

Submission for the Journal of Insurance Regulation

**Tale of Two Regions:
Natural Catastrophe Insurance and Regulation in the
United States and the European Union**

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ABSTRACT

The risk of disaster is an important issue, regionally and globally. In particular, extreme events create major public policy issues related to catastrophe funding. Governments, responding to the public desire for economic security in light of disaster risk, have taken a variety of approaches ranging from full public funding to a laissez faire strategy to manage the challenge. This paper surveys governmental intervention strategies in the European Union and the United States in an effort to better understand the public policy options and implications of intervention as it relates to natural catastrophes. Both of these regions, with large and well-developed insurance markets, serve as models for consideration by less-developed regions prone to catastrophes as well as developed regions considering reform. Using the government approaches of these major insurance markets as guides, this study provides policy makers with a set of structural intervention choices, along with the implications they have for private insurance markets.

INTRODUCTION

During recent decades, natural catastrophes as well as man-made disasters have posed a rising threat to societies and the world economy. In 2009, economic losses due to natural catastrophes and man-made disasters were about \$62 billion (Swiss Re, 2010). The overall losses were highest in the U.S. and in Europe, exceeding \$20 billion (Swiss Re, 2010). One of the challenges of dealing with disasters relates to the volatility of losses. Figure 1 provides a visual representation of the volatility based on worldwide losses from 1980-2007.

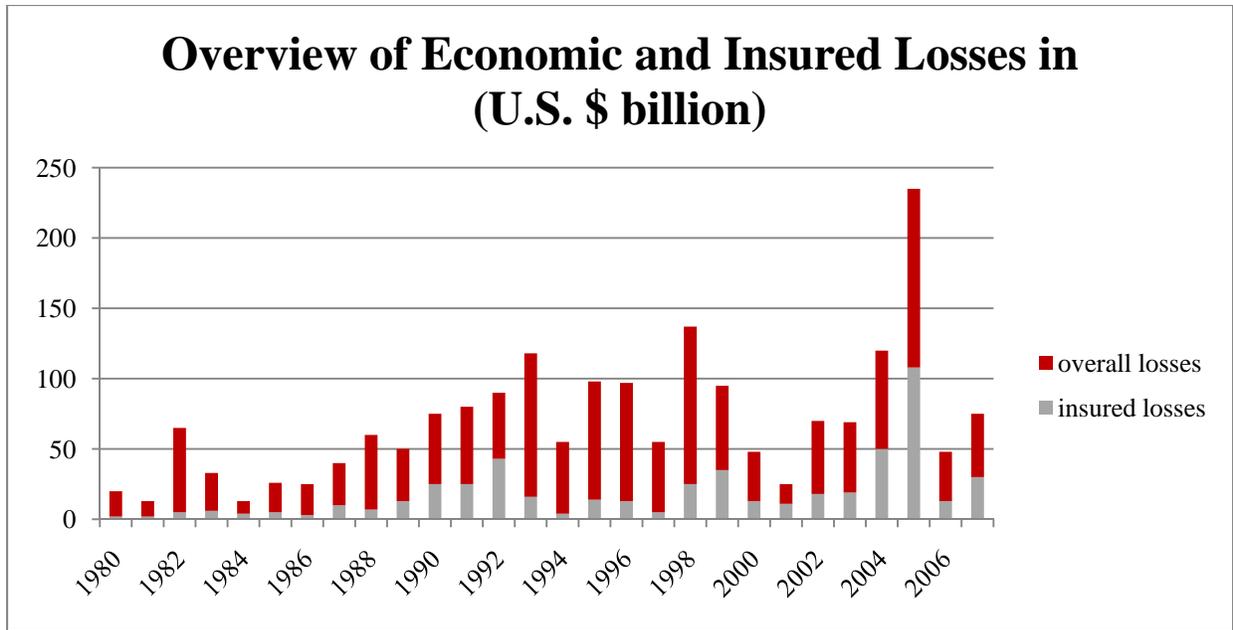


Figure 1: Economic and insured losses from 1980 – 2007 in 2008 U.S. Dollars
(Source: Munich Re NatCat Service, 2009)

Figure 1 also illustrates the often large difference between total economic and insured losses. From the standpoint of public policymakers, this is a key difference. In general, insured losses cover only a portion of the total financial losses resulting from an event (e.g. natural disaster). The uninsured portion of the losses can be substantial. For example, in 2009, worldwide insured losses were \$26 billion; however, this represented only 42 percent of the economic losses (Swiss Re, 2010). Uninsured losses result from 1) failure of the insurance market to offer adequate protection; or 2) buyers choosing not to purchase adequate insurance coverage. In the case of catastrophic risk, private insurers may not be able to adequately address the information problems they encounter in attempts to price and underwrite. Where they are able to arrive at rates in which they have confidence, buyers may have insufficient income to afford to pay (Skipper and Kwon, 2007).

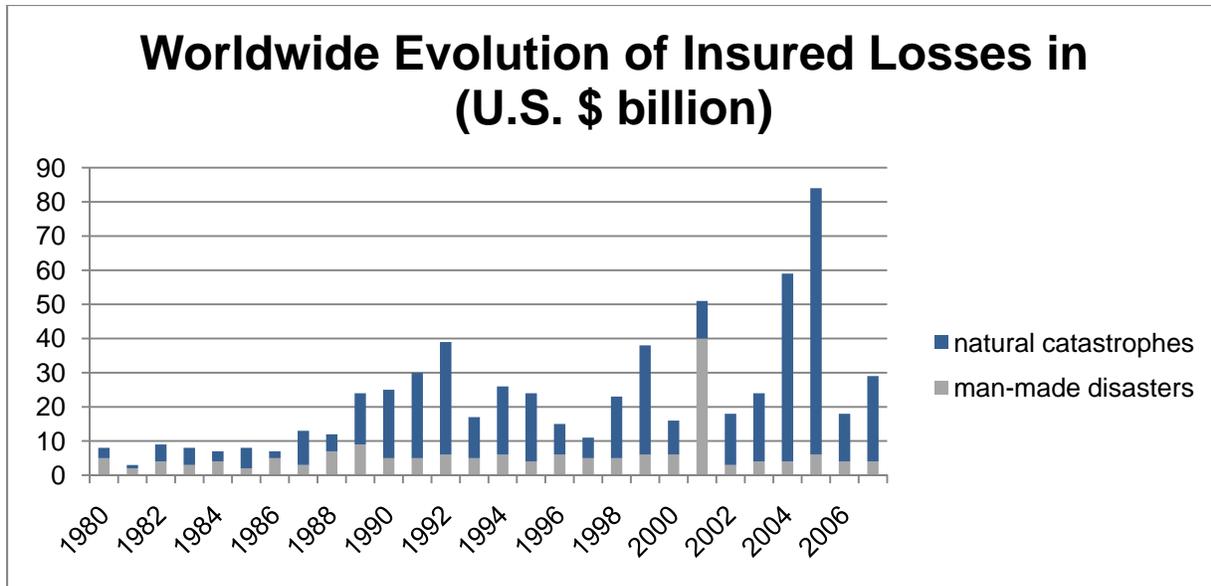


Figure 2: Overview of insured losses from 1980-2007 (in 2007 U.S. dollars)

(Source: Wharton Risk Center with data from Swiss Re and Insurance Information Institute)

According to data from Swiss Re, Munich Re, and the Insurance Information Institute (III), there has been a significant increase in both economic and insured losses in recent years (Doherty, Grace, Klein, Kunreuther, Michel-Kerjan and Pauly, 2010). While the losses stem from both natural and man-made causes, Figure 2 suggests that in most years, natural catastrophes dominate the insured losses around the world. For this reason, we focus our discussion on the treatment of natural catastrophes.¹

The significant increase in losses has several potential drivers. First, the frequency of natural disasters has risen. In the US, we have seen increased hurricane activity², while in Europe winter storms have created significant losses.³ Apart from the increase in the raw frequency of

¹ We also include a brief discussion of the Terrorism Risk and Insurance Act (TRIA) to highlight government intervention in man-made catastrophes.

² For example since 1944, there have only been seven hurricane seasons with five or more major hurricanes. Two of those were in 2004 and 2005 (Dumm, Johnson and Simons, 2009).

