market of last resort. In 2007 the legislature rejected planned rate increases of 55 percent for wind coverage on top of an additional surcharge of nearly 25 percent (Citizens Property Insurance Corporation 2006). Rates for all Citizens policies were frozen for two years following double-digit rate increases in 2005 and 2006.

Deficits are covered by assessments on all property and casualty insurers and policyholders in the state. Assessments have been necessary even after relatively small losses, such as those experienced in 1995 after Hurricanes Opal and Erin. (Those assessments were levied by the predecessors to Citizens.) Large operating losses in both 2004 and 2005 also triggered assessments. The legislature decided to cushion the impact by appropriating \$715 million to reduce Citizens' 2005 deficit (liabilities in excess of assets) of \$1.8 billion. A regular assessment of \$163 million was levied, and an additional 1.4 percent emergency assessment was levied on most property and casualty insurance policies issued after July 1, 2007, which will raise \$888 million over ten years.³⁵ (Emergency assessments are levied if regular assessments and Citizens policyholder assessments are insufficient to fully fund the deficit.) The assessments will pay off \$4.7 billion worth of bonds issued by Citizens. These bonds are not explicitly backed by the state.

The California Earthquake Authority

Following the Northridge earthquake in 1994, California created a state-sponsored plan to offer earthquake insurance to homeowners. Like flood insurance, earthquake insurance is not part of a standard homeowners' policy but must be purchased separately. However, state law requires insurers to offer earthquake coverage as a rider to their homeowners' policies. To discourage insurers from withdrawing from the market, California modified its requirement by allowing insurers to offer the state-sponsored plan; private firms today provide only about 30 percent of policies purchased (Government Accountability Office 2007, 59).

Premiums are risk-based and vary depending on the home's location relative to a fault zone, its type of construction, its age, and the type of soil underneath it. Discounts are given for mitigation measures and retrofitting. Rates for basic coverage were reduced by an average of over 20 percent effective July 1, 2006. Claims have been minimal, totaling less than \$50,000 for 2005 and 2006, for example.

The California Earthquake Authority (CEA) insures about 750,000 policyholders and has a total claims paying capacity of \$8.2 billion (PriceWaterhouseCoopers 2007). As of June

³⁵ Citizens Property Insurance Corporation, financial statements for years ended December 31, 2005, and December 2004, available at www.citizensfla.com.

30, 2007, the CEA had a net worth of about \$2.7 billion;³⁶ most of that capacity is based on private reinsurance (\$1.8 billion), debt, and postevent assessments on participating insurers. Should capacity be insufficient to cover claims, payments would be either prorated or disbursed over time. The state has no legal obligation to stand behind the CEA, but many policyholders might assume an implicit guarantee.

Lack of coverage may be an issue after the next major earthquake. Only about 12 percent of households in California have earthquake insurance today, compared with about 30 percent when the Northridge earthquake hit. Many analysts believe that individuals have a difficult time making choices involving low-probability, high-consequence events. As more years pass without a big earthquake to remind them of the risk, drops in coverage might be expected (see Wharton Risk Management and Decision Processes Center 2008). However, the design of the policy is also a contributing factor; insured policyholders still bear substantial risk.³⁷ For example, the basic policy carries a deductible of 15 percent of the value of insurance on the property, rather than a dollar amount, which on a standard homeowners' policy might typically be \$1,000. In addition, the standard policy limits coverage for contents (\$5,000) and additional living expenses (\$1,500) and excludes coverage for swimming pools, patios, decks, and detached garages.

³⁶ California Earthquake Authority, unaudited balance sheet, June 30, 2007, available at www.earthquakeauthority.com.

³⁷ To reduce their exposure, policyholders could purchase private earthquake coverage by switching to one of the homeowners' insurance companies that does not participate in the CEA.

