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A GLOBAL COMPARISON OF CATASTROPHE INSURANCE

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ABSTRACT

The United States has been the victim of seemingly countless catastrophes since the turn of the century. The damage caused by the series of hurricanes and various other natural disasters have led the United States to lead the world in total insured catastrophe losses. This report explores possible explanations for why this total is so high and provides suggestions for limiting such losses in the future. In particular, the catastrophe responses of Chile and Japan are studied to find solutions that the United States has yet to employ.

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I do, I do, I do!

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We did it!

Chapter 1

Introduction

“I’ll never forget Hurricane Katrina – the mix of a natural and a man-made catastrophe that resulted in the death of over 1,500 of our neighbors. Millions of folks were marked by the tragedy,” U.S. Congressman Cedric Richmond said on the sixth anniversary of the 2005 hurricane that struck New Orleans¹. Although when it made landfall the storm itself was rated an average Category 3 on the 1-5 scale of hurricane ratings, the damage was strong enough to trigger a catastrophic chain of events through southern Louisiana. New Orleans was particularly vulnerable with half of its foundation built on land below sea level. That risk, along with the weakly designed levees surrounding the city that were in place to prevent local bodies of water from flooding, combined to produce one of the most costly natural disasters in U.S. history².

How can a country prepare to handle an event that costs upward of \$100 billion like Hurricane Katrina? The United States is not the only nation that has been hurt by such disasters. The 2010 earthquake that struck Haiti caused over 200,000 fatalities and \$8 billion in repair costs. The Indonesian tsunami that hit the day after Christmas in 2004 took the lives of over 160,000 people and resulted in almost \$4.5 billion in damages³. In addition to the immeasurable human and emotional loss, the monetary damages caused by these disasters force countries to develop plans to minimize future catastrophic loss.

Because the monetary damage of a catastrophe is often too much for a single insurer to handle on its own, insurance companies transfer some of their risk to reinsurance companies. Although the same few companies reinsure the threat of catastrophes internationally, the handling of these catastrophes, when they do occur, varies greatly from country to country. For example, the United States places a

¹ Richmond

² History.com Staff

³ Center for Research on the Epidemiology of Disasters (CRED)

greater emphasis on the importance of reinsurance than does any other country in the world. Likewise, the United States has spent more on catastrophes than any other country. This thesis explores the reasons why the United States' losses are the most costly and provides recommendations for reducing those costs by analyzing the handling of catastrophes internationally.

Chapter 2

Defining a Catastrophe

A catastrophe, as defined by the Merriam-Webster Dictionary, is “(a) a violent and sudden change in a feature of the earth [or] (b) a violent usually destructive natural event (as a supernova).” The same definition applies in the insurance industry, but with numerical requirements attached. A catastrophe is an event that typically exceeds a total of \$25 million in claims. There is also a threshold for the number of policyholders who place those claims, as well as a threshold for the number of insurance companies handling them⁴. Catastrophes recognized by the insurance industry include hurricanes, earthquakes, tornadoes, and other natural disasters⁵.

In the words of late nineteenth century author H.G. Wells, “Human history becomes more and more a race between education and catastrophe”⁶. A catastrophe is a life-altering event that occurs so infrequently that prediction techniques are not always of particular value. Even if modern technology can forecast the arrival of a large storm, such warning may not be sufficient to prevent the loss of life and property. With every catastrophe, insurers, government officials, and catastrophe modelers adjust their current systems to account for previously unidentified factors. With each event, they shorten the gap between education and catastrophe – but there is still much progress to be made. Catastrophes occur so infrequently that new data previously unaccounted for still is not enough for technology to catch all warning signs from natural disasters. The race between the two is a marathon, not a sprint.

⁴ Insurance Information Institute

⁵ Devlin [3]

⁶ Kane

Catastrophes Pertaining to This Research

There are many ways to classify the extent of a catastrophe. Catastrophes are typically categorized by their resulting death tolls. In this manner of thinking, one would consider the Haitian earthquake of 2010, which resulted in 225,570 deaths, as the worst catastrophe since 2000 (see Table 1). Another method of categorization is by total costs, both insured and uninsured. In this case, the Japanese earthquake and tsunami of 2011, which caused \$210 billion of damages, would be the biggest catastrophe since the turn of the century (see Table 2)⁷.

Table 1. Top 10 Catastrophes by Total Deaths, 2000-2015

Country	Catastrophe Type	Year	Total Deaths
Haiti	Earthquake	2010	222,570
Indonesia	Earthquake	2004	165,708
Myanmar	Hurricane	2008	138,366
China	Earthquake	2008	87,476
Pakistan	Earthquake	2005	73,338
Russia	Heat Wave	2010	55,736
Sri Lanka	Earthquake	2004	35,399
Iran	Earthquake	2003	26,796
Italy	Heat Wave	2003	20,089
India	Earthquake	2001	20,005

⁷ Center for Research on the Epidemiology of Disasters (CRED)

Table 2. Top 10 Catastrophes by Total Damage, 2000-2015

Country	Catastrophe Type	Year	Total Damage (Billions)
Japan	Earthquake	2011	\$210.00
USA	Hurricane	2005	\$125.00
China	Earthquake	2008	\$85.00
USA	Hurricane	2012	\$50.00
Thailand	Flood	2012	\$40.00
Chile	Earthquake	2010	\$30.00
USA	Hurricane	2008	\$30.00
Japan	Earthquake	2004	\$28.00
China	Extreme Temperatures	2008	\$21.10
USA	Industrial Accident	2010	\$20.00

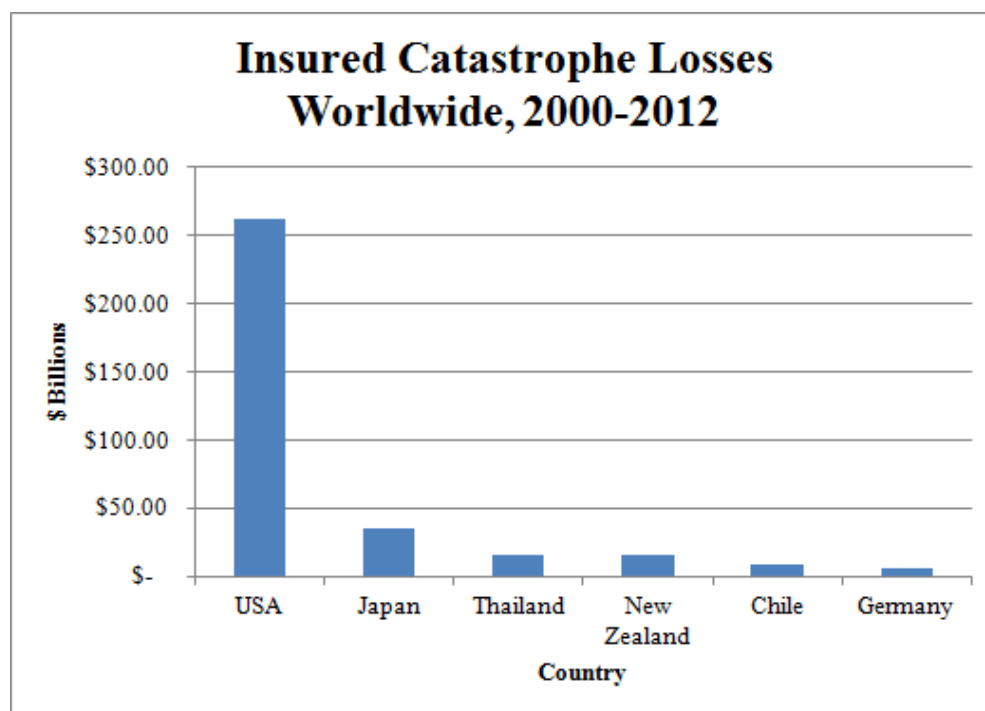
This research focuses on the most costly insured catastrophes in terms of monetary damages since 2000. Since the turn of the century, the United States has endured more costly catastrophes than any other country. With the exception of the terrorist attacks on September 11, 2001, all of these disasters have been the result of natural causes. Although the United States is geographically large, its size alone is not an explanation as to why the country is the world's greatest disaster recovery and insurance spender. As evidenced in Figure 1⁸, the insured catastrophe losses in United States was, in total, more than three times the total insured catastrophe losses of the rest of the world combined between 2000 and 2012. Part of the explanation for such a drastic difference is the value of property in the United States. For example, although the aforementioned earthquake in Haiti was technically more destructive than any of the catastrophes to strike the United States, the total damage was only \$8 billion. To achieve a better understanding of why these statistics are as they are, significant catastrophes in a select few countries are examined – specifically Hurricane Katrina in 2005, the Chilean earthquake of 2010, and the Japanese tsunami of 2011.