³ Winter storm seasons in 2005, 2007, 2009 and 2010 have been particularly high. In fact, each of these seasons saw a winter storm represented on the list of the ten most costly European winter storms of all time (Swiss Re, 2010).

notable loss events, the relative frequency of ‘great’ natural catastrophes has risen as well.⁴ The upward trend is noted in Figure 3. Second, the loss magnitude of catastrophic events has increased in recent years. The main drivers, other than the physical intensity of events, appear to be that both population and property values at risk in hazard-prone areas have drastically increased over time.⁵ Combined, these issues have resulted in a rising severity of disaster-level events during recent decades (e.g. Kunreuther, 2008). According to data from Munich Re (2010), the ten most costly losses since 1970 have all happened in the last two decades; seven of them can be assigned to the last decade.

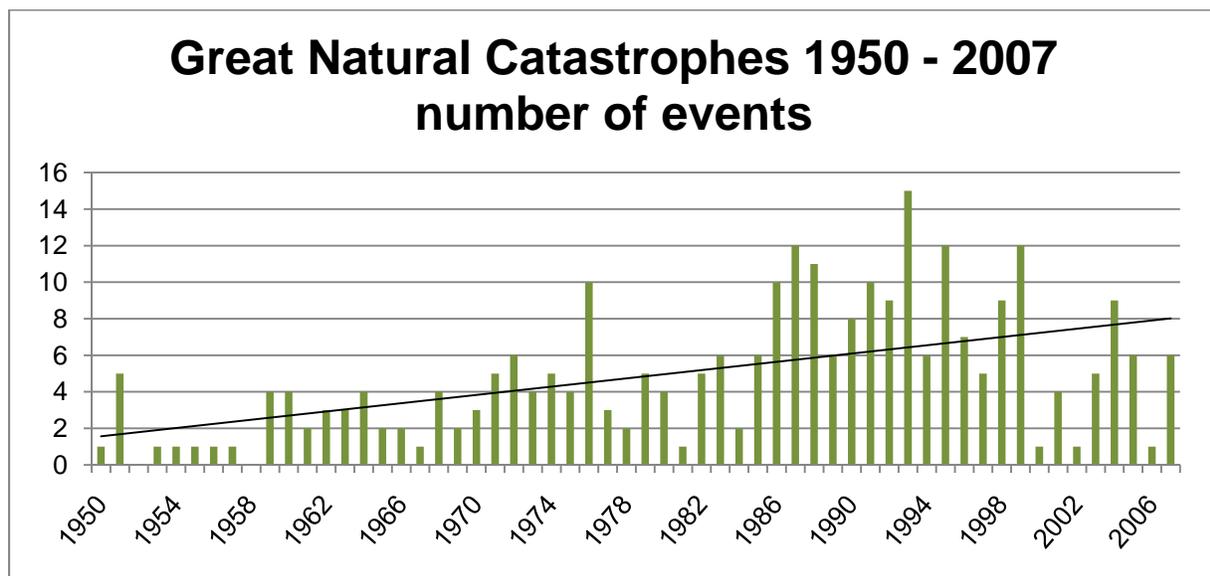


Figure 3: Overview of Great Natural Catastrophes 1950-2007

⁴ According to Munich Re, a natural catastrophe is considered ‘great’ if the region where the catastrophe occurs is unable to ‘help itself.’ In other words, regional economic losses, losses of life and social losses overwhelm the system, making interregional and/or international assistance necessary (Munich Re, 2003).

⁵ In the 1960s alone, the U.S. coastal population increased by 16%, from 95 million people to over 110 million; in the 1980s, the population grew another 11% (14 million). Between 2000 and 2010, the coastal population is estimated to have increased approximately 9% (NOAA). According to Schwarze and Wagner (2008), there are similar issues in Europe. In Germany, for instance, the population and settlement in flood-prone areas are increasing. These areas are attractive for property owners as well as industry. It should be noted that the path of the storms or weather patterns can greatly impact the economic damages. Thus, in some cases, had the systems moved through more populated areas, the total losses would have almost certainly been larger. So past losses may not be indicative of maximum possible losses.

(Source: Munich Re NatCat Service, 2009)

Considering their significant exposure to natural catastrophes and immense losses during recent history, the U.S. and Europe both have taken steps to deal with natural disasters and their economic consequences. This paper aims to analyze selected European catastrophe insurance markets and policies, and compare them with the catastrophe protection environment in the U.S. Marlett et. al. (2001a, 2001b) conducted a broad international review of mitigation and financing techniques. This paper focuses more specifically on public policy comparisons between the EU and U.S. and the implications for catastrophe financing primarily. Perhaps the first major realization is that while both the U.S. and EU have some consistency across their respective markets in terms of public policy response, specific differences at the state level in the U.S. and the country level in the EU provide examples of financial strategies to deal with heightened catastrophic exposures. We will highlight some of the regional policies, market interventions, and insurance facilities established in different states and countries to finance catastrophe perils. We also will describe the impact these have on insurance markets as well as consumers.

An examination of the array of techniques used by insurance markets and governments to finance catastrophe risks offers several insights. First, we can identify some best practices that can be applied to financing catastrophic loss in these and other locations and/or for other perils. We also may gain information on market failures useful in the development of public policy designed to help finance large losses. Given the global nature of the market for catastrophe insurance, as well as initiatives to develop international solvency and regulatory standards in the insurance industry, a better understanding of the similarities and differences of catastrophe insurance markets is important.

We begin by contrasting the size of the EU and U.S. insurance markets as well as their exposures, both in terms of the likelihood of catastrophes and the values at risk. We then briefly summarize the regulatory framework in which EU and U.S. insurers operate. Finally, we analyze how the risk factors combine with the market and regulatory factors to create a regional strategy for funding catastrophic loss.

THE ENVIRONMENTS FOR INSURANCE AND CATASTROPHES

Before comparing the types of regulatory interventions in the marketplaces by governments, we first need to understand the size and nature of the private insurance markets in the U.S. and Europe as well as the natural catastrophe exposures in different regions. This is followed by a discussion of the major natural catastrophe exposures. Once we understand the scope of both the private market capacity and the overall exposures we can then begin to look at the types of governmental intervention that has occurred in these markets.

Size of the Insurance Markets

The pure size of the U.S. and European Union insurance markets make them important areas of focus for this type of study. For example, the U.S. insurance market is the largest national market in the world, accounting for about one quarter of the \$4.22 trillion⁶ worldwide insurance premiums in 2008, (Swiss Re, 2009). However, in 2008, the private market of the EU, accounted for the equivalent of about \$1.5 trillion, making the region's insurance market slightly larger than the U.S. market, with its net written premiums of \$1.1 trillion in the same year. The split of aggregate premiums between life and nonlife insurance is similar for the U.S.

⁶ This figure dropped to about \$4.06 trillion in 2009, largely due to the global financial crisis and its affect on insured values, according to Swiss Re (2010).

and EU.⁷ Despite the comparability of overall insurance market size between the EU and the U.S., United States' risk market penetration appears to be substantially higher than that of the EU. According to Swiss Re (2010) and Swiss Re (2009), Europe's 2009 insured losses represented 29.3% of its economic losses compared with 48.2% in the U.S.⁸ In part, this may be the result of the types of regulatory interventions describe later in this study.

Natural Catastrophe Exposures

Both the EU and the U.S. are subject to meteorological, hydrological and geophysical events. However, the exposure to each natural peril is generally geographically concentrated. For example, hydrological events such as flood and mudslide are common in the EU and US. In the EU, these events mainly occur in Great Britain and Eastern Europe although within the past five years Switzerland and France have suffered catastrophic losses to flood as well. Flood losses are often severe. According to Swiss Re, six of the ten most costly losses consisted, at least in part, of flood damages.⁹

In many cases, the peril of flood is related to catastrophic storms, which have disastrous wind as well as flooding potential. According to the Munich Re World Map of Natural Hazards (2009), Europe's exposure to storms is concentrated in the central part of the continent, especially in Germany, the Netherlands and France. The U.S. exposure to meteorological events such as storms and hurricanes mainly exists along the U.S. East coast and in the Gulf of Mexico.¹⁰ Comparing the EU with the U.S. exposure, recent losses reveal that the severity of the

⁷ Approximately 61% of overall EU insurance premiums are life premiums as compared with 59% in the U.S., and 49% are non-life premiums as compared with 41% in the U.S. Property insurance accounts for 20% of overall non-life premiums (CEA, 2010).

⁸ The European insurance market penetration represents a marked improvement over 2008, when only 11.1% of economic losses were insured (Swiss Re, 2009).

⁹ These floods were due to major hurricanes in the U.S. (Swiss Re, 2009).

