The role of public and private insurance in reducing losses from extreme weather events and disasters

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This article describes the challenges that victims, insurers and governments face in dealing with insurance for low-probability high-consequence events in both developed and developing economies. In developed economies, given their limited experience with catastrophes, there is a tendency for all three parties to engage in short-term intuitive thinking rather than long-term deliberative thinking when making insurance-related decisions. Here, public-private partnerships can encourage investment in protective measures prior to a disaster, deal with affordability problems and provide coverage for catastrophic risks. Insurance premiums based on risk provide signals to residents and business as to the hazards they face and enable insurers to lower premiums for properties where steps have been taken to reduce their risk. To address issues of equity and fairness, homeowners who cannot afford insurance could be given vouchers tied to loans for investing in loss reduction measures. The National Flood Insurance Program provides an opportunity to implement a public-private partnership that could eventually be extended to other extreme events, while the United Kingdom’s Flood Re provides a good case study. In developing economies, insurance penetration is historically very low. This requires innovative solutions to catastrophic risk insurance such as risk pooling, parametric insurance and micro insurance. Nevertheless, the uninsured and uncompensated losses of disasters remain extensive, implying the need for public-private partnerships.

Keywords: extreme weather events, climate disasters, flood insurance, disaster insurance, public-private partnerships, catastrophic risk pooling, parametric insurance, micro insurance

INTRODUCTION

The Intergovernmental Panel on Climate Change’s Fifth Assessment Reports, including Working Group I’s Report, Climate Change 2013: The Physical Science Basis;


Parts of this article draw from the analysis of insurance as a risk transfer mechanism in R Lyster, Climate Justice and Disaster Law (Cambridge University Press, Cambridge 2015).
Working Group II’s Report, *Climate Change 2014: Impacts, Adaptation and Vulnerability*, as well as one of its earlier reports, WG II’s *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)*, all attest to an escalation in climate-related disasters occasioned by more extreme weather events due to an increase in the variability of the earth’s climate. In recent times, the world has experienced more severe disasters than ever before. Hurricane Patricia which hit Mexico on 24 October 2015 had maximum sustained wind speeds of 215 mph (345 km/h), making it the most intense tropical cyclone on record in the Western Hemisphere and the strongest globally in terms of one-minute maximum sustained winds. On 21 February 2016, Cyclone Winston, with sustained winds of more than 325 km/h that devastated Fiji, was one of the biggest storms ever recorded in the Southern Hemisphere.

Insurers are also recognizing that the costs of climate disasters are escalating beyond anything experienced before, largely due to the intersection of the risk associated with extreme weather with residential and business property in harm’s way. The data collected on climate disasters by insurers and reinsurers are a credible source upon which to rely. Worldwide, insured losses from weather-related disasters have risen from US$5.1 billion per year between 1970 and 1989 to US$27 billion annually over the past two decades. Current climate risks could cost emerging economies anywhere between 1 and 12 per cent of GDP by 2030, increasing to 19 per cent under a high climate change scenario.

In the summer of 2010, China and Pakistan experienced extraordinary rainfall resulting in 6000 deaths. One-fifth of Pakistan was flooded, affecting 20 million people, inundating thousands of schools and health centres and destroying 2.2 million hectares of crops, making this the worst natural disaster in Pakistan’s history. Although this flood resulted in an estimated $6.0 billion in damage and $9.5 billion in economic loss, only $100 million was insured as it occurred in very low income areas of the country. Five million people were affected by undernourishment with

severe damage of crops leading to higher food prices. In China, an estimated 230 million people were affected, 15 million of whom became homeless, and overall damage was estimated to be US$53 billion, with insured losses of only US$761 million. Almost all of the losses had to be absorbed by the victims, government and NGOs.8

Lloyd’s calculated the total damage from the 2011 Thai flood as US$30 billion or 8.68 per cent of GDP.9 Insured losses were US$12 billion or 3.47 per cent of GDP, leaving an insurance gap of US$18 billion or 5.21 per cent of GDP. However, when the impact on international supply chains is included, the World Bank estimates the total loss to be US$45.7 billion, making this one of the top five costliest natural disasters in modern history.10 Then, in November 2013, Typhoon Haiyan struck the Philippines, causing an estimated total damage of US$14.5 billion with only US$300 million of the loss insured. In September 2015, Asia Pacific Economic Cooperation (APEC) Finance Ministers acknowledged that the region is now experiencing more than 60 per cent of the world’s disasters, with damages reaching US$1.2 trillion in the past decade (2001–2010).11