References

- AIR Worldwide. 2006. *Understanding Climatological Influences on Hurricane Activity: The AIR Near-term Sensitivity Catalog*. Boston, MA.
- A.M. Best Co. 2002. "A Year After Terror, Commercial Insurers Look Closer at Concentrations of Risk." *BestWire*, Oldwick, NJ (September 12).
- _____. 2008. "A.M. Best Special Report: U.S. P/C Industry Records Strong Results—But for How Long?" Press release. Oldwick, NJ (January 29).
- Bank for International Settlements. 2007. "Triennial and Semiannual Surveys on Positions in Global Over-the-Counter Derivatives Markets at End-June 2007." Basel (November).
- Bengtsson, Lennart. 2001. "Enhanced Hurricane Threats." *Science* (293) 5529 (July 20): 440-41.
- Bradford, David F., and Kyle D. Logue. 1997. "The Influence of Income Tax Rules on Insurance Reserves." Working Paper 5902. National Bureau of Economic Research, Cambridge, MA (January).
- Braun, Anton, Richard M. Todd, and Neil Wallace. 1998. "The Role of Damage-Contingent Contracts in Allocating the Risks of Natural Catastrophes." Working Paper 586D. Federal Reserve Bank of Minneapolis, Minneapolis, MN (April).
- Bureau of Economic Analysis. 2001. *Survey of Current Business*. Washington, DC: U.S. Department of Commerce (August).
- Citizens Property Insurance Corporation. 2006. "Citizens Board Votes to Table Rate Increase Pending Legislative Action." Press release. Jacksonville, FL (December 7).
- _____. 2007. "Citizens At-a-Glance." PowerPoint presentation to the House Insurance Committee. Jacksonville, FL (December 13). www.citizensfla.com/about/generalinfo.cfm?show=pdf&link=/shared/documents/citizensPresentation12-07.pdf.
- Congressional Budget Office. 1997. "CBO Cost Estimate for H.R. 230, Natural Disaster Protection and Insurance Act of 1997." Washington, DC (October 8).
- _____. 1998. "CBO Cost Estimate for H.R. 219, Homeowners' Insurance Availability Act of 1998." Washington, DC (September 23).
- _____. 2000. "Cost Estimate: H.R. 21, Homeowners' Insurance Availability Act of 1999." Washington, DC (February 9). www.cbo.gov/ftpdocs/18xx/doc1837/hr21.pdf.
- _____. 2002. "Federal Reinsurance for Disasters." Washington, DC (September). cbo.gov/ftpdocs/37xx/doc3787/09-20-FederalReinsurance.pdf.
- _____. 2005. "Federal Terrorism Reinsurance: An Update." Washington, DC (January). cbo.gov/ftpdocs/60xx/doc6049/01-05-Terrorism.pdf.
- _____. 2007a. "Federal Reinsurance for Terrorism Risks: Issues in Reauthorization." Washington, DC (August). www.cbo.gov/ftpdocs/85xx/doc8520/08-02-TRIA.pdf.
- _____. 2007b. "Cost Estimate: H.R. 2761, Terrorism Risk Insurance Revision and Extension Act of 2007." Washington, DC (September 6). www.cbo.gov/ftpdocs/86xx/doc8600/hr2761.pdf.
- _____. 2007c. "Cost Estimate: H.R. 3121, Flood Insurance Reform and Modernization Act of 2007." Washington, DC (September 20). www.cbo.gov/ftpdocs/86xx/doc8648/hr3121.pdf.
- _____. 2007d. "Cost Estimate: Terrorism Risk Insurance Program Reauthorization Act of 2007." Washington, DC (October 29). www.cbo.gov/ftpdocs/87xx/doc8761/TRIASenate.pdf.
- _____. 2007e. "Cost Estimate: H.R. 3355, Homeowners' Defense Act of 2007." Washington, DC (October 30). www.cbo.gov/ftpdocs/87xx/doc8774/hr3355.pdf.
- _____. Forthcoming. "The Expected Impacts of Climate Change in the United States." Washington, DC.
- Cummins, David. 2006. "Should the Government Provide Insurance for Catastrophes?" *Federal Reserve Bank of St. Louis Review* 88(4): 337-79.
- _____. 2008. "CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments." *Risk Management and Insurance Review* 11(1) (Spring): 23-47.
- Dailery, Peter S., and Gerhard Zuba. 2007. "Examining U.S. Hurricane Landfall Probability." *AIR Currents* (October 10). www.air-worldwide.com/-public/html/air_currentsitem.asp?ID=1333.
- Danzon, Patricia M., and Scott E. Harrington. 2001. "Workers' Compensation Rate Regulation: How Price Controls Increase Costs." *Journal of Law and Economics* 44 (April): 1-36. www.journals.uchicago.edu/doi/pdf/10.1086/320270.