⁸ Kunreuther and Michel-Kerjan

Table 3. Top 10 Insured Catastrophes, 2000-2015

Country	Catastrophe Type		Year	Total Insured Losses (Billions)
United States	Hurricane		2005	\$76.30
United States	Terrorist Attacks		2001	\$39.00
Japan	Earthquake & Tsunami		2011	\$35.70
United States	Hurricane		2012	\$35.00
United States	Hurricane		2008	\$21.60
United States	Hurricane		2004	\$15.70
Thailand	Flood		2011	\$15.30
New Zealand	Earthquake		2011	\$15.30
United States	Hurricane		2005	\$14.70
United States	Hurricane		2005	\$11.90

Figure 1. Insured Catastrophe Losses Worldwide, 2000-2012



Chapter 3

A Summary of Recent Global Catastrophes

Hurricane Katrina

Figure 2. Areas Affected by Hurricane Katrina



On August 23, 2005, meteorologists noticed a tropical depression forming in the Caribbean. Five days later, the storm had grown so rapidly that warnings from the National Weather Service sparked a series of evacuations from the Gulf Coast region. Louisiana's largest city, New Orleans, was especially endangered since the city is completely delimited by water with an elevation below sea level. Because New Orleans had been flooded five times prior to the arrival of Hurricane Katrina, levees had been built along the surrounding bodies of water to prevent further flood damage from threatening the city.

⁹ Hutchinson

Although the levees engineered along the Mississippi River proved sturdy, Lake Pontchartrain and Lake Borgne were still susceptible to flooding because their levees were constructed on weak foundations¹⁰.

The mayor of New Orleans delivered an official evacuation order on August 28, 2005. When Hurricane Katrina hit land on August 29, it registered as a Category 3 hurricane that stretched 400 miles in diameter. As the storm progressed, it eventually developed into Category 5, the most dangerous hurricane classification. “By 9 a.m., low-lying places ... were under so much water that people had to scramble to attics and rooftops for safety. Eventually, nearly 80 percent of the city was under some quantity of water”¹¹. Although the evacuation was ordered, and over a million New Orleans residents fled the city, there were still thousands of people who were either unable or unwilling to leave. The New Orleans Convention Center and the Louisiana Superdome, home of the NFL’s New Orleans Saints, were opened to those flooded out of their own homes¹².

What made Hurricane Katrina a catastrophe was not the size of the storm, but the devastating expanse of its aftermath. The delayed government response proved to be the factor that hurt New Orleans the most. Local government agencies were unable to respond to the disaster as they themselves were submerged due to the flood¹³. It took several days for the federal government, seemingly uninformed of the tragic effects the storm had on the Gulf Coast, to respond to Hurricane Katrina. Although the Coast Guard had already rescued thousands of people stranded on their roofs, there were still plenty of people stranded in the waterlogged city. In particular, those without cars or other means of transportation had no way out¹⁴. Those who sought refuge in the Louisiana Superdome were short on food and water, as well as sanitary areas to cleanse themselves. By September 2, the federal government finally intervened by sending troops to the disaster area to deliver food and water to those in need. With the help of the armed

¹⁰ History.com Staff

¹¹ History.com Staff

¹² The Editors of Encyclopedia Britannica

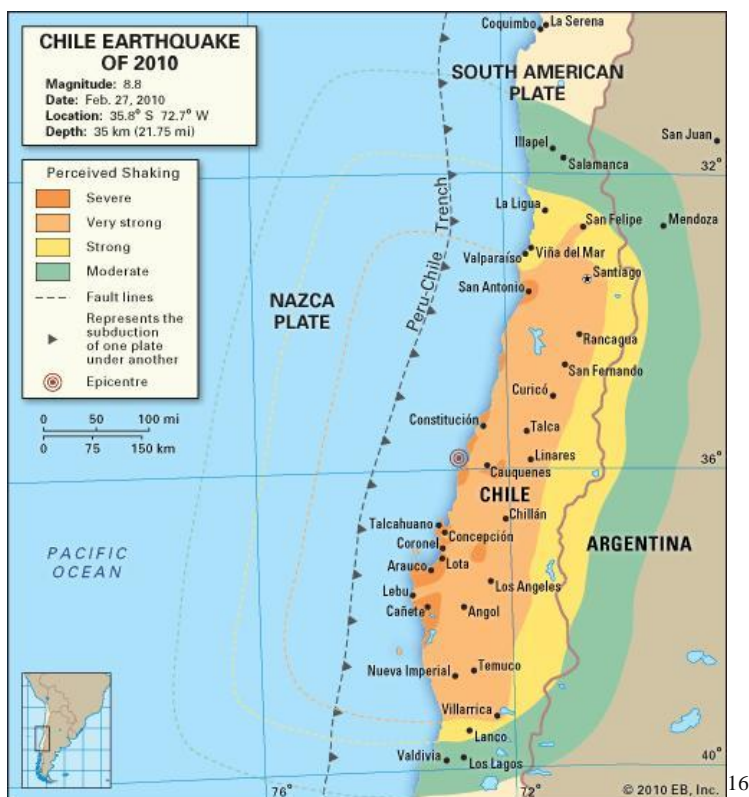
¹³ The Editors of Encyclopedia Britannica

¹⁴ History.com Staff

forces from Canada and Mexico, the process of cleaning and rebuilding New Orleans began. Almost a month and a half after the hurricane, the U.S. Army finally rid the city of the remaining floodwaters¹⁵.

Chilean Earthquake and Tsunami

Figure 3. Areas Affected by the Chilean Earthquake



On February 27, 2010, an earthquake below the waters of the Pacific Ocean reached a magnitude of 8.8, the shocks of which struck Chile. The earthquake unleashed a tsunami that destroyed the town of Constitución. Many of the deaths could have been avoided had officials warned those who lived on the coast of the impending tsunami. However, the officials ignored the warnings, leading to major legal consequences. Two years after the disaster, leaders of the Chilean National Emergency Office and the Hydrographic Oceanographic Service were “charged with negligence for ignoring tsunami warnings and

¹⁵ The Editors of Encyclopedia Britannica

¹⁶ Rafferty

failing to notify coastal residents of approaching surges.” Later, it was also found that the latter organization sought to hide their disregard for the warnings¹⁷.

Chile, because it is prone to natural disasters due to its location near the junction of two tectonic plates, has an up-to-date system for detecting earthquakes. After Chile was hurt by a violent earthquake in the 1960s, building codes were updated to make sure that structures were properly constructed to withstand harmful seismic activity. Although numerous buildings remained standing after the 2010 quake, those in Concepción were more weakly built than those in Chile’s prosperous cities like Santiago, leaving many of them in ruins. The electrical system of the country was damaged as well, leading to power outages and blackouts even a month after the earthquake occurred. After this natural disaster, it was determined that 500 people had died, with 30% of those deaths due to the resulting tsunami. Survivors in the town of Concepción found themselves short on food and water. Out of desperation, people turned to stealing from their neighbors to survive until officials arrived with supplies¹⁸.