¹⁰ On average the U.S. East Coast has had 5.57 hurricanes per year with 2.1 of them making landfall. Florida is the state most exposed to hurricanes. (www.iii.org)

storms can be on a similar scale. For instance, Windstorm Kyrill in 2007 caused economic losses of \$10 billion, virtually comparable to Hurricane Rita in 2005 which caused economic losses of \$15 billion (Swiss Re, 2006, 2008).

Finally, geophysical events such as earthquakes pose a catastrophic threat to the EU and the U.S. even though they can be expected to occur with lower frequency than meteorological and hydrological events.¹¹ According to the Munich Re Map of Natural Hazards, within the EU, most exposed to earthquakes are regions near the Alps such as Austria, southern Germany and Italy. Also according to the Map, while the U.S. exposure is primarily concentrated in California, states in the Midwest and Mid-south affected by the New Madrid Fault, as well as other parts of the country sit along fault lines, thus making the country's geographic exposure to future earthquake significant.

The Insurance Regulatory Environment

The regional concentration of natural catastrophe exposure has partially contributed to the fragmented way in which the U.S. and EU have chosen to address the issues. However, another key factor impacting the regional solutions lies in the overall structure of insurance regulation for each market. For example, in the U.S., the insurance market is regulated largely at the state level. The National Association of Insurance Commissioners (NAIC) does create some uniformity in insurance regulation across the U.S.¹²

¹¹ Even though expected losses caused by disasters such as earthquakes are nearly as high as they are for hurricanes, those hazards differ regarding their frequencies. Whereas there have been just a few earthquakes in the past, the U.S. east coast is hit by a hurricane making landfall on average twice a year (Swiss Re, 2008).

¹² The National Association of Insurance Commissioners (NAIC) was founded in 1871 as a voluntary organization at the federal level that consists of the insurance regulators of each state, the District of Columbia and the U.S. territories. The NAIC develops model laws and model regulations although the state insurance departments are in charge of creating enforceable laws as well as regulatory activities. The scope of state regulatory activities affecting catastrophe risk management include rate regulation, regulation of underwriting practices, residual market mechanisms, regulation of claims handling, and solvency regulation (Grace and Klein, 2009; Randall, 1999).

The European Union (EU) attempts to create a single market. General speaking, the EU faces almost the same challenges as faced by the NAIC, but the circumstances are different (Klein and Wang, 2009). The main differences are due to the fact that the EU consists of sovereign member states. Several regulatory standards such as Solvency I and Solvency II have been partially aimed at the goal of harmonizing the insurance market. These standards regulate capital requirements and accounting guidelines and are therefore focused on the financial strength of the European insurance market (Klein and Wang, 2009). Each nation regulates conduct of the insurance companies and related businesses within its insurance marketplace.

The solvency capital requirements prescribed by Solvency II are arguably much more stringent than the risk-based capital requirements required by U.S. insurance regulators (Klein and Wang, 2009). Capital and surplus available to pay catastrophic claims can be critical. In the U.S., for instance, a number of insurers became insolvent due to Hurricanes Iniki, Andrew and the 2004-2005 hurricanes. The 2004-2005 hurricanes resulted in the failure of five insurers in Florida and approximately \$1 billion in claims that had to be covered by the Florida Insurance Guaranty Association. The costs of those claims were assessed back against private insurers and ultimately passed on to their policyholders. Grace and Klein (2009) discuss how lax solvency regulation may have contributed to the failure of these companies.

While the national markets within the EU have quite uniform capital requirement standards, there are varied approaches as to how to deal with natural catastrophes and loss compensation. Similarly, the U.S. insurance marketplace, despite efforts to achieve greater uniformity of insurance regulation across states, remains fragmented by state regarding how to prepare for catastrophes. The next section highlights key catastrophe funding strategies used in

the EU and the U.S. government intervention in loss funding varies widely, as do the outcomes and challenges.

COMPARATIVE ANALYSIS OF NATURAL CATASTROPHE MANAGEMENT

In order to address the challenges of insuring catastrophic risks, governments have intervened, in part, by providing additional capacity for the funding of catastrophic losses. A comparison of the various U.S. approaches with that of select EU countries reveals how differently various countries and regions view the government's role in providing economic security in light of catastrophic exposures. These alternative approaches, having different strengths and weaknesses, offer insights about the effects of alternative forms of government intervention in catastrophe management.

Insurance for catastrophes may carry two types of positive externalities, or benefits, to society: 1) reduces an individual or business's pre-loss residual uncertainty, making risky decisions (such as choice to live or construct new factories near large water sources) less onerous; and 2) reduces an individual or business's private cost on a post-loss basis, thereby decreasing the destabilizing economic effects of disasters (Skipper and Kwon, 2007). Policy makers hold varied perspectives on whether catastrophe insurance and financing should be treated as a public good, depending both on how widespread they believe the benefits of catastrophe insurance to be and on the extent of social adequacy (as opposed to individual equity) that is considered the cultural norm. This paper reviews a variety of examples of both factors from the EU and the U.S.

Approaches to catastrophe management are compared here using a taxonomy that classifies each according to the extent the government intervenes in the financing of catastrophe losses. The examples provided include systems that:

- 1) Rely heavily on private market solutions alone, and thus incorporate risk-based pricing;
- 2) Have a foundation in private markets and risk-based pricing but because of mandatory insurance requirements and/or the inability for many to avoid or adequately mitigate, include a residual market that allows for limited cross-subsidization of risk;
- 3) Rely heavily on government-sponsored, or social, insurance solutions, either at the primary, reinsurance level or both, thus incorporating cross-subsidization in pricing; and
- 4) Primarily compensate for losses ex-post through government disaster assistance.

The extent to which government intervenes may be primarily associated with the characteristics of the disaster risks faced, although it can be argued that such decisions are politically highly-charged as well. The treatment of government choice in the current research does not attempt to determine the degree to which politics plays a role in a government's decision to intervene. Instead, the intent of the authors is purely to illuminate the array of government interventions chosen given the disaster risk factors, without political speculation.

The nation members of the EU as well as individual states within the U.S. have created a variety of types of intervention for pre-loss funding of natural catastrophe risk. The U.S. solutions, however, do not tend to parallel the various EU strategies in their specific purposes. In the U.S., government involvement in managing catastrophe risk has been largely decided on a peril-by-peril basis while European countries typically take a multi-peril view of their intervention responsibilities. In general, U.S. state interventions on a pre-loss basis only occur

with regard to catastrophic perils that pose a particularly high threat to that state – with respect to event likelihood and magnitude as well as existing evidence that private insurance to fund the risk is largely unavailable or unaffordable. Two notable exceptions are the National Flood Insurance Program (NFIP) and TRIA, government-sponsored insurance programs aimed at flood and terrorism risks, respectively. It is also important to note that in contrast to some of the EU solutions, none of the U.S. strategies mandates participation by citizens, at least not by statute.¹³

Private Insurance Market Solutions

Government strategies for pre-catastrophe financing vary widely. Germany and Great Britain for instance rely on insurance market oriented solutions, meaning that coverage for natural disasters is available in a competitive insurance market.

Non-Subsidized Private Insurance: The German and UK Approaches

Some countries have elected against government intervention that incorporates a government-run facility or subsidized private market pricing. In Germany for instance, flood insurance is not subsidized by the state. Flood insurance rates therefore depend on a property's value and location (Schwarze and Wagner, 2004). As a consequence, premiums tend to be high, especially for regions highly exposed to flood risk. The gap between insured and uninsured losses can be considerable. The Elbe flood in 2002 for instance caused damages of Euro 11.6 billion of which only Euro 1.8 billion or just over 15 percent was insured losses (Munich Re, 2003).

¹³ The majority of homeowners in the U.S. require mortgage financing. U.S. lenders virtually always require hazard insurance be secured for the property, at a minimum policy amount that will cover the loan payoff in the event of an insured loss. Thus, effectively, most U.S. homeowners must participate in property insurance.

Great Britain has similar problems regarding insurance coverage as well as capacity. In Great Britain, catastrophe insurance is available within a bundled policy in an effort to create diversification across different types of hazards (Huber, 2004). This design results in pockets of capacity constraint. As insurance companies try to avoid substandard risks, insurance against flood is either not available or not affordable in a couple of regions in Great Britain where floods occur historically with some frequency (Ungern-Sternberg, 2004).