- Dixon, Lloyd, and Rachel Kagnoff Stern. 2004. *Compensation for Losses from the 9/11 Attacks*. Santa Monica, CA: RAND Institute for Civil Justice (November).
- Dixon, Lloyd, et al. 2007. *The Federal Role in Terrorism Insurance: Evaluating Alternatives in an Uncertain World* (Santa Monica, CA.: RAND).
- Doherty, Neil A., and S. Tinic. 1981. "Reinsurance under Conditions of Capital Market Equilibrium: A Note." *Journal of Finance* 36: 949-53.
- Donnelly, Jeffrey P., and Jonathan D. Woodruff. 2007. "Intense Hurricane Activity over the Past 5,000 Years Controlled by El Nino and the West African Monsoon." *Nature* 447 (May 24): 465-68.
- Elsner, James B. 2007. "Tempests in Time." *Nature* 447 (June 7): 647-79.
- Elsner, James B., James P. Kossin, and Thomas H. Jagger. 2008. "The Increasing Intensity of the Strongest Tropical Cyclones." *Nature* 455 (September): 92-95.
- Emanuel, Kerry. 2005. "Increasing Destructiveness of Tropical Cyclones over the Past 30 Years." *Nature* 436 (August): 686-88.
- _____. 2006a. "Anthropogenic Effects on Tropical Cyclone Activity." Massachusetts Institute of Technology, Cambridge, MA. wind.mit.edu/%7Eemanuel/anthro2.htm.
- _____. 2006b. "Climate and Tropical Cyclone Activity: A New Model Downscaling Approach." *Journal of Climate* 19 (October 1): 4797-4802.
- Emanuel, Kerry, Ragoth Sundararajan, and John Williams. 2008. "Hurricanes and Global Warming: Results form Downscaling IPCC AR4 Simulations." *Bulletin of American Meteorological Society* 89 (March): 347-67. [ftp://texmex.mit.edu/pub/emanuel/PAPERS/Emanuel_etal_2008.pdf](http://texmex.mit.edu/pub/emanuel/PAPERS/Emanuel_etal_2008.pdf).
- Florida Hurricane Catastrophe Fund. 2007. "Changes in the FHCF Coverage Due to Legislative Changes." Tallahassee, FL (January 24). www.sbafla.com/fhcf/pdf/legislation/Special%20Session%20FHCF%20Changes%201-24-07.pdf.
- Florida Office of Insurance Regulation. 2008. "Florida Office of Insurance Regulation Files Formal Complaint to Suspend Allstate Companies' Licenses." Tallahassee, FL (February 19). www.floir.com/PressReleases/viewmediarelease.aspx?ID=2875.
- General Accounting Office. 2002. "Catastrophe Insurance Risks: The Role of Risk-Linked Securities and Factors Affecting Their Use." GAO-02-941. Washington, DC (September).
- _____. 2003a. "Catastrophe Insurance Risks: Status of Efforts to Securitize Natural Catastrophe and Terrorism Risk." GAO-03-1033. Washington, DC (September).
- _____. 2003b. "September 11: Overview of Federal Disaster Assistance to the New York City Area." GAO-07-72. Washington, DC (October).
- Goldenberg, Stanley B. et al. 2001. "The Recent Increase in Atlantic Hurricane Activity: Causes and Implications." *Science* (293) 5529 (July 20): 474-79.
- Government Accountability Office. 2007. "Natural Disasters: Public Policy Options for Changing the Federal Role in Natural Catastrophe Insurance." GAO-08-7. Washington, DC (November).
- _____. 2008. "Initial Results on Availability of Terrorism Insurance in Specific Geographic Markets." GAO-08-919R. Washington, DC (July 11).
- Grace, Martin F., and Robert W. Klein. 2007. "Facing Mother Nature." *Regulation* (Fall): 28-34.
- _____. 2008. "Insurance Regulation: The Need for Policy Reform." Paper presented at the American Enterprise Institute Conference on the Future of Insurance Regulation, Washington, DC (July 9). www.aei.org-20080707_GraceKleinInsuranc.pdf.
- Grace, Martin F., and Hal S. Scott. 2008. "Optional Federal Chartering of Insurance: Rationale and Design of a Regulatory System." Paper presented at the American Enterprise Institute Conference on the Future of Insurance Regulation, Washington, DC (July 9). www.aei.org/docLib/20080707_GraceScottOptionalFed.pdf.
- Grossi, Patricia, and Robert Muir-Woods. 2006. "The 1906 San Francisco Earthquake and Fire: Perspectives on a Modern Super Cat." Risk Management Solutions, Newark, CA. www.rms.com/Publications/2006_SF_EQ.pdf.
- Guy Carpenter Securities. 2003. "The World Catastrophe Reinsurance Market: 2003." Guy Carpenter & Company, New York, NY (September).
- _____. 2008. "The Catastrophe Bond Market at Year-End 2007." Guy Carpenter & Company, New York, NY (February).
- Harbin, Dana. 2006. "Hurricanes Katrina and Rita: Coverage Disputes and Pending Litigation." Institute for Risk Management, Dallas, TX (July). www.irmi.com/Expert/Articles/2006/cooper05.aspx.