There was a relatively rapid reconstruction turnaround for Chile after the earthquake and tsunami. Refugees were provided with over 50,000 homes built after the disaster. “In July 2013 the government reported that some 74 percent of the 222,000 home-rebuilding projects it had subsidized were complete. The rest of the projects were largely complete by the middle of 2014”. Even though the coasts still suffered from tsunami damage, hurting the fishing industry and dissuading tourists from visiting those areas, repairs of highways and airports were nearly finished within four months of the quake. The earthquake did have surprising benefits for Chile, however, as it prepared its citizens for another massive earthquake that struck in April 2014¹⁹.

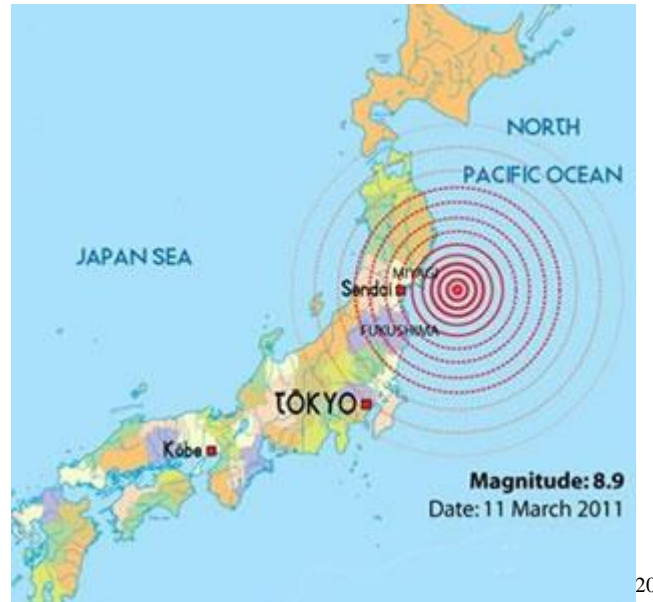
¹⁷ Rafferty

¹⁸ Rafferty

¹⁹ Rafferty

Japanese Earthquake and Tsunami

Figure 4. Areas Affected by the Japanese Earthquake



On March 11, 2011, Japan was struck by the sixth largest earthquake since the turn of the twentieth century. Located dangerously close to the intersection of the Pacific tectonic plate and the plate on which Japan rests (its extent remains unknown to geologists), Japan is consistently at risk for natural disasters. According to British news source *The Guardian*:

The Pacific plate moves fast in tectonic terms, at a rate of 9cm (3.5 inches) a year. This leads to the rapid buildup of huge amounts of energy. As the Pacific plate moves down, it sticks to the overhead plate and pulls it down too. Eventually, the joint breaks, causing the seafloor to spring upwards several meters.²¹

When the friction between the two plates occurred just below sea level, the energy released was strong enough to cause an earthquake that registered at 8.9 on the Richter scale²². The tsunami killed 19,846 people, and cost Japan \$35.7 billion in insurance losses.

²⁰ Matthews

²¹ Sample

²² Sample

The massive earthquake, because it occurred underwater, triggered a tsunami that headed rapidly toward Japan. Figure 4 illustrates the impact of the earthquake and resulting tsunami²³. Within an hour, waves estimated at heights of 7-10 meters reached Japan's shores. The waves reached as far as six miles inland, leaving 217 square miles submerged²⁴. The primary cause of nearly 20,000 deaths was by drowning due to extreme flooding. However, the death toll could have been much higher had it not been for Japan's early warnings of the imminent natural disaster.

The most destructive consequence of the tsunami, beyond the deaths and flooding, was the nuclear meltdown at the Fukushima Daiichi Nuclear Power Plant. Although the power plant was designed to withstand potential natural disasters, it was not constructed to survive a tsunami of this size. The strength of the tsunami disrupted the power plant's cooling system. The backup generators were damaged by the waves, cutting the power and preventing the cooling system from working. Some fuel rods within the plant melted and, after dropping to the floor, were hot enough to burn holes in the side of the plant²⁵. As a result, there was a radioactive release from Fukushima. The government responded by requiring an evacuation within a 12.5-mile radius from the power plant. Planes were forbidden from flying within 18 miles of the site. "In mid-April Japanese nuclear regulators elevated the severity level of the nuclear emergency at the Fukushima Daiichi facility from 5 to 7—the highest level on the scale created by the International Atomic Energy Agency..." It was several months before the edge of the evacuation radius was deemed inhabitable again. Even several years later, the plant continues to leak radioactive material into the Pacific Ocean²⁶.

²³ Matthews

²⁴ Oskin

²⁵ Rafferty

²⁶ Oskin

Chapter 4

Insurance Industry Response to Catastrophes

As mentioned before, catastrophic events encourage nations to adjust their current response systems. Each natural disaster brings to light new information that had previously gone unnoticed. After making these adjustments, countries hope to be better prepared for the next catastrophe that strikes.

United States

After Hurricane Katrina, many insurance companies had no desire to continue doing business in the affected states. One of the most recent studies lists Hurricane Katrina's insurance costs at \$76.3 billion²⁷. Naturally, this was quite a blow for the insurance companies that sold policies in Louisiana and surrounding states. As a result, many insurance companies left Louisiana after Katrina, leaving most people to insure their property with Louisiana Citizens Property Insurance Corporation. This organization defines itself as an "insurer of last resort," providing inexpensive insurance to those unable to afford competitive premiums from private insurers²⁸. As the largest remaining insurer in the state, Louisiana Citizens Property Insurance Corporation held 174,000 policies in 2008. However, the state knew that it was crucial to diversify the insurance providers available to its citizens. Therefore, over twenty new P/C insurers were introduced in Louisiana in the years following Katrina. Jim Donelon, Louisiana's Insurance Commissioner, "[attributes this outcome] in part to strategies including legislative reforms, active recruitment of companies and the Citizens Property Insurance Depopulation program"²⁹. Starting in 2005, the state implemented new building codes to ensure that infrastructure would remain sound in the event of a similar disaster, including discounts to those whose homes fit the restrictions imposed by the Louisiana

²⁷ Kunreuther and Michel-Kerjan

²⁸ Louisiana Citizens Property Insurance Corporation

²⁹ Insurance Journal

State Uniform Construction Code³⁰. The state legislature also developed incentives to encourage citizens to purchase property insurance. Though small and regionally focused, these companies cut the number of policies held by Louisiana Citizens Property Insurance Corporation in half; by the middle of 2015, the 174,000 policies dropped to 86,645³¹.

It was clear that the United States needed to make changes so that it would not be similarly hurt by a disaster in the future. The Insurance Information Institute made the following essential observation:

The 2005 hurricane season exposed many weaknesses in the nation's preparedness for megadisasters. For example, many people in flood zones had failed to buy flood insurance ... and many communities in harm's way did not have or had not enforced strong building codes, which would have reduced the amount of wind damage. In addition, the disasters drew attention to the need to reconsider land use patterns in areas most vulnerable to storm damage. And as has happened after other major disasters, many small businesses that suffered damage from the storms failed to reopen, in part because they hadn't bought business income (also known as business interruption) and extra expense insurance which would have helped cover income lost when the business was shut down and the expense of getting back on track after the reconstruction period.³²

These key factors identify where the United States spends much of its money in the process of rectifying the damage done by catastrophes. The state of Mississippi, another victim of Hurricane Katrina, has recently taken steps to move forward. Legislation was approved in March 2014 to update building codes after being identified as a "hurricane-prone" state by the Insurance Institute for Business and Home Safety. Through insurance rate reductions, the state is incentivizing people to live in buildings with the up-to-date qualifications. In addition, the Insurance Institute for Business and Home Safety and the Department of Homeland Security are working together to design buildings better suited to endure the strong winds brought on by hurricanes. The state of Florida is taking somewhat of a different approach. The state is in possession of the Florida Hurricane Catastrophe Fund, which acts as a reinsurance agent with \$17 billion of coverage. Although the reinsurance provision of the fund drives up insurance

³⁰ Insurance Journal

³¹ Jones

³² Insurance Information Institute

premiums somewhat, it is an extra layer of safety for insurers. It does, however, reduce the likelihood of the state of Florida needing to use tax dollars to pay for hurricane-related damages³³.