There are both costs and benefits to the approach of Germany and Great Britain's programs. From an economic perspective, the designs of the programs in Germany and Great Britain provide a relatively high level of actuarial soundness. This provides for a high level of ex-ante loss control (Kunreuther, 2006).¹⁴ As a consequence, policyholders can reduce their premiums by developing effective loss prevention methods such as mitigation or risk avoidance (e.g. not moving to a hazard-prone area). Hence, fair premiums reduce the effects of moral hazard as policyholders can improve their insurance ratings through mitigating behavior.

There is an additional significant benefit of the British system. Considering the common traits risks should have in order to be considered insurable, the independence of risks within a portfolio is important. Ideally, each loss occurrence should be independent from similar losses. As natural hazards tend to be accumulation risks, such independence is difficult to achieve. The British system, by bundling several natural hazards into one insurance policy (Huber, 2004), comes closer to achieving the desired loss independence on a portfolio basis than do other systems. Additionally, bundling different risk types into one package also increases market

¹⁴ That means that policyholders purchase insurance coverage in exchange for a price that reflects their individual risk.

penetration. For instance, much like in the U.S., mortgages will only be available to British property owners who purchase insurance coverage against natural hazards (Huber, 2004).

Non-Subsidized Private Insurance: The New York, Arkansas and Tennessee Approaches

In the U.S., there are regions where, despite considerable exposure, private markets still effectively offer coverage. New York State is significantly exposed to tropical windstorm risk although it has not experienced a severe storm in many years. Arkansas and Tennessee are both exposed to a substantial earthquake risk, with the New Madrid Fault Zone crossing the shared boundary of these states. To date, however, the New Madrid has produced no major insured losses. Given the lack of severe loss history, all three of these states still rely heavily on the private insurance market to provide protection for their citizens.

What states in the U.S. have in common that have chosen a purely competitive market strategy for catastrophe coverage is the lack of recent (or any) severe loss history. New York is exposed to a substantial threat of tropical storms; a record 15 hurricanes made their way into the North Atlantic in 2005 (New York City Office of Emergency Management, 2010). Fortunately for the state's citizens and insurance carriers, the most severe losses resulting from tropical storms have been from flood rather than wind itself (New York City Office of Emergency Management, 2010). As for the earthquake risk in Arkansas and Tennessee, three powerful earthquakes shook the region near the New Madrid Fault in the winter of 1811-1812, "causing landslides and disrupting river commerce" but no major quakes have been felt since (Shelby County Tennessee Office of Emergency Management, 2010). In each of these states, it appears by reading insurance trade press that rather than shy away from insuring these catastrophic exposures, insurers utilize the exposure to catastrophic loss as an advertising tool, encouraging

homeowners and businesses to purchase adequate insurance to protect against a worst-case event (Best's Review, 2010).

Private insurers are generally more willing to cover catastrophic perils in areas where the risk is perceived to be relatively low. Insurers use models to assess catastrophe risk and do not rely on historical loss experience for assessing catastrophe risk. There have been some issues regarding the cost and availability of homeowners insurance in coastal areas in the Mid-Atlantic and Northeastern states (e.g., Long Island), but these issues have been much less significant than in the Southeast and Gulf Coast states. The perceived risk in the coastal areas in the Mid-Atlantic and Northeast is lower because the estimated probability (frequency) of severe storms/hurricanes is much lower in these states than in the Southeast and Gulf Coast.

Subsidized Private Market Solutions: The Florida and North Carolina Approaches

In most U.S. states that are particularly catastrophe prone, a state residual market exists to provide all-risk insurance coverage for properties unable to find affordable private market coverage or specified-peril coverage for properties across the state. All of the states in the Southeast and Gulf Cost have residual market mechanisms that cover wind risk from hurricanes.¹⁵ Some have separate wind pools and others use FAIR plans or a state sponsored insurance company to cover both wind and non-wind perils. We use the states of Florida and North Carolina as examples of such residual markets. Florida and North Carolina, both exposed to severe tropical storm potential and both having recent hurricane loss history to differing degrees of severity, have both opted for private and government options to protect citizens and their property from storm damages.

¹⁵ See Cole, et. al. (2009a and 2009b) for descriptions of various programs in coastal states.

Citizens Property Casualty Insurance Corporation (Citizens) in Florida was created by Florida statute in 2002 to serve as a market of last resort for property (especially homeowners) insurance and now also serves as a competitive insurer. North Carolina, also taking action against the threat of coastal weather risk to the health of the state's insurance industry, formed the North Carolina Insurance Underwriting Association, known as the Beach Plan, to provide insurance coverage for homeowners on the state's coast.¹⁶ North Carolina laws places more restrictive limits on the coverage that can be sold by the Beach Plan in comparison to what Citizens is allowed to sell in Florida.

In different ways, each of these states creates cross-subsidization from non-coastal to coastal risks. In North Carolina, the subsidy is a product of contributions required to be made by all North Carolina property insurers to the Beach Plan's operations. In Florida, the subsidization is less direct and results from the interpretation of state statutes regarding Citizens property policy pricing and post-loss assessments of insurers doing business in the state.¹⁷ Florida has had severe availability problems with respect to the private market place in coastal areas that have been exacerbated by tight constraints on homeowners insurance rates in these areas. During this period of rate constraints (roughly 2007 to present), there has been significant growth in Citizens; the number of policies in force in Citizens has grown from 400,000 in 1993 to 1.3 million as of March 2011. It accounts for approximately 20 percent of the total amount of homeowners insurance written in Florida with heavy concentrations of exposures in coastal areas (Florida Office of Insurance Regulation, 2011).

Florida is unique in that it is the only state with a government-sponsored reinsurer – the Florida Hurricane Catastrophe Fund (FHCF). The Florida Hurricane Catastrophe Fund (FHCF), however, is a public reinsurer intended to stabilize reinsurance affordability and availability for primary

¹⁶ For more information, see Cole et al (2009) and Marlett (2009).

¹⁷ See Newman and Nyce (2009) for a more complete discussion.

property insurers operating within the hurricane-prone state. The FHCF was created to provide a less expensive voluntary source of reinsurance for hurricane risk. It does have one inherent cost advantage over private reinsurance because it is not subject to federal or state taxation, but its much-lower-than-market rates have contributed to deficits it has incurred due to losses from the 2004-2005 hurricanes. The Fund's capacity to cover hurricane losses in the future is questionable. Like the state's residual insurer, Citizens, the FHCF can assess multiple lines of insurance policies throughout Florida on a post-loss basis. According to Cole, et. al. (2011), an inability of the Fund to cover hurricane losses in a given year results in subsidies from future policyholders (not just in property lines) to the current policies in force.

Market penetration is extremely high in Florida and North Carolina, and insured values are substantial. Both states require insurers to offer discounts for storm mitigation efforts by policyholders in an effort to promote voluntary fortification of property, and thus reduce the magnitude risk associated with windstorm events.

Government-Sponsored Insurance Solutions

While some regions manage catastrophe risk on a largely market-based rating system, others have government-oriented solutions for insuring natural catastrophes. France offers a reinsurer of last resort for natural disaster insurance owned by the government. California, with its history of high-magnitude earthquakes, has chosen to create a state-sponsored insurance fund called the California Earthquake Authority (CEA) to provide voluntary earthquake coverage to its citizens.¹⁸ Additionally, in the U.S. there are two national level programs related to catastrophe risk — The NFIP and TRIA. The Spanish system is the most government oriented,

¹⁸ Private insurers are still allowed to write earthquake coverage.

with mandatory natural catastrophe insurance offered at the federal level by the state monopolistic Consorcio de Compensacion de Seguros (Ungern-Sternberg, 2005). Each of these versions of government intervention is discussed below.

Mandatory Private Insurance with Subsidized Government Reinsurance Option: The French Approach¹⁹

France only offers reinsurance, rather than ‘ground-up’ insurance, at the Federal level. Private market primary insurers offer disaster insurance but are allowed to share these risks with the state-owned reinsurer, Caisse Centrale de Reassurance (CCR).²⁰ The CCR is not a monopolistic disaster reinsurer. In fact, there are several reinsurers writing business with primary reinsurers in France. The CCR is only an optional source of reinsurance for primary insurers, providing reinsurance coverage for multiple types of natural hazards except storms (Michel-Kerjan, 2001).