- Harrington, Scott E. 2000. *Insurance Deregulation and the Public Interest*. Washington, DC: AEI-Brookings Joint Center for Regulatory Studies.
- Harrington, Scott E., and Greg Niehaus. 2001a. "Government Insurance, Tax Policy, and the Affordability and Availability of Catastrophe Insurance." *Journal of Insurance Regulation* 19(4): 591-612.
- _____. 2001b. "On the Tax Costs of Equity Finance: The Case of Catastrophe Insurance." Working paper, University of South Carolina, Columbia, SC (May).
- Hartwig, Robert P. 2006. "9/11 and Insurance: The Five Year Anniversary." Insurance Information Institute, New York, NY (September).
- _____. 2007. "2007—First Nine Months Results." Press release. Insurance Information Institute, New York, NY (December 19). www.iii.org/media/industry/financials/2007firstninemonths/.
- Holland, Gregg J., and Peter Webster. Forthcoming. "Heightened Tropical Cyclone Activity in the North Atlantic: Natural Variability or Climate Trend?" *Philosophical Transactions of the Royal Society*.
- Holtz-Eakin, Douglas. 2005. Statement before the House Committee on the Budget. Congressional Budget Office, Washington, DC (October 6; later published as "Macroeconomic and Budgetary Effects of Hurricanes Katrina and Rita").
- Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007: The Physical Science Basis: Summary for Policymakers*. Geneva (February 5). www.ipcc.ch/SPM2feb07.pdf.
- Kunreuther, Howard. 2006. "Has the Time Come for Comprehensive Natural Disaster Insurance?" In *On Risk and Disaster: Lessons from Hurricane Katrina*, eds. Ronald J. Daniels, Donald F. Kettl, and Howard Kunreuther. Philadelphia, PA: University of Pennsylvania Press.
- Kunreuther, Howard C., and Erwann O. Michel-Kerjan. 2007. "Climate Change, Insurability of Large-Scale Disasters and the Emerging Liability Challenge." Working Paper 12821. National Bureau of Economic Research, Cambridge, MA (January).
- Kunreuther, Howard, and Mark Pauly. 2006. "Rules Rather Than Discretion: Lessons from Hurricane Katrina." *Journal of Risk and Uncertainty* 33 (September): 101-16.
- Lane, Morton N., and Roger G. Beckwith. 2007. "A Half Term Report for 2007 Securitizations." Lane Financial, Wilmette, IL.
- Lewis, Christopher M., and Kevin C. Murdock. 1996. "The Role of Government Contracts in Discretionary Reinsurance Markets for Natural Disasters." *Journal of Risk and Insurance* 63(4): 567-97.