Chile

Chile is somewhat of a phenomenon in that it is quite prepared for natural disasters. In comparison to countries like Haiti, which also was struck by an earthquake in 2010, Chile is home to citizens who place a great emphasis on insurance. Its major cities like Santiago and Valparaiso are the most sufficiently covered under insurance policies, but even rural citizens understand the importance of protecting their property³⁴. In addition, the Chilean government enforced strict construction codes in the years prior to the quake. New buildings must be constructed so they do not crumble during earthquakes with magnitudes as high as 9.0. These buildings are fit to stand even if they are somehow damaged during the quake, so long as they do not give way. Local government officials must check these buildings frequently and thoroughly to ensure that they are up to code³⁵.

Protecting corporate property is of great importance to Chileans. Commercially, over three-quarters of large businesses and one-third of small businesses defend themselves by purchasing insurance for natural disasters like fires and earthquakes. However, less than one-fourth of Chilean homeowners insure their property. Because insurers assume little catastrophic risk internally, much of that risk is transferred to international reinsurers. When the earthquake of 2010 hit, international reinsurance companies assumed an astounding 95% of the losses. To put this into perspective, reinsurance companies typically assume half of the losses. Forty percent of the assumed 95% of losses were divided evenly between treaty reinsurance – which, as its name implies, involves a treaty in which the reinsurer agrees to

³³ Insurance Information Institute

³⁴ Swiss Re

³⁵ Franklin

pay for risks ceded by the insurer – and excess of loss reinsurance³⁶. The remaining 60% was facultative, meaning the reinsurer is not required to offer protection.

The insurance industry showed its strength in its response to the 2010 earthquake. Within two months of the disaster, almost all of the resulting claims were filed. Within a year, “more than 95% of residential and 80% of commercial losses [had] been paid. Many of the projects built via concession deals³⁷ with the private industry were insured, providing recovery from the reinsurance system that otherwise would have fallen on the state”³⁸. Finally, not a single insurance company went bankrupt because of the earthquake³⁹.

That being said, Chile’s response to the 2010 earthquake was not perfect. “Chile’s navy and emergency preparedness office failed to issue a tsunami warning that might have saved hundreds of lives after the Feb. 27 quake, and [President] Bachelet didn’t order soldiers to impose order in the streets until after looting had spun out of control”. Some complain that the government response to the quake was too slow. Sebastian Pinera, Bachelet’s successor, complained of the lack of immediate establishment of control after the earthquake. He expressed his concerns that Chile did not emphasize that it was in a “state of catastrophe”⁴⁰.

Although Chile may not have been flawless in its response, the nation had learned quickly from Hurricane Katrina and the Haitian earthquake that an extended delay of aid can lead to destruction too severe to rectify in a timely manner. After completely analyzing the catastrophe’s damage, the Chilean government created a threefold plan: “a financing program, a legislative agenda, and a reconstruction plan”⁴¹. Bachelet was quick to request relief aid from other countries. She also called for rapid reconstruction, particularly of transportation infrastructure. Her goals were put into action within just ten

³⁶ Felfie, Paul, et al.

³⁷ According to Investopedia, a concession agreement is “an agreement between the owner of a facility and the concession owner or concessionaire that grants the latter exclusive rights to operate a specified business in the facility under specified conditions. Regardless of the type of concession, the concessionaire usually has to pay the party that grants it the concession ongoing fees that may either be a fixed amount or a percentage of revenues.”

³⁸ Felfie, Paul, et al.

³⁹ Felfie, Paul, et al.

⁴⁰ Associated Press and Quilodran

⁴¹ Fernandois

days of the earthquake: the government delivered over 12,000 tons of relief to those in need, and 90% of those living in destruction areas regained power and water. In addition, a national telethon raised money to provide homes for the poor who were left without shelter⁴².

Some say that the 2010 earthquake was a blessing in disguise for Chile. The government's reconstruction efforts actually stimulated the economy in the latter part of 2010 through 2012⁴³. After the quake, Chile enforced new earthquake standards. Chile's reconstruction plan focused primarily on an early warning system for potential catastrophes. It also emphasized the importance of building regulations and meticulous inspections. When an earthquake struck in 2014 with a force similar to that of 2010, there were only six casualties recorded⁴⁴. The new warning system – consisting of sirens, mobile device alerts, and aid from local firefighters and police – notified civilians in Coquimbo within minutes of the tremors. Chile paid particular attention to the relief procedures designed by the United Nations. In fact, it was so successful after the 2014 earthquake that it has become the UN model for disaster relief⁴⁵.

Japan

Earthquake insurance is split into two categories in Japan: residential earthquake insurance and commercial property earthquake insurance. The government plays an important role in residential earthquake insurance. The law regarding Earthquake Insurance, implemented after the 1964 Niigata earthquake, uses the government support to cover claims that policyholders, insurers, and reinsurers cannot handle. Commercial earthquake insurance, on the other hand, has no government support. It relies solely on the capacity reinsurers can absorb. Commercial earthquake insurance is an “extension of the standard policy,” of which there is a limit on the number of policies permitted⁴⁶.

⁴² Associated Press and Quilodran

⁴³ Fermandois

⁴⁴ Investor's Business Daily [A14]

⁴⁵ Franklin

⁴⁶ Katsura Saito Financial Services Agency

The 2011 earthquake and tsunami cost Japan \$35.7 billion in insurance⁴⁷. Large international reinsurers handled the disaster well due to their geographic diversification. Middle-sized insurers, however, were hurt and ended up leaving the region. Japanese head of Swiss Re, Takashi Goda, was quoted in an interview saying, “The insurance industry paid no more than 17% of the overall economic cost for the disastrous event. In terms of improving penetration, both insurers and industry associations have been active in promoting earthquake insurance through community-based promotional activities and other channels”⁴⁸. The insurance industry paid a relatively small portion of the overall costs due to the Japanese reinsurance system, in which the government covers costs beyond a designated cap. Before the earthquake and tsunami, the government funded catastrophe costs that exceeded \$14.4 billion – a threshold lowered to \$8.6 billion after the disaster to help the insurance industry recover, as shown in Figure 5⁴⁹. Because each disaster leads to new observations, the Japanese insurance industry looks to update its modeling system for catastrophes such as this. One major update is the inclusion of aftershocks in accounting for the severity of earthquakes⁵⁰. Data scarcity does remain an issue, but it will only improve over time due to technological advancements⁵¹.