¹⁹ Apart from the French system of publicly reinsuring natural catastrophes, Great Britain’s Pool Re serves as a reinsurer of last resort for the coverage of terrorism risk. Basically, the major goal of Pool Re is to provide the market with additional capacity to insure property against terrorism losses. Pool Re is structured as follows: Primary insurers collect an additional premium for terrorism coverage depending on the risks (e.g. the city-center of London is charged more than suburbs). Those premiums are forwarded to Pool Re. If claims exhaust the capacities of Pool Re, each insurer must deposit another 10% of the premiums that have been already paid to the pool. Not until these premiums are exhausted, will the state intervene as insurer of last resort (Kunreuther, 2002). In this case, the state provides Pool Re with a guarantee similar to a stop-loss treaty, but this retrocession is not free. The government charges premiums for reinstatements as necessary after a major flood occurs (Thomann, 2003).

²⁰ The CCR was created in 1946 when 34 insurers were nationalized. Today, the CCR belongs to the top 20 reinsurance carriers in the world with a AAA rating from Standard & Poor’s (CCR, 2010). The CCR’s basic structure consists of a two-fold insurance cover. This dual coverage system compounds a 50% quota share and a stop loss treaty with an unlimited governmental guarantee (Michel-Kerjan, 2001). Under the quota share treaty, the insurer cedes a proportion of its premiums and its risk to the CCR. The quota share treaty is supposed to protect the CCR against anti-selection issues (CCR, 2010). That means that the primary insurers have an incentive for appropriate underwriting methods due to their obligation to retain a specific portion of the risk themselves. The layer that is not covered by the quota share treaty is subject to stop-loss coverage. Consequently, the insurer can protect itself against high frequency as well as high severity hazards. The CCR’s coverage scheme is a dual coverage system consisting two separate treaties: a quota share and a stop-loss treaty.

In France, disaster coverage is compulsory and automatically added to the property insurance contracts (Cummins, 2006). Further, property and casualty insurance is mandatory for all property owners and tenants. Consequently, there is an extremely high insurance coverage density. The extra premiums collected for disaster coverage are received by the primary insurers which then decide if they want to retain or cede these risks to either a private reinsurer or to the CCR. A primary insurer can charge an additional loading to their premium in order to voluntarily purchase reinsurance coverage from the state (Michel-Kerjan, 2001).

According to Michel-Kerjan (2001), the CCR is an example of an effective sharing of risks between the private and public sectors that has been able to compensate past losses well. The unlimited stop-loss guarantee provided by the state distributes the CCR with extraordinary financial strength. Nevertheless, the French system suffers from significant adverse selection issues because the catastrophe portion of the primary insurance coverage is mandatory and the corresponding share of the premium is the same for all homeowners, yet primary insurers reinsure with the CCR voluntarily, subject to a rate structure that is not property-risk sensitive. As a consequence, primary insurers tend to reinsure only the substandard risks while keeping the preferred risks in their own book of business (Ungern-Sternberg, 2003).

The CCR's storm exclusion complicates reinsurance claims settlements. In 1999, for instance, France experienced a number of severe storms not covered under the CCR contracts. However, due to the fact that these storms also caused major floods in some areas it became unclear which of the water damages were due to flood and which were due to wind (Michel-Kerjan, 2001). This program challenge is arguably more complex than systems in which the losses are paid based on the primarily layer of coverage. Therefore, French primary insurers must

compensate for all insured flood losses without full knowledge at time of claims settlement of the amounts of reimbursement are forthcoming from the CCR.

It is questionable to what extent the French system is capable of dealing with the next big event. On one hand, France has unlimited coverage that can offset damages, but on the other hand it will be the taxpayers who ultimately pay much of these damages. Thus, the French system is based on social adequacy rather than equity, resulting in intentional cross-subsidies between different classes of risk. As discussed before, cross subsidy is non-optimal from an economics perspective and also ineffective in terms of incentives for individual mitigation.

Voluntary, Subsidized Government Insurance: The California Approach to Earthquake and U.S.-Wide Approach to Flood and Terrorism Risks

In the U.S., there are no laws requiring the purchase of insurance against catastrophe perils other than flood (to be discussed later), and even in the case of flood the law simply allows lenders to require flood insurance for properties subject to high risk of flood. It appears that U.S. lenders generally require borrowers to carry homeowners insurance on their properties which will typically include coverage for wind-caused losses. It does not appear that most require earthquake coverage given that the take-up rate on earthquake insurance has been estimated to be 12% in California, and this figure has been steadily dropping (California Department of Insurance, 2011). The California Earthquake Authority (CEA) serves as virtually the only provider of earthquake coverage in California as private insurers are allowed to offer earthquake insurance coverage in the state, most do not.²¹

Limiting its financial business to underwriting and funding earthquake loss, the CEA is an example of quasi-government insurance. Relatively expensive premiums, high deductibles

²¹ About 70% of earthquake coverage in California is underwritten by CEA, according to the California Department of Insurance (2011).

and opportunity cost (i.e., same funds could be used for mitigation measures in lieu of paying an earthquake insurance premium) have been cited specifically by Californian homeowners when asked why they do not purchase CEA coverage. Earthquake insurance rates vary by region, proximity to a fault, type of home construction and other factors. CEA does not pay until the structural damage is higher than 15% of the home's insured value. Moreover, CEA policy deductibles are a relatively high 10-15% of insured value. The resulting low levels of market penetration make it virtually impossible to achieve a reasonable spread of risk and, as discussed earlier, encourage the insurance problem of adverse selection.

Only one U.S. natural peril – flood – has prompted Federal intervention. The national range of the flood risk, combined with a growing population and the property development challenges related to it, likely explain much of the historic pressure for involvement in the flood risk at the Federal level. The NFIP was designed primarily to provide homeowners living in flood-prone areas with affordable insurance against flood damages. Flood insurance is offered at rates below those the private market was willing to bear, and are thus subsidized by the Federal government. In addition to its insurance purpose, the NFIP design was intended to provide incentives for appropriate land-use planning and effective flood mitigation (Anderson, 1974).

Considering the current status of the NFIP, the most significant problem is the lack of actuarial soundness. According to statistics provided by Browne and Halek (2009), the NFIP compensated losses of \$33,466,476,902 between 1978 and 2007 while collecting only \$32,910,854,743 in premiums. This has resulted in an overall loss ratio during that time of 101.6%. In 2005, the year of Hurricane Katrina, the loss ratio was substantially worse at 784% (Browne and Halek, 2009). More current estimates by the Property Casualty Insurers

Association of American (PCI) suggest that the NFIP currently has \$17.75 billion of debt. (Reactions, 2011).

Beyond the issue of overall underfunding, the NFIP faces challenges regarding the equity of its ratemaking process. Generally, the NFIP has two classifications for its rates: full risk rates and subsidized rates. The full risk rates are considered to be risk-based (i.e., actuarially sound) whereas the subsidized rates only cover 35%-40% of the full risk, meaning that 60%-65% of losses are expected to be in excess of the premium charged.²² About 25% of NFIP policies are priced on a subsidized rate basis (Browne and Halek, 2009). The event of Hurricane Katrina necessitated that NFIP borrow \$20 billion from the Federal government. Considering the current underfunding issues, the NFIP is not reasonably expected to repay this loan, at least not in the near future. The Federal government is in fact expected to forgive the entire debt (Lehrer, 2008). As a consequence, the U.S. taxpayers would eventually have to pay for a large portion of the damages caused by Hurricane Katrina.

The NFIP has been discussed and criticized thoroughly in the literature (e.g., Michel-Kerjan and Kousky, 2010; Brown and Hoyt, 2000). Despite short comings and challenges, it remains a viable program. Recently, the NFIP was extended by Congress through September 30, 2011 (Postal, 2010).

One man-made example of a government reinsurance backstop for a man-made catastrophic peril is the Terrorism Risk Insurance Act of 2002 (TRIA).²³ As explained by Marlett, Griffith, Pacini, and Hoyt (2003), the insured losses stemming from 9/11 were the

²² See Gardner and Marlett (2004).

²³ The Terrorism Risk Insurance Act takes effect when the U.S. Treasury Secretary declares an event as act of terrorism. As soon as the aggregated losses exceed an amount of \$ 5 million, government and insurance industry are supposed to share the losses of the next layers.

largest insured event at that time creating a significant market disturbance that had both wide geographic and political impact. Put simply, based on TRIA, commercial insurers are required to “make available” terrorism insurance for commercial insureds. TRIA creates a federal backstop or cost sharing mechanism for terrorism claims (e.g. Cummins, 2007). TRIA has been extended twice and is now set to expire on December 31, 2014.