- _____. 1999. "Alternative Means of Redistributing Catastrophic Risk in a National Risk-Management System." In *The Financing of Catastrophic Risk*, ed. Kenneth A. Froot. Chicago, IL: University of Chicago Press.
- Litan, Robert E. 1990. "Earthquake! Planning and Paying for the 'Big One.'" *Brookings Review* (Fall): 42-48.
- _____. 2006. "Sharing and Reducing the Financial Risks of Future 'Mega-Catastrophes.'" Issues in Economic Policy 4. Washington, DC: Brookings Institution (March). www.brookings.edu/~media/Files/rc/papers/2006/03business_litan02/200603_iiep_litan.pdf
- Litan, Robert E., and Phil O'Connor. 2008. "The Consumer Benefits of an Optional Federal Charter: The Case of Auto Insurance." Paper presented at American Enterprise Institute Conference on the Future of Insurance Regulation, Washington, DC (July 9). www.aei.org/docLib/20080707_LitanO'Connor.pdf.
- Mann, Michael E., and Kerry A. Emanuel. 2006. "Atlantic Hurricane Trends Linked to Climate Change." *EOS* (American Geophysical Union) 87(24) (June 13): 233-44.
- McQueen, M. P. 2008. "Florida's Allstate Fight Intensifies." *The Wall Street Journal* (January 17): D4.
- Michel-Kerjan, Erwann, and Frederic Morlaye. 2008. "Extreme Events, Global Warming, and Insurance-Linked Securities: How to Trigger the 'Tipping.'" *Geneva Papers* 33: 153-76.
- Morgan Stanley. 2001. "An Update on WTC—Related Issues." New York, NY (December 12).
- Musulini, Rade. 1997. "Can Our Children Afford 'Affordable' Insurance?" *Emphasis* 2: 2-5.
- National Council on Compensation Insurance. 2006. "Comments to the President's Working Group on Financial Markets on the Long-Term Availability and Affordability of Terrorism Risk Insurance." Boca Raton, FL (April). www.ncci.com/ncci/media/pdf/Terrorism_NCCI_Presidents_Group.pdf.
- Nordhaus, William D. 2006. "The Economics of Hurricanes in the United States." Working Paper 12813. National Bureau of Economic Research, Cambridge, MA (December).
- Nyber, Jahan, et al. 2007. "Low Atlantic Hurricane Activity in the 1970s and 1980s Compared to the Past 270 Years." *Nature* 444 (June 7): 698-701.
- Pilke, R. A., Jr., et al. 2005. "Hurricanes and Global Warming." *Bulletin of the American Meteorological Society* 86(11): 1571-75.