⁴⁷ Kunreuther and Michel-Kerjan

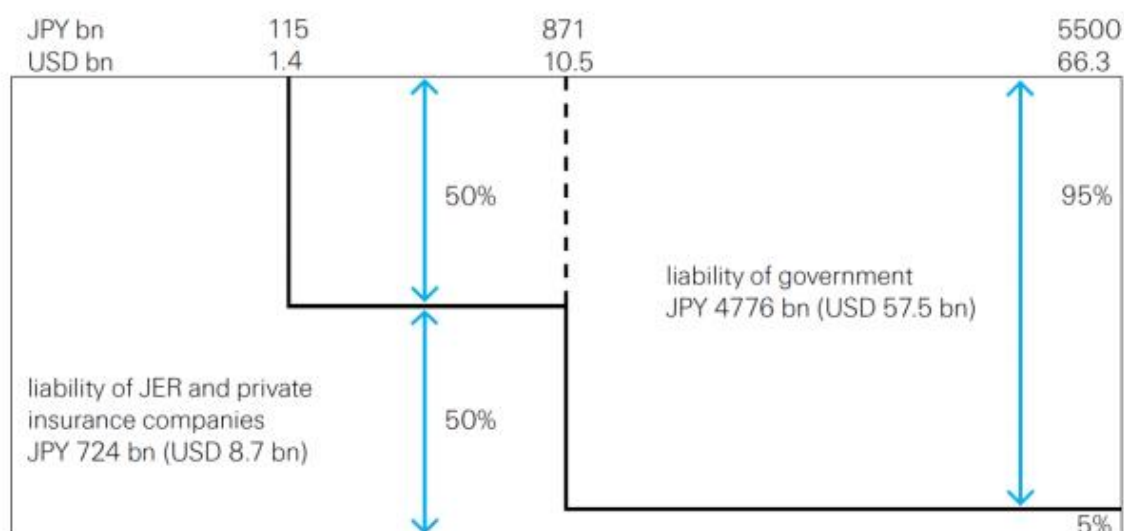
⁴⁸ Goda

⁴⁹ Nguyen

⁵⁰ Goda

⁵¹ Artemis

Figure 5. Japan's Earthquake Risk Sharing



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There are still improvements to be made in Japan. The country suffers from a “protection gap between economic and insured losses.” Reinsurance becomes ever more crucial to relieve the state from funding what insurers cannot. Japan, like fellow Asian nation China, is looking into alternate forms of reinsurance. These include catastrophe bonds, insurance-linked securities, and collateralized reinsurance products. In fact, Japanese companies issued several catastrophe bonds in 2014 and 2015. The Kizuna Re II was a \$245 million earthquake bond issued in 2014 and updated to \$290 million in 2015; another earthquake catastrophe bond, the Nakama Re, was a \$300 million policy issued in May of 2014. The Aozora Re was a \$100 million typhoon catastrophe bond issued in 2014⁵³. These bonds are designed to diversify risk so the reinsurance industry does not solely assume all the losses caused by catastrophic damage.

⁵² Nguyen

⁵³ Artemis

Chapter 5

Lessons Learned: Improvements to the United States Catastrophe Response System

Insurance Regulation in the United States

The United States employs a unique system of insurance regulation. Unlike most countries, where insurance is regulated federally, the United States leaves insurance regulation to the states. The federal government has the power to intervene if necessary; however, there have been very few circumstances where this has been the case. The National Association of Insurance Commissioners offers regulatory suggestions that the states can, but are not forced to, follow. Insurance companies are primarily regulated in the state in which they are domiciled. The companies can operate in other states as well, but those states have less control over the actions of said companies.

Insurance regulation is heavily based on accounting standards, primarily Statutory Accounting Principles (SAP) and Generally Accepted Accounting Principles (GAAP). Insurers are required to meet two capital requirements: the “fixed minimum” requirement and the risk based capital (RBC) requirement, which is calculated by the equation below⁵⁴.

$$RBC=0.5(R0+\sqrt{R1^2 + R2^2 + R3^2 + R4^2 + R5^2})$$

where:

R0 – investments in affiliates

R1 – fixed income assets

R2 – equity assets

R3 – credit

R4 – loss reserves

R5 – premiums

⁵⁴ Klein and Wang

Insurance experts argue that this accounting-based method of calculating RBC is detrimental to the United States: “If regulators placed more emphasis on financial risk assessment than accounting values, insurers would have greater incentives to use the most efficient methods and face fewer impediments”⁵⁵, according to Robert Klein and Shaun Wang. They also note that there are few regulatory incentives to limit catastrophe risk. The RBC model does not adequately account for catastrophes. There should be an additional R6 in the equation specifically dedicated to such a category, rather than including catastrophe risk in R5, the premium category dedicated to accounting for “risks of underpricing and rapid growth”⁵⁶. With this extra category, insurance companies would be less likely to underestimate catastrophic loss. There are also no requirements for insurers to create an internal risk modeling system. Very few insurers employ the enterprise risk management (ERM) outlook on risk. Without a well-rounded risk management system, catastrophe risk can be overlooked.

Catastrophe Response System

There are several mechanisms used by insurers to handle catastrophes. The first is the insurer’s surplus, often considered the “first layer of protection”⁵⁷. The surplus account poses several problems. One issue is that the surplus is not solely reserved for catastrophes in the event they occur. The account could be reduced due to other circumstances (such as investment in treasury bills or money market funds⁵⁸), leaving insurers with less than enough to deal with a major disaster. Second, the relatively high surplus account could cause regulators to pressure insurers to lower their prices, as they have less need for risk loading⁵⁹. Finally, income added to the surplus is subject to taxation, stunting the account’s growth.

⁵⁵ Klein and Wang [609]

⁵⁶ Klein and Wang [610]

⁵⁷ Klein and Wang [617]

⁵⁸ Business Filings

⁵⁹ Klein and Wang [618]

Another mechanism used by insurers is reinsurance, the assumption of the insurer's risk by a separate insurance company. Reinsurance is often used to provide layers of protection for losses beyond what an insurer can afford to pay out. Insurers in the United States can choose to reinsure with either domestic or foreign companies. According to Klein and Wang, "of all the U.S. regulatory policies, its treatment of foreign reinsurance may be having the most adverse effects on the cost and extent of catastrophe risk financing"⁶⁰. Insurance expert J.D. Cummins identifies the outdated collateralization⁶¹ system in the United States as a barrier to success through reinsurance. First, collateralization requirements for foreign reinsurance companies are costly. Second, collateralization requirements "reduce the supply of reinsurance for U.S. insurers"⁶². Third, it is a disincentive for domestic insurers to verify the riskiness of working with foreign reinsurance companies. Finally, the system in the United States is at odds with the systems in place internationally because "U.S. requirements are directly opposed to the EU reinsurance directive that effectively abolishes collateralization"⁶³.

Ideally, domestic insurers would have their own catastrophe reserves, such as the aforementioned risk based capital R6 category. Both insurance companies and the states in which they are domiciled are in agreement that such reserves should exist and either be taxed favorably or not at all. Nevertheless, it will take some time before catastrophe reserves are implemented nationally. Before they are created, updates to the SAP and GAAP methods of accounting need to be made. Also, the federal government remains a threatening barrier to their implementation. The government is concerned about insurers manipulating taxation rules regarding the reserves: "Giving favorable tax treatment to catastrophe reserves would reduce federal tax revenues and does present some challenges in crafting rules that would

⁶⁰ Klein and Wang [619]

⁶¹ As defined by Investopedia, collateralization is "the act where a borrower pledges an asset as recourse to the lender in the event that the borrower defaults on the initial loan. Collateralization of assets gives lenders a sufficient level of reassurance against default risk, which allows loans to be issued to individuals [and] companies with less than optimal credit history [and] debt rating."

⁶² Klein and Wang [619]

⁶³ Klein and Wang [620]

prevent their abuse”⁶⁴. A temporary fix to this issue is to add the R6 catastrophe component to the RBC equation, as mentioned previously.

Another proposal for catastrophe relief is a federal catastrophe reinsurance fund. Although the fund does not yet exist, the general plan would include state coverage of lower risk levels and federal coverage of risks that the states are unable to handle⁶⁵.