The terrorism insurance market continues to grow. According to a 2010 report by Marsh, insurance take-up rates for terrorism coverage continued to rise in 2009. In 2003, the firm found that only 27 percent of surveyed firms purchased terrorism coverage. By 2009, that rate was up to 61 percent (Marsh, 2010). Rates for the coverage fell to \$25 per million of total insured value from \$37 just a year before. The report indicates that capacity in the stand-alone terrorism insurance market, which provides an alternative or supplement to TRIA coverage has grown to a theoretical maximum of \$3.76 B representing a significant increase.

While there is a private market for terrorism coverage, experts suggest that the absence of TRIA would cause a significant market disruption and negative impact on the economy (e.g., Marlett et. al., 2003; Hubbard, Deal, and Hess, 2005). The Terrorism Risk Insurance Program Reauthorization Act (TRIPRA) extends TRIA through December 31, 2014 (The U.S. Department of the Treasury, 2011).

Mandatory, Subsidized Government Insurance: The Spanish Approach

Spain manages the risk with rigid government control of the insurance cost and compensation. Spain established the Consorcio de Compensacion de Seguros (Consorcio) in 1954 (Cummins, 2006). The Consorcio is a public insurer owned by the Spanish government which provides coverage for natural catastrophes as well as terrorism risk, bundled into a single

policy.²⁴ The coverage is mandatory and is provided as an add-on to private market property insurance policies. The premiums are collected by the primary insurers and are passed through to the Consorcio. Due to the fact that insurance is compulsory for all property owners, the Consorcio can operate under special conditions. This means that the Consorcio is able to offer premiums on a flat-rate basis without the problems of adverse selection (Ungern-Sternberg, 2003). The important advantages of such a system are comparatively low-cost premiums and universal coverage.

One of the major disadvantages of the Spanish system is that regulators and government can raise the insurance rates to compensate for potential damages in high-risk areas of the country. Consequently, people who live in hazard-prone regions are subsidized by other members of the community of insureds. Thus, some property owners are obligated to pay rates that are higher than the risk they represent, resulting in an inequitable compensation system that can promote excessive risk taking (Kunreuther, 2006). Thus, in the Spanish system loss damages are arguably higher than they would have otherwise been considering forgone mitigation and risk avoidance activities property owners would have been incentivized to undertake had mitigation been linked to reduction in premiums.

Ex Post Government Intervention

²⁴ When the EU passed the 3rd EU Non-Life Insurance Directive in 1994, EU markets were subject to open competition. Monopolistic insurance systems were not allowed anymore. In order to retain its monopoly system, Spain started to treat the payments made to the Consorcio as 'surcharges' rather than as premiums (Ungern-Sternberg, 2004). These surcharges are mandatory for all property owners. Alternative (and mutually exclusive) coverage through private insurance is allowed, but purchase of private coverage does not negate the Consorcio surcharges. Due to the fact that property owners pay for the Consorcio insurance regardless of whether they choose to enjoy its coverage, virtually no property owner in Spain opts to purchase coverage on the private market. During recent decades, the Consorcio has enjoyed favorable financial performance. The Spanish government consistently reinvested interest income and surplus and could therefore increase the reserves of the Consorcio. Between 1991 and 1999 the Consorcio had an average loss ratio of 71% (Ungern-Sternberg, 2003).

As stated earlier, there has been a significant gap between economic and insured losses of natural disasters during recent decades. The low percentage of insured losses is due to both a lack of individual awareness regarding the frequency and severity of natural disasters as well as insufficient availability of affordable insurance coverage. Additionally, disaster response by governments may also contribute to this gap. Considering the fact that in most countries the government supplies ex-post relief in the event of a disaster, homeowners may waive ex-ante insurance coverage. Browne and Hoyt (2000) call this phenomenon ‘charity hazard.’ This means that people tend to behave in a less risk averse manner when they expect support by others, e.g. by their community or by a government emergency program (and therefore by the taxpayers). A survey by the German Committee for Disaster Reduction shows that even after a major flood which occurred in Europe during the summer of 2002, half of the affected uninsured people were not planning to purchase insurance coverage in the future. The German government had handsomely reimbursed its citizens for their damages, resulting in an adverse effect on the incentives for buying insurance. Thus, ex-post government aid generally undermines property owners’ incentives for ex-ante protection provision. The resulting lack of insurance demand, and therefore coverage, leads to increasing premiums and consequently further decreasing demands (Schwarze and Wagner, 2004). Treatment of public disaster relief in such a relatively small country is easily swayed by political interests, such as re-election concerns rather than by true socio-economic effects. For instance, Germany experienced the huge Elbe flood in 2002 just a couple of weeks before elections. The political parties, in the midst of election campaigns at the time, each tried to gain as many votes as possible by promising the people, who suffered terrible losses, high amounts of government reimbursement for damages.

Government intervention in the ex-post response to catastrophes can have a huge impact on the demand for insurance, resulting in a vicious cycle of increasing premiums and therefore further decreasing demand. This effect is problematic from the insurer's perspective, as shrinking numbers of policyholders complicate the balance within the portfolio and advance the problem of adverse selection (Cole et al, 2009).

Generally, the British system is a good example of a private and liberalized insurance market in terms of loss compensation. That does not mean, however, that the state is not involved in the management of natural catastrophes at all. In fact, the British system is characterized by the so-called Gentlemen's Agreement (Huber, 2004), a set of informally-defined rules that characterize the British system of dealing with floods. The Gentlemen's Agreement exists between government and private insurance industry and defines the responsibilities of each regarding flood loss control and compensation of flood damages. Based on the Agreement, the British government is primarily responsible for mitigating flood damages (e.g. building dikes) whereas the private insurance industry is in charge of compensating for damages after a flood has occurred (Huber, 2004). Thus, the essential target of this convention of shared responsibility is the achievement of a risk-related protection against flood perils for every British home owner without burdening the national budget.

The Gentlemen's Agreement is not without problems. As stated above, the private insurance industry is responsible for providing damage recovery. Based on recent conflicts, apparently the government's intention within the Agreement along these lines is for the private industry to offer insurance capacity such that every British homeowner who wants to buy insurance can reasonably obtain it. The industry's interpretation of its role apparently differs as some insurance companies appear to go so far to avoid risk as to 'redline' entire districts deemed

to be prone to flood (Ungern-Sternberg, 2004). The practice of redlining is possible under the Gentlemen's Agreement as it states that if there is exposure to regular flooding, insurance can be declined (Huber, 2004). Considering the increasing trend in flood frequency and severity during recent decades, those high hazard areas with regular flooding exposure will probably expand and emerge more often.

When premiums for natural catastrophes reflect the actual risk, prices can become prohibitively high for some property owners. Consequently, homeowners may knowingly retain the risk rather than purchase (adequate) insurance. This does increase the overall level of uninsured losses. Furthermore, the insufficient density of natural catastrophe insurance is also due to a lack of awareness (Kunreuther, 1996). Due to a usually very low frequency of natural disasters, people may underestimate their individual loss exposure or misinterpret event probabilities (e.g., thinking that after a 100-year hurricane has occurred one is likely safe for the next 100 years).

There are also conflicts regarding the loss-mitigating role of the British government within the Gentlemen's Agreement. As the government is responsible for ex-ante loss control, the development of housing in floodplain areas should ideally be prohibited or at least limited. In fact, Crichton (2008) states that, according to a government report, 11% of all new houses since 2000 have been built in floodplain areas. This is possible under the Gentlemen's Agreement as it also says that floodplain development is allowed given the condition that there is nowhere safer to build (Crichton, 2008). Given the fact that urbanization will probably further increase during the next decades, it is questionable whether the Gentlemen's Agreement is a sufficient solution to the threat that the flood hazard poses to Great Britain.

In the U.S., the Federal Emergency Management Agency (FEMA) provides financial assistance to individuals and businesses in response to declared disasters. On March 1, 2003, the Federal Emergency Management Agency (FEMA) became part of the U.S. Department of Homeland Security (DHS), a Federal agency created to have broad domestic protection powers in the wake of the Terrorist Attacks of 9/11/01. Homeland Security's National Response Framework (NRF) presents the guiding principles that enable all response partners to prepare for and provide a unified national response to disasters and emergencies, and establishes a comprehensive, national, all-hazards approach to domestic incident response.²⁵

Through the structure provided by the NRF, FEMA steps in to assist and provide financial relief in the form of grants and/or loans to states, communities, businesses and individuals directly impacted by catastrophes. The primary role of the post-disaster assistance provided by FEMA is to fill the insurance gap, and help citizens financially recover from losses for which insurance is not available. North American research into the effects of post-loss government financial assistance on mitigation efforts have come back with similar results – all supporting the concept that an expectation of disaster assistance reduces the property owner's incentives to engage in personal mitigation (Kaplow, 1991; Kelly and Kleffner, 2003; Kunreuther and Pauly, 2006). Based on research findings, policy makers must be careful to balance funding for post-loss assistance with funding for pre-loss mitigation.²⁶

CONCLUSIONS AND OUTLOOK

Different and varied approaches may be effective for dealing with natural catastrophes and their insurability. Regions employ varying levels of government intervention, each approach

²⁵ The National Response Plan was replaced by the National Response Framework effective March 22, 2008.