Weather risks are changing faster in North America than anywhere else in the world.12 In 2012, Hurricane Sandy devastated the Caribbean and the east coast of the United States and caused widespread damage. The US National Hurricane Center reports13 that due to its tremendous size it drove a catastrophic storm surge14 into the New Jersey and New York coastlines. The features of the hurricane included winds,15 extraordinary size,16 storm surge (the highest of which was 12.65 feet (3.85 metres) in New York,17 and rainfall (up to 713 millimetres), which, along with storm surge, contributed to record flooding in New York and New Jersey adjacent to the Hudson River, with more than 650 000 houses either damaged or destroyed.18 Up to 8.5 million customers lost power for weeks or even months in some areas. As of 2015, estimates

7. Abhas Jha (n 6) 14.
14. Storm surge is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tide, and is expressed in terms of height above normal tide levels. Sandy caused water levels to rise along the entire east coast of the United States from Florida northward to Maine; Eric S Blake, ibid 8.
15. Ibid 4.
17. Ibid 8.
of assessed damage were around US$75 billion (2012 US$), a total surpassed only by Hurricane Katrina of 200519 (for which the damage was estimated to be between $96 and $125 billion).20 Insured losses for Hurricane Sandy amounted to only US$20 billion.21

ANALYSING CLIMATE DISASTERS AND INSURANCE IN THE US

Unsurprisingly, the number of Presidential disaster declarations in the United States has dramatically increased over the past 50 years. Figure 1 shows the total number of Presidential declarations and those that were triggered by flooding events (inland floods and storm surges from hurricanes). This pattern highlights the need to encourage those at risk to invest in loss reduction measures prior to a disaster, rather than waiting until after the event occurs. Insurance coupled with other risk management programmes can play an important role. Insurance is designed to spread risk: each policyholder pays a relatively small premium to an insurer who can then cover the large losses suffered by a few. Ideally, those who invest in loss prevention measures are rewarded by having the price of their coverage reduced to reflect their lower expected claims payments.

Unfortunately, insurance against low-probability, high-consequence events presents a challenge for individuals at risk, insurers and regulators for good reason. Decision-makers have limited experience with these events and even experts are likely to conclude that there is considerable uncertainty as to the probability of

![Figure 1 Number of US Presidential Disaster Declarations: 1958–2010](https://example.com/figure1.png)

**Source:** E Michel-Kerjan, S Lemoyne de Forges and H Kunreuther, ‘Policy Tenure under the U.S. National Flood Insurance Program (NFIP)’ (2012) 32 Risk Analysis 644.

**Figure 1 Number of US Presidential Disaster Declarations: 1958–2010**

these events occurring and their resulting consequences. As a result, insurance decisions often differ from those recommended by normative models of choice. Consider the following examples:

**Example 1:** Most homeowners in flood-prone areas do not voluntarily purchase flood insurance – even when it is highly subsidized – until after they suffer damage from a disaster. If they then do not experience losses in the next few years, they are likely to cancel their policy. Similarly, demand for earthquake insurance in California increased significantly after the Northridge earthquake of 1994 – the last severe quake in the state; today relatively few homeowners have coverage.

**Example 2:** State insurance regulators sometimes have restricted insurers from setting premiums that reflect risk, in part to address equity and fairness issues for consumers in need of flood insurance. For example, following Hurricane Andrew in 1992, the Florida insurance commission did not allow insurers to charge risk-based rates and restricted them from cancelling existing homeowners’ policies. After the severe hurricanes of 2004 and 2005 in Florida, the state-funded company, Citizens Property Insurance Corporation that had been the insurer of last resort, offered premiums in high-risk areas at subsidized rates, thus undercutting the private market. Today, Citizens is the largest provider of residential wind coverage in Florida.