Changes in Response to Hurricane Katrina, Inspired by Chile and Japan

According to researchers Klein and Wang, the United States is in desperate need of changes to its catastrophe response system. The summary of their concerns is as follows:

The current U.S. government posture toward catastrophe risk and its financing is a growing disaster in itself. There is essentially little support for and encouragement of conventional or alternative private catastrophe risk financing. Further, state regulatory policies and management of special catastrophe funds as well as residual market mechanisms further depress the demand for and supply of private capital and have increased government underwriting of catastrophe risk at inadequate prices. The proposal for a national cat fund would likely exacerbate the underpricing of insurance and government absorption of catastrophe risk. Together, these policies and proposals are moving in the wrong direction – they are discouraging efficient risk management by property owners and other stakeholders.⁶⁶

A major hindrance to the improvement of catastrophe insurance is that “the rising costs of disasters in recent years are due primarily to the high concentration of value at risk in increasingly urbanized, hazard-prone coastal areas, plus the relatively high degree of insurance penetration within the U.S. market, compared to less developed countries”⁶⁷. In the United States, there is a high concentration of property in coastal areas prone to hurricanes and other natural disasters⁶⁸; half of the properties at risk are in New York, Texas, and Florida. There is an extremely high probability of a hurricane causing significant damage in the future, so it is important to protect property susceptible to damage. The cost of

⁶⁴ Klein and Wang [618]

⁶⁵ Klein and Wang [626]

⁶⁶ Klein and Wang [627]

⁶⁷ Kunreuther and Michel-Kerjan [2]

⁶⁸ Insurance Information Institute

catastrophes is especially high due to “hidden insurance subsidies,” caused by three factors. First, insurance rates do not match up with their actuarially fair premium (potential losses multiplied by their respective probabilities, resulting in the expected value of a loss) based on risk exposure and historical catastrophe rates. Second, in some areas, funds were set up to ensure that all people have property insurance. However, if these funds run out of money, insurance companies take the hit. If insurance companies also cannot afford to pay the claims, they “pass the cost on to all property insurance policyholders in the state through explicit policy surcharges ... or indirectly in the form of higher property insurance rates”⁶⁹. Third, the reconstruction of destroyed buildings in high-risk areas is quite expensive.

The United States has taken some measures to reduce the cost of natural disasters. The National Flood Insurance Program (NFIP), managed by the Federal Emergency Management Agency (FEMA), was initiated in 1968 in response to destructive flooding in the 1950s and 1960s. NFIP is a voluntary program that any community has the opportunity to join. In order to join, those communities must require new construction, as well as reconstruction of buildings already standing, to be built at least at the sea level considered the “100-year flood” level. This means that the buildings must have a foundation above the level of a flood that has a 1% chance of occurring each year. Once this is done, the community members and businesses can purchase flood insurance. However, there are several issues with NFIP. The first is that compliance is difficult to regulate. For example, after a flood in Vermont in the summer of 1998, an astounding 84% of homeowners were without flood insurance, of which 45% were required to have purchased it because they had joined NFIP. Also, fewer than half of Hurricane Katrina’s victims were protected by flood insurance. Second, citizens of the United States have grown used to federal aid in times of need. In other words, the more the government steps in, the more it tends to pay with each subsequent natural disaster. Third, the buildings that were in place before NFIP are subsidized even though they pose a much greater risk than those built to the code designated by the plan. Fourth, the properties damaged by floods are often flooded repetitively:

⁶⁹ Insurance Information Institute

As of 2009, there were 71,000 insured “repetitive loss properties,” representing only 1.2 percent of the NFIP portfolio but accounting for 16 percent of total claim payments between 1978 and 2008. About one in ten of these repetitive loss properties have received cumulative flood insurance reimbursements that have exceeded the value of the house.⁷⁰

Finally, there is a concern that the NFIP may not be able to remain financially sound due to the unpredictability of catastrophic events. Because three particularly destructive catastrophes struck in just eight years (Hurricanes Katrina, Ike, and Sandy), the NFIP racked up a debt of \$24 billion by the end of 2013. Clearly, the \$3.5 billion in total annual premiums is not sufficient to cover that much debt.

The National Flood Insurance Reform Act (NFIRA) was introduced in 2012 to update NFIP. Its goal is the enforcement of actuarially fair insurance premiums while ensuring affordability for policyholders. The act includes up-to-date flood risk maps, identifying areas of concern for future natural disasters. There are three key components to NFIRA’s success. The first is the requirement of flood insurance. All properties susceptible to flood damage must be insured, and this insurance requirement should be enforced. Chile’s emphasis on the importance of mandatory insurance is a perfect example of this goal. After its 2010 earthquake, the Chilean government was quick to ensure that every citizen understood the benefits of purchasing earthquake insurance. Although the message did not reach all Chileans, enough of the population purchased insurance and made sure their buildings met industry requirements to ensure that there were only six casualties in the earthquake four years later. The United States must mirror Chile in its enforcement of insurance compliance. One way to spark an interest in purchasing home and property insurance is by making such policies more affordable. In Chile, on average, home and property insurance combined costs about \$150 USD per month⁷¹. In the United States, on the other hand, high-risk areas like Florida and Louisiana ask for the same monthly amount just for home insurance⁷². Insurance policies that are more inclusive of the wide economic range of potential catastrophe victims would encourage a greater percentage of the population to purchase such insurance,

⁷⁰ Kunreuther and Michel-Kerjan [5]

⁷¹ Retire Early Lifestyle

⁷² Value Penguin

which, in turn, would reduce the overall debt induced by natural disasters. Full compliance with the purchase of insurance would increase the risk pool for insurers. Balancing high-risk customers with low-risk ones would help reduce insurance premium prices. This enforcement of compliance must be coupled with strict enforcement of current building codes. Regular checking of buildings, particularly of those in highly-populated disaster-prone areas, is a simple method of hedging against catastrophe costs. The cost of these inspections is worth paying if it prevents the destruction of those buildings in the event of a catastrophe.

Second, it is crucial to create up-to-date risk maps indicating areas susceptible to repeated damage in the event of a natural disaster. Takashi Goda of Swiss Re noted after the 2011 earthquake and tsunami that Japanese experts continually update their data and technology to account for new findings after each natural disaster. While their most recent information is still never perfect, each realization is a step toward more closely accounting for various levels of risk. If the United States had the most accurate information available, insurance companies could use these most recent risk maps to update actuarially fair premiums. Given the destructive catastrophes just of the past fifteen years, these premiums are bound to increase beyond what some people in disaster-prone areas have the capacity to pay. To address unaffordability, experts suggest an insurance voucher system. This system would compensate for the difference between current premiums and the actuarially fair premiums enforced after new risks are recognized. The compensation would only be made available to those already living in areas prone to catastrophic loss. The vouchers are not handouts that could be used for any purpose – the recipients could only use the vouchers to help pay for an increased premium. Modeled after programs like the Food Stamp Program, the dollar amount of each voucher would be dependent on “the family’s income, other socio-demographic information (e.g. number of children living at home) and the magnitude of the increase in the insurance premium”⁷³.

⁷³ Kunreuther and Michel-Kerjan [7]

Third, in addition to the voucher system, mitigation loans should be included in insurance premiums. No real success can be achieved unless infrastructure susceptible to damage is protected and updated regularly. As emphasized throughout this research, Chile's enforcement of building codes after the 2010 earthquake was a crucial component of the country's successful withstanding of the 2014 earthquake. Meeting those codes saved not only billions of dollars, but also hundreds of lives. Mitigation loans incorporated into the insurance payment system can put the United States on a track to successful risk hedging that parallels Chile's. This combination would be dramatically less expensive than purchasing insurance and mitigation means separately:

By spreading the upfront costs of a loss reduction measure over time through a home improvement loan, residents in flood-prone areas would have an economic incentive to mitigate the risk of future flood damages. Suppose a family was offered a 20-year loan at 3 percent to elevate their home four feet at a cost of \$25,000. If they undertook this measure, their risk-based annual flood insurance premium would be reduced from \$4,000 to \$520. If the family takes the loan, the annual payment would be \$1,680. From a financial viewpoint, this package should be attractive, since the reduction in the annual insurance premium of \$3,480 is much greater than the cost of the loan.⁷⁴

Affordable policies that combine risk vouchers with other forms of risk reduction encourage potential customers to purchase insurance, thereby increasing the risk pool and further curtailing prices in the future. In addition, if more people are inclined to purchase the affordable insurance, the government is less likely to resort to tax funds to compensate for disaster losses.