- PriceWaterhouseCoopers. 2007. "California Earthquake Authority, Report on Audits of Financial Statements for the Years Ended December 31, 2006, and 2005." New York, NY.
- Priest, George. 1996. "The Government, the Market, and the Problem of Catastrophic Loss." *Journal of Risk and Uncertainty* 12(2/3): 219-37.
- Real Estate Roundtable. 2002a. "Survey Confirms Economic Toll of Terrorism Insurance Gap: Over \$10 Billion of Real Estate Projects Affected Across the U.S." Washington, DC (September 4).
- _____. 2002b. "Terror Insurance Drag on Real Estate Still Climbing: Over \$15.5 Billion of Projects in 17 States Now Affected." Washington, DC (September 19).
- Risk Management Solutions. 2006. "U.S. and Caribbean Hurricane Activity Rates: The New RMS Medium-Term Perspective and Implications for Industry Loss." Newark, CA (March). www.rms.com/publications/60huactivityrates_whitepaper.pdf.
- Rust, Edward B., Jr., and Kerry Killinger. 2007. "The Financial Services Roundtable Blue Ribbon Commission on Mega-Catastrophes: A Call to Action." Financial Services Roundtable, Washington, DC. www.fsround.org/media/pdfs/FINALmegacat4.pdf.
- Shadow Financial Regulatory Committee. 2002. "A Proposed Federal Backstop for Terrorism Insurance and Reinsurance." Washington, DC (September 23). www.aei.org/publications/pubID.14325/pub_detail.asp
- _____. 2006. "Federal Preemption for Financial Services Firms." Washington, DC (May 8). www.aei.org/research/shadow/publications/pubID.24338,projectID.15/pub_detail.asp
- Smetters, Kent. 2004. "Insuring Against Terrorism: The Policy Challenge." *Brookings-Wharton Papers on Financial Services* 2004: 139-82.
- State Board of Administration of Florida. 2006. *Florida Hurricane Catastrophe Fund, Fiscal Years 2005-2006 Annual Report*. Tallahassee, FL. www.sbafla.com/fhcf/pdf/reports/2005_2006.pdf.
- _____. 2008. "Florida Hurricane Catastrophe Fund." PowerPoint presentation to the Reinsurance Association of America. Tallahassee, FL (February 12). www.sbafla.com/fhcf/pdf/announcements/RAA%202-12-08.pdf.
- Stiglitz, Joseph E. 2006. "Panel Discussion: What Is the Appropriate Role of the Federal Government in the Private Market for Credit and Insurance? What Is the Outlook?" *Federal Reserve Bank of St. Louis Review* 88(4): 392-95.
- U.S. Department of the Treasury. 2008. *Blueprint for a Modernized Financial Regulatory Structure*. Washington, DC (March). www.treas.gov/press/releases/reports/Blueprint.pdf.
- Vecchi, Gabriel A., and Brian J. Soden. 2007. "Increased Tropical Atlantic Wind Shear in Model Projections of Global Warming." *Geophysical Research Letters* 34 (April 18) L08702, doi:10.1029/2006GL028905.
- Wallison, Peter J. 2006. "Groundhog Day: Reliving Deregulation Debates." Financial Services Outlook. Washington, DC: American Enterprise Institute (October). www.aei.org/docLib/20061019_200610FSOg.pdf
- Webel, Baird. 2007. "Insurance Regulation: Optional Federal Charter Legislation." CRS Report for Congress RL34286. Washington, DC: Congressional Research Service (December 14).
- _____. 2008. "Insurance Regulation: Issues, Background, and Current Legislation." CRS Report for Congress RL32789. Washington, DC: Congressional Research Service (April 23).
- Webster, P. J., et al. 2005. "Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment." *Science* 309 (September 16): 1844-46.
- Wharton Risk Management and Decision Processes Center (in conjunction with Georgia State University and the Insurance Information Institute). 2008. *Managing Large-Scale Risks in a New Era of Catastrophes*. Philadelphia, PA: Wharton School, University of Pennsylvania (March). www.opim.wharton.upenn.edu/risk/library/wharton_LargeScaleRisks_FullReport_2008.pdf.
- Wilson, James Q. 2007. "A Real Insurance Fraud." American Enterprise Institute, Washington, DC (November 28). www.aei.org/publication27158.