²⁶ FEMA does offer funding for pre-loss disaster mitigation on a limited, competitive basis, based on the merits of individual applications.

offering both advantages and disadvantages. Some systems rely heavily on private market solutions alone, and thus incorporate risk-based pricing, for some risks. In the case of catastrophes, however, no government intervention may result in a gap in financing, as insurers have difficulty arriving at a fair price for the risk, or alternately the fair price, once determined, is prohibitively expensive for many potential buyers. Such market problems result in large amounts of uninsured economic loss.

Reducing the problems of underinsurance and economic volatility, some regions provide a catastrophe financing system that has a foundation in private markets and risk-based pricing with a residual market that allows for limited cross-subsidization of risk. Others rely heavily on government-sponsored, or social, insurance solutions, either at the primary, reinsurance level or both, thus incorporating large-scale cross-subsidization in pricing. Still, for some especially difficult risks a government may choose primarily to compensate for losses ex-post through government disaster assistance.

Private market solutions, such as those employed in Germany, Great Britain, New York, Arkansas and Tennessee, have distinct advantages with respect to premiums and mitigation incenting. Fair and actuarially-sound premiums and deductibles incent those who purchase the privately-available insurance to engage in mitigation, and even risk avoidance, where feasible. Private insurance against natural catastrophes can be prohibitively costly for some, however, resulting in low market penetration and necessitating governmental disaster response or private charity on a post-loss basis. Underinsurance and reliance on charity may decrease the mitigation incentive and thus create a moral hazard for citizens choosing not to insure. Consequently, it is virtually impossible for private market solutions to achieve risk-sensitive premiums and simultaneously maintain universal loss compensation and mitigation.

In Spain and France, insurance coverage is mandatory for all property owners by statute, resulting in a high insurance market penetration. However, having the Consorcio as monopoly state insurer, the government involvement in Spain is significant. In fact, the Spanish government is able to raise premiums when current rates are insufficient to provide coverage for certain hazard prone areas in the country. This automatically increases the level of cross subsidy, an unfavorable result from an economic point of view. California, by contrast, although offering earthquake insurance through a monopolistic State fund, does not mandate coverage. As a result, the CEA suffers from low market penetration and problems of adverse selection. Florida and North Carolina have both developed State-administered strategies for subsidizing insurance coverage against tropical storms. Both have achieved high market penetration, although issues of subsidization remain.

In France, where the state is only involved in the reinsurance market, significant societal benefits are achieved. First, the capacity of the private insurance market is enhanced. Second, there is still competition in the primary market which results in risk-adjusted rates and a reduced level of moral hazard. In France, where primary insurance coverage against natural disasters is mandatory, there is a high level of market penetration, minimal adverse selection, and virtually no free-rider consequences resulting from individuals who underestimate their exposure to natural catastrophes. Generally, such mandatory insurance systems are based on a high level of solidarity; from an economic standpoint, solidarity may or may not be optimal, depending upon each nation's social policy as to what level of solidarity is desirable. Florida and North Carolina, both utilizing a private system with a residual market to provide protection against tropical windstorm losses, still achieve high market penetration without requiring coverage. But to

differing degrees, both suffer from cross-subsidization of risk to achieve nearly universal coverage.

Based on this discussion of key cases of government intervention (or lack thereof) to deal with natural catastrophes, it becomes clear that neither the private-market-rate nor the subsidized-government-rate structure alone has become the dominant solution. In some areas, a hybrid system has been used with favorable results. Cultural norms and public policy concerns may drive many of the decisions. Also, the geographic concentration of natural catastrophe exposures makes it difficult to find a universal solution to funding these perils. Both the U.S. and the EU struggle with finding the right balance of ex ante government intervention, understanding that after a loss, the government is almost always called upon to fill the financial gap left by uninsured economic losses.

Government post-loss disaster assistance, in the absence of mandatory insurance requirements, decreases incentives for mitigation. It also decreases property owners' incentives to purchase adequate insurance. Cross subsidization through the use of government mechanisms that do not charge risk-based rates and constraints on private insurers' rate structures also reduce incentives for mitigation and risk avoidance. Regardless of the specific goals of a policy maker, these negative externalities that may be created by government intervention must be carefully weighed against the benefits of social insurance to society.

REFERENCES

Allen, Anne B., May 1997. "Not Just for Coastal States Anymore: National Disaster Legislation," *Risk Management*, 44 (5): 49.

American Institute for Research, 2006. "An Evaluation of the National Flood Insurance Program: Final Report," Washington, DC: AIR.

Anderson, Dan R., 1974. "The National Flood Insurance Program: Problems and Potential," *The Journal of Risk and Insurance*, 41 (4): 579-599.

Browne, Mark J. and Martin Halek, 2009. "Managing Flood Risk: A Discussion of the National Flood Insurance Program and Alternatives," Working Paper, Wisconsin School of Business Department of Actuarial Science, Risk Management and Insurance University of Wisconsin.

Browne, Mark J. and Robert E. Hoyt, 2000. "The Demand for Flood Insurance: Empirical Evidence," *Journal of Risk and Uncertainty*, 20 (3): 291-306.

California Department of Insurance, March 2011. Press release. <http://www.insurance.ca.gov/0400-news/0100-press-releases/2011/release042-11.cfm>. Accessed August 1, 2011.

California Earthquake Authority, 2011. <http://www.earthquakeauthority.com/index.aspx?id=13&pid=2>. Accessed August 1, 2011.

CEA, 2010. *CEA Statistics No. 42, European Insurance in Figures*, CEA Insurers of Europe, November 2010.

Cole, Cassandra R., David Macpherson, Patrick F. Maroney, Kathleen A. McCullough, James W. Newman and Charles Nyce, 2009. "A Review of the Development of Residual Market Mechanisms in Florida," *Journal of Insurance Regulation*, 28 (1): 55-80.

Cole, Cassandra R., Patrick F. Maroney, Kathleen A. McCullough and Charles Nyce, 2009. "The Role of State-Run Insurers in Providing Property Coverage in Coastal States with High Hurricane Exposure," *CPCU eJournal*, December 2009: 1-11.

Cole, Cassandra R., David Macpherson, Patrick F. Maroney, Kathleen A. McCullough, James W. Newman and Charles Nyce, 2011. "The Use of Post-Loss Financing of Catastrophe Risk," *Risk Management and Insurance Review*, February 2011: 1-35.

Crichton, David, 2001. "UK and Global Insurance Responses to Flood Hazard," International Workshop on Non-Structural Measures for Water Management Problems, London: 235-251.

Cummins, J.D., 2007. "Reinsurance for Natural and Man-Made Catastrophes in the United States; Current State of the Market and Regulatory Reforms," *Risk Management and Insurance Review* 10(2), 179-179.

Cummins, J. David, 2006. "Should the Government Provide Insurance for Catastrophes?" *Federal Reserve Bank of St. Louis Review*, 88 (4): 337-79.

Davidson, Ross J., Winter 1998. "Working Toward a Comprehensive National Strategy for Funding Catastrophe Exposures," *Journal of Insurance Regulation*, 17 (2): 134-169.

Derrig, Richard, Jay S. Fishman, Martin Grace and Joan Schmit, Fall 2008. "Catastrophe Management in a Changing World: The Case of Hurricanes," *Risk Management and Insurance Review*, 11 (2): 269-280.

Doherty N., M. Grace, R. Klein, H. Kunreuther, E. Michel-Kerjan and M. Pauly, 2010. "Managing Large-Scale Risks in a New Era of Catastrophes," Wharton Risk Management and Decision Center in conjunction with Georgia State University and Insurance Information Institute.