Finally, the United States can follow Japan and explore alternate forms of catastrophe reinsurance. In recent years, Japan has focused on diversification of risk through insurance-linked securities like catastrophe bonds. Catastrophe bonds are similar to regular bonds – investors purchase the bonds, and the proceeds from the bond premiums are used to fund disaster losses should an insurer or reinsurer be unable to cover all of it. Catastrophe bonds are particularly attractive to customers for several reasons. First, catastrophe bonds have little or no connection with stock market movement. Second, investors typically receive high returns on their purchases. Third, these bonds are not nearly as volatile as

⁷⁴ Kunreuther and Michel-Kerjan [7]

other forms of investment⁷⁵. What distinguishes catastrophe bonds from generic bonds is the “special condition that states that if the issuer (insurance or reinsurance company) suffers a loss from a particular pre-defined catastrophe, then the issuer’s obligation to pay interest and/or repay the principal is either deferred or completely forgiven”⁷⁶. The United States first employed catastrophe bonds at the end of the twentieth century to mitigate risk after natural disasters like Hurricane Andrew. Another alternative method of reinsurance Japan has explored is collateralized reinsurance. As mentioned previously, international collateralization tends to be expensive for the United States. It remains an option, but the United States may want to consider using more affordable methods. Continued use of these alternative methods, like the aforementioned voucher system, would spread the risk over several different channels, thus limiting the necessity for the government to fund the loss via taxes. (For more information on the structure of catastrophe bonds, please reference the Supplementary Figures in the Appendix.)

⁷⁵ Swiss Re Capital Markets

⁷⁶ Investopedia

Chapter 6

Conclusion

Given the high frequency of destructive catastrophes since the turn of the century, it has become increasingly more critical to find ways to reduce risk and total insurable losses. The United States especially needs to implement methods of risk mitigation, as it was home to seven of the ten worst insurable catastrophes from 2000-2015. The sheer size of the United States accounts for part of the reason behind the large loss totals. However, although there are already many programs designed to reduce monetary loss, a comparison of disaster relief efforts between the United States, Chile, and Japan identifies areas of improvement for the current American system.

The United States must look to diversify its methods of risk assumption. Japanese insurance and reinsurance companies transfer risk to investors through insurance-linked securities. Catastrophe bonds, in particular, are attractive to financiers looking to invest in products with low risk and high potential returns. By advertising such investment opportunities, the American system would benefit in two ways: (1) American insurers would not have to assume as much risk, therefore reducing insurance premium costs and encouraging consumers to purchase insurance; and (2) the government would not have to fund losses to the same extent as those in the past.

The United States can also seek improvement through the National Flood Insurance Reform Act, legislation designed to offer accurate risk information as well as make insurance more affordable for everyone in risk-prone areas. Like Chile, the United States must stress the importance of mandatory insurance. The combination of an increased risk pool and frequent infrastructure assessments will save, respectively, money in long-term investments and lives during the next catastrophic event. People currently paying premiums lower than what is actuarially fair should not be punished because of the new risk mapping. A government-sponsored voucher would compensate for some of the price difference by taking into account the current socioeconomic status of each insurance holder. Finally, mitigation loans would be included in insurance premiums rather than be treated as a separate entity. These loans fund

frequent architectural checks, as is the case in Chile, so that losses due to building damage decrease in future years.

The implementation of these changes will help the United States reduce its total insurance costs from catastrophic loss. Learning from fellow nations experiencing similar situations, American insurance companies and legislators can constantly adapt current systems to ensure that the current relief measures are the most efficient and cost-effective. Openness to adjustments will help the United States, over time, become a model of catastrophe relief for the rest of the world.

Appendix

Supplementary Figures

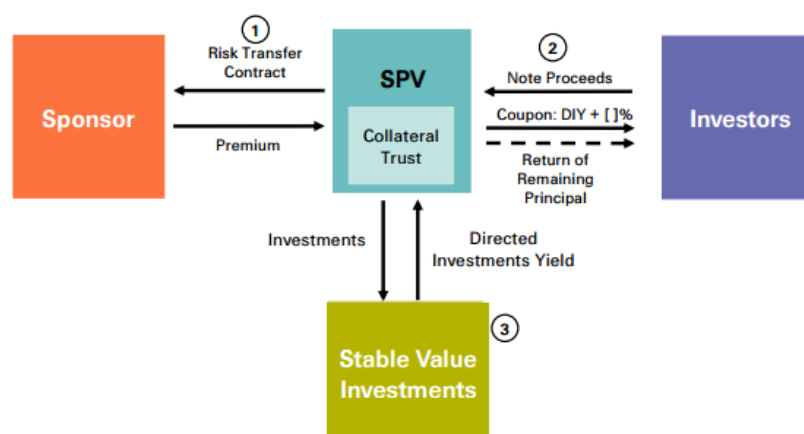
TABLE 1: THE 25 MOST COSTLY INSURED CATASTROPHES IN THE WORLD, 1970-2012

\$ BILLION	EVENT	VICTIMS (DEAD AND MISSING)	YEAR	AREA OF PRIMARY DAMAGE
76.3*	Hurricane Katrina; floods	1,836	2005	USA, Gulf of Mexico
39	9/11 terrorist attacks	3,025	2001	USA
35.7	Earthquake (M 9.0) and tsunami	19,135	2011	Japan
35.0*	Hurricane Sandy; floods	237	2012	USA
26.2	Hurricane Andrew	43	1992	USA, Bahamas
21.7	Northridge Earthquake (M 6.6)	61	1994	USA
21.6	Hurricane Ike; floods	136	2008	USA, Caribbean
15.7	Hurricane Ivan	124	2004	USA, Caribbean
15.3	Floods; heavy monsoon rains	815	2011	Thailand
15.3	Earthquake (M 6.3); aftershocks	181	2011	New Zealand
14.7	Hurricane Wilma; floods	35	2005	USA, Gulf of Mexico
11.9	Hurricane Rita	34	2005	USA, Gulf of Mexico, et al.
11.0	Drought in the Corn Belt	123	2012	USA
9.8	Hurricane Charley	24	2004	USA, Caribbean, et al.
9.5	Typhoon Mireille	51	1991	Japan
8.5	Hurricane Hugo	71	1989	Puerto Rico, USA, et al.
8.4	Earthquake (M 8.8); tsunami	562	2010	Chile
8.2	Winter Storm Daria	95	1990	France, UK, et al.
8.0	Winter Storm Lothar	110	1999	France, Switzerland, et al.
7.4	Storms; over 350 tornadoes	350	2011	USA (Alabama et al)
7.2	Major tornado outbreak	155	2011	USA (Missouri et al)
6.7	Winter Storm Kyrill	54	2007	Germany, UK, NL, France
6.2	Storms and floods	22	1987	France, UK, et al.
6.2	Hurricane Frances	38	2004	USA, Bahamas
6.0	Hurricane Irene	55	2011	USA, Caribbean

*Including payment by the U.S. National Flood Insurance Program.

Sources: Authors' calculation. Data from Swiss Re and Insurance Information Institute (in 2012 prices). Note: Years from 2001-2012 are in bold.

How do Cat Bonds Work?



1. The sponsor (the insurer or reinsurer looking to get protection) enters into a risk transfer contract (reinsurance or derivative) with a special purpose company established specifically for the transaction (SPV)
2. The SPV capitalizes itself by issuing Notes (the "Cat Bonds") to Investors in the capital markets in an amount equal to the limit of the risk transfer contract
3. Proceeds from the securities offering are transferred into a collateral trust account and invested to provide a stable return
4. If no covered event occurs during the risk period the bonds will be redeemed at 100% of face value. In case of a covered event meeting the thresholds set forth in the risk transfer contract, funds will be withdrawn from the collateral account to make an event payment to the sponsor. The redemption price of the bonds is reduced accordingly

BIBLIOGRAPHY

- Artemis. "Catastrophe Bond Issuance in Asia Pacific to Increase: Fitch." *Artemis.bm - Catastrophe Bonds, ILS, Reinsurance, Risk Transfer*. Steve Evans, 21 Aug. 2015. Web. 26 Dec. 2015.
- Associated Press, and Federico Quilodran. "Disaster Experts Praise Chile Earthquake Response." *Cleveland.com*. Plain Dealer and Northeast Ohio Media Group, 10 Mar. 2010. Web. 7 Feb. 2016.
- Bruggeman, Veronique, Michael G. Faure, and Tobias Heldt. "Insurance against Catastrophe: Government Stimulation of Insurance Markets for Catastrophic Events." *Duke Environmental Law & Policy Forum*. Vol. 23. 2012. 185-204. *Gale LegalTrac*. Web. 26 Dec. 2015.
- Center for Research on the Epidemiology of Disasters (CRED). "Disasters List." *The International Disaster Database*. Web. 9 Jan. 2016.
- Devlin, Sean. "Cat Modeling & Pricing." *Comp. Swiss Re. Proc. of CAS Seminar on Reinsurance*, 6 June 2011, Philadelphia. 2011. 1-59. *Casualty Actuarial Society*. Web. 4 Jan. 2016.
- The Editors of Encyclopedia Britannica, ed. "Hurricane Katrina." *Encyclopedia Britannica Online*. Web. 1 Jan. 2016.
- Encyclopedia Britannica. "Japan Earthquake and Tsunami of 2011." Web. 31 Dec. 2015.
- Felfie, Paul, et al. *Chile: One Year On*. Aon Benfield, 2011. Print.
- Fernandois, Arturo, comp. *Chile and Its Earthquake: Preparedness, Response, and Lessons*. Mar. 2011. Gobierno de Chile, *National Research Council (U.S.) Commission on Geosciences, Environment, and Resources*. Web. 18 Jan. 2016.
- Franklin, Jonathon. "How Did Chile Manage to Survive Its Recent Earthquake Virtually Unscathed?" *The Guardian*. Rockefeller Center, 25 Sept. 2015. Web. 18 Jan. 2016.
- Goda, Takashi. "Tohoku Earthquake – A Year After." *Swiss Re*. 13 Mar. 2012. Web. 26 Dec. 2015.

History.com Staff. "Hurricane Katrina." *History.com*. A+E Television Networks, 2009. Web. 26 Dec. 2015.

Hutchinson, K. J. "Unit 2 Section C - Causes and Effects of Tropical Storms and Responses to Them." Map. *Worldlywise Wiki*. Apr. 2010. Web. 31 Dec. 2015.

Insurance Information Institute. "Catastrophes: Insurance Issues." Dec. 2015. Web. 4 Jan. 2016.

Insurance Journal. "10 Years after Katrina/Rita Louisiana Citizens' Market Share at 1.8%." Wells Media Group, 12 Aug. 2015. Web. 25 Feb. 2016.

Investopedia. Dictionary of Financial Terminology. 2016. Web. 28 Feb. 2016.

Investor's Business Daily. "Lessons of a Quake-Proof Chile." *Investor's Business Daily* 4 Apr. 2014: A14. *Business Source Premier*. Web. 30 Dec. 2015.

Jones, Stephanie K. "Hurricane Katrina: The Numbers Tell Their Own Story." *Insurance Journal*. Wells Media Group, 26 Aug. 2016. Web. 3 Jan. 2016.

Kane, Angela. "A Race between Education and Catastrophe." *The Global Forum on Disarmament and Non-Proliferation Education*. Comp. United Nations Office for Disarmament Affairs. 10 Aug. 2012, Nagasaki, Japan. 2012. 1-4. *United Nations*. Web. 31 Mar. 2016.

Katsura Saito Financial Services Agency. "Catastrophe Risks and Reinsurance in Japan." *OECD*. 29 Oct. 2004. Web. 17 Feb. 2016.

Klein, Robert W., and Shaun Wang. "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 (2009): 607-37. *Wiley Online Library*. Web. 26 Dec. 2015.

Kunreuther, Howard, and Erwann Michel-Kerjan. "Implementing the National Flood Insurance Reform Act in a New Era of Catastrophes." *Public Policy Initiative: Issue Brief* 1.9 (2013): 1-8. *Penn Wharton: University of Pennsylvania*. Web. 7 Jan. 2016.

- Louisiana Citizens Property Insurance Corporation. "Company Overview." 2008. Web. 06 Apr. 2016.
- Matthews, Sherrie Voss. "UTSA Community Members Reach out to Japan Earthquake, Tsunami Victims." Map. *UTSA Today*. The University of Texas at San Antonio, 14 Mar. 2011. Web. 1 Jan. 2016.
- Nguyen, Tristan. *Insurability of Catastrophe Risks and Government Participation in Insurance Solutions. PreventionWeb*. United Nations Office for Disaster Risk Reduction, 2013. Web. 7 Feb. 2016.
- Oskin, Becky. "Japan Earthquake and Tsunami of 2011: Facts and Figures." *Live Science*. 7 May 2015. Web. 31 Dec. 2015.
- Rafferty, John P. "Chile Earthquake of 2010." *Encyclopedia Britannica. Encyclopedia Britannica Online*. Web. 1 Jan. 2016.
- Retire Early Lifestyle. "Retire to Chile, South America." Web. 28 Feb. 2016.
- Richmond, Cedric. *Remembering Hurricane Katrina. Congressman Cedric Richmond: 2nd District of Louisiana*. 29 Aug. 2011. Web. 9 Jan. 2016.
- Sample, Ian. "Japan Earthquake and Tsunami: What Happened and Why." *The Guardian*. Guardian News and Media, 11 Mar. 2011. Web. 31 Dec. 2015.
- Swiss Re. "Chile Earthquake Expected to Be a Major Insurance Event." 31 Mar. 2010. Web. 26 Dec. 2015.
- Swiss Re. "International Perspectives on Solvency Modernisation: United States of America." 10 Oct. 2011. Web. 26 Dec. 2015.
- Swiss Re. "Japan Tsunami – No Longer an Unmodelled Risk." May 2012. Web. 26 Dec. 2015.
- Swiss Re Capital Markets. "What Are Insurance Linked Securities (ILS), and Why Should They Be Considered?" *Presentation to the CANE Fall Meeting (2012): 1-17. Casualty Actuarial Society*. Web. 28 Feb. 2016.

United States. Financial Economics and Risk Assessment Government and Finance Division. *Hurricane Katrina: Insurance Losses and National Capacities for Financing Disaster Risks*. Washington: GPO, 2008. *HeinOnline*. Web. 26 Dec. 2015.

"Using Cash Flow Surpluses for Investment or to Pay Down Debt." *BizFilings*. Business Filings, 24 May 2012. Web. 28 Feb. 2016.

ValuePenguin. "Average Cost of Homeowners Insurance (2016)." 2016. Web. 28 Feb. 2016.

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