Dumm, Randy E., Mark E. Johnson and Martin M. Simons, 2009. "Inside the Black Box: Evaluating and Auditing Hurricane Loss Models," *Journal of Insurance Regulation*, 41-48.
Government Accounting Office, 2008. Initial Results on Availability of Terrorism Insurance in Specific Geographic Market, United States Government Accountability Office (GAO).

Federal Emergency Management Agency, 2011. <http://www.fema.gov/about/what.shtm>. Accessed January 11, 2011.

Florida Office of Insurance Regulation, 2011. <http://www.floir.com/Office/DataReports.aspx>. Accessed April 18, 2011.

Gardner, Lisa and David C. Marlett, 2004. "Cross-Country Comparisons between Flood Insurance Underwriting and Rating Practices: Recommendations for the NFIP," *CPCU eJournal*, October.
Grace, Martin F. and Robert W. Klein, 2009. "The Perfect Storm: Hurricanes, Insurance, and Regulation," *Risk Management and Insurance Review*, 12 (1): 81-124.

Harrington, Scott E. and Greg Niehaus, Summer 2001. "Government Insurance, Tax Policy, and the Affordability and Availability of Catastrophe Insurance," *Journal of Insurance Regulation*, 19 (4): 591-612.

Huber, Michael, 2004. "Reforming the UK Flood Insurance Regime. The Breakdown of a Gentlemen's Agreement," Discussion Paper No. 18, Centre for Analysis of Risk and Regulation, London School of Economics and Political Science, London.

Jaffee, Dwight, Howard Kunreuther and Erwann Michel-Kerjan, 2010. "Long-Term Property Insurance," *Journal of Insurance Regulation*, 167-187.

Kaplow (1991). Incentives and government relief for risk. *Journal of Risk and Uncertainty*, 4, pp. 167-175.

Kelly, Mary and Anne E. Kleffner (2003). Optimal loss mitigation and contract design. *The Journal of Risk and Insurance*, 70(1), pp. 53-72.

Klein, Robert W. and Shaun Wang, 2009. "Catastrophe Risk Financing in the United States and the European Union: A Comparative Analysis of Alternative Regulatory Approaches," *Journal of Risk and Insurance*, 76 (3): 607-637.

- Kunreuther, Howard, Neil Doherty and Anne Kleffner, May 1993. "On Shaky Ground? Earthquakes and the Insurance Industry," *Risk Management*, 40 (5): 36.
- Kunreuther, Howard, 1996. "Mitigating Disaster Losses through Insurance," *Journal of Risk and Uncertainty*, 12: 171-187.
- Kunreuther, Howard, 2002. "The Role of Insurance Managing Extreme Events: Implications for Terrorism Coverage," *Risk Analysis*, 22 (3): 427-437.
- Kunreuther, Howard and Erwann Michel-Kerjan, 2004a. Dealing with Extreme Events: New Challenges for Terrorism Risk Coverage in the U.S.; Wharton School, University of Pennsylvania, Philadelphia.
- Kunreuther, Howard and Erwann Michel-Kerjan, 2004b. Policy Watch: Challenges for Terrorism Risk Insurance in the United States; The Journal of Economic Perspectives, Vol. 18, No.4.
- Kunreuther, Howard, 2006. "Reflections on U.S. Disaster Insurance Policy for the 21st Century," Wharton School, University of Pennsylvania, Philadelphia.
- Kunreuther, Howard and Mark Pauly (2006). Insuring against catastrophes. Paper for *Financial Risk Management in Practice: The Known, The Unknown and The Unknowable*, Boston, MA, Sponsored by Wharton School, University of Pennsylvania.
- Kunreuther, Howard, 2008. "Managing Large-scale Risks in a New Area of Catastrophes," Wharton School, University of Pennsylvania, Philadelphia.
- Lehrer, Eli, 2008. "Reforming the National Flood Insurance Program after 35 Years of Failure," *Issue Analysis*, Competitive Enterprise Institute.
- Marlett, David and Richard Corbett, Spring 1998. "The Potential Impact of Proposed Multi-Peril Underwriting on Catastrophe Loss Variability," *Journal of Insurance Regulation*, 16 (3): 357-361.
- Marlett, David C. and Carl Pacini, Fall 1999. "Insurer Stock Price Responses to the Creation of the California Earthquake Authority," *Journal of Insurance Regulation*, 18:80-108.
- Marlett, David C., George Flanigan, Lisa Gardner, Rob Issacs, Elaine Sebald, Tim Query, 2001a. "Managing Flood Losses: An International Review of Mitigation and Financing Techniques Part I", *CPCU Journal*, vol. 54, no.2 Summer: 75-93.
- Marlett, David C., George Flanigan, Lisa Gardner, Rob Issacs, Elaine Sebald, Tim Query, 2001b. "Managing Flood Losses: An International Review of Mitigation and Financing Techniques Part II", *CPCU Journal*, vol. 54, no.3 Fall: 150-173.
- Marlett, David C., John Griffith, Carl Pacini, and Robert E. Hoyt, 2003. "Terrorism Insurance Coverage: the Market Impact on Insurers and Other Exposed Industries." *Journal of Insurance Regulation* 22(2): 41-62.

Marlett, David C., 2009. "Insuring Coastal Properties in the Mid-Atlantic Region," *Journal of Insurance Regulation*, 91-122.

Marlett, David C., September, 2010. "The National Insurance Consumer Protection Act's Potential Impact on the Social Resiliency of Hazard-Prone Regions," *CPCU eJournal*, 63 (9)

Marsh McLennan, 2010. "Marsh Report: Terrorism Risk Management Costs Fall as Federal Reinsurance Backstop Stabilizes Terrorism Insurance Market," *Wireless News*, Jun 27, 2010.

Michel-Kerjan, Erwann O. and Carolyn Kousky, 2010. "Come Rain or Shine: Evidence on Flood Insurance Purchases in Florida," *Journal of Risk and Insurance* 77 (2): 369-397.

Michel-Kerjan, Erwann, 2001. "Insurance against Natural Disasters: Do the French Have the Answer? Strengths and Limitations," Laboratoire D'Econometrie, Paris.

Munich Re, 2003. "Topics: Annual Review: Natural Catastrophes 2002," Munich Re Group.

National Oceanic and Atmospheric Administration (NOAA). 1998 (on-line). "Population: Distribution, Density and Growth" by Thomas J. Culliton. NOAA's State of the Coast Report. Silver Spring, MD: NOAA Postal, A.D., 2010. "NFIP Extended After Multiple Hiccups," *National Underwriter, P&C*, 114 (44) 24-24, 31.

Randall, Susan, 1999. "Insurance Regulation in the United States: Regulatory Federalism and the National Association of Insurance Commissioners," *Florida State University Law Review*, 26 (3): 625-699.

Reactions, 2011. "Many NFIP rates 70% Below True Risk Cost: PCI", *Reactions* April 1, 2011.

Schwarze, Reimund and Gert Wagner, 2004. "The Aftermath of Dresden: New Directions in German Flood Insurance," *The Geneva Papers on Risk and Insurance*, 29 (2): 154-186.

Schwarze, Reimund and Gert Wagner, 2008. Naturgefahrenversicherung in Europa – Unterschiedliche Antworten auf den Klimawandel," *Vierteljahrshefte zur Wirtschaftsforschung*, 77: 5-17.

Skipper, Harold D. and W. Jean Kwon, 2007. *Risk Management and Insurance: Perspectives in a Global Economy*. Blackwell Publishing, Oxford.

Swiss Re, 2008. "Natural Catastrophes and Man-made disasters in 2007," *Swiss Re Sigma*, Vol. 1/2008.

Swiss Re, 2009. "Natural Catastrophes and Man-made disasters in 2008," *Swiss Re Sigma*, Vol. 2/2009.

Swiss Re, 2010. "Natural Catastrophes and Man-made disasters in 2008," *Swiss Re Sigma*, Vol. 1/2010.

Thomann, Christian, 2003. *Pool Re: Versicherung von Terrorrisiken in Großbritannien*, Band 20 Hannover Reihe, Karlsruhe.

Ungern-Sternberg, Thomas von, 2003. "State Intervention on the Market for Natural Damage Insurance in Europe," CESIFO working paper No. 1067.

Ungern-Sternberg, Thomas von, 2004. *Efficient Monopolies: The Limits of Competition in the European Property Insurance Market*, Oxford University Press Inc., New York.

Ungern-Sternberg, Thomas von, 2005. „Staatseingriffe im Markt für Versicherung gegen Naturkatastrophen,“ University of Lausanne.