The above two examples indicate that insurance today is not effectively meeting two of its most important objectives:

- Providing information to those residing in hazard-prone areas as to the nature of the risks they face;
- Incentivizing those at risk to undertake loss reduction measures prior to a disaster.

The insurance industry played both of these roles very effectively when the factory mutual companies were founded. In 1835, Zachariah Allen, a prominent textile mill owner, improved his property to reduce the likelihood of fire loss and requested a reduction in his insurance premium. When his request was denied, he called upon other local textile mill owners who shared his loss-prevention philosophy to create a mutual insurance company that would insure only factories that had undertaken risk reduction measures. The premiums remaining at the end of the policy period would be returned to policyholders in the form of dividends.22

Over the next 20 years a number of mutual insurance companies were formed. The mutuals required inspections of factories prior to issuing a policy and after insurance coverage was in force. Poor risks had their policies cancelled; premiums reflected risk and were reduced for factories that instituted loss-prevention measures. For example, the Boston Manufacturers worked with lantern manufacturers to encourage them to develop safer designs and then advised their policyholders that they had to purchase lanterns from those companies meeting their specifications. In many cases, factory mutual companies would only provide coverage to firms that adopted specific loss prevention methods. For example, one company, the Spinners Mutual, only insured risks where automatic sprinkler systems were installed.23 Today, FM Global continues to play this role. They work closely with their policyholders to reduce risk threats to their property by undertaking cost-effective loss prevention measures.

This part of the article proposes a strategy for insurance, offered in developed economies, to take steps to return to its roots. The examples and empirical data presented here are taken primarily from experience in the United States; however, the concepts have relevance to any country that utilizes insurance to protect its residents and businesses against potentially large losses.

The next three sections explore the rationale for the actions taken by each of the interested parties illustrated in the above examples by focusing on their decision processes prior to and after a disaster. We then propose two guiding principles for insurance and outline a long-term strategy with roles for the private and public sectors if these principles are implemented. Reforming the US’s National Flood Insurance Program to encourage mitigation for reducing future losses, while providing financial protection to those at risk, is an opportunity that should be seriously considered. The concluding section suggests directions for future studies and research so insurance can play a central role in reducing losses from extreme events.

THE ROLES OF INTUITIVE AND DELIBERATIVE THINKING

A large body of cognitive psychology and behavioural decision research over the past 30 years has revealed that individuals and organizations often make decisions under conditions of risk and uncertainty by combining intuitive thinking with deliberative thinking. In his thought-provoking book *Thinking, Fast and Slow*, Nobel Laureate Daniel Kahneman has characterized the differences between these two modes of thinking. Intuitive thinking (System 1) operates automatically and quickly with little or no effort and no voluntary control. It is often guided by emotional reactions and simple rules of thumb that have been acquired by personal experience. Deliberative thinking (System 2) allocates attention to effortful and intentional mental activities where individuals undertake trade-offs, recognizing relevant interdependencies and the need for coordination.

Choices are normally made by combining these two modes of thinking and generally result in good decisions when individuals have considerable past experience as a basis for their actions. With respect to low-probability high-consequence (LP-HC) events, however, there is a tendency to either ignore a potential disaster or overreact to a recent one so that decisions may not reflect expert risk assessments. For example, after a disaster, individuals are likely to want to purchase insurance even at high prices, while insurers often consider restricting coverage or even withdrawing from the market. In these situations, both parties focus on the losses from a worst-case scenario without adequately reflecting on the likelihood of this event occurring in the future.

IMPACT OF INTUITIVE THINKING ON CONSUMER BEHAVIOUR

Empirical studies have revealed that many individuals engage in intuitive thinking and focus on short-run goals when dealing with unfamiliar LP-HC risks. More specifically,
individuals often exhibit systematic biases such as the *availability heuristic*, where the judged likelihood of an event depends on its salience and memorability.26 There is thus a tendency to ignore rare risks until after a catastrophic event occurs. This is a principal reason why it is common for individuals at risk to purchase insurance only after a large-scale disaster.

**Purchase of flood insurance**

A study of the risk perception of homeowners in New York City revealed that they underestimate the likelihood of water damage from hurricanes. This may explain why only 20 per cent of those who suffered damage from Hurricane Sandy had purchased flood insurance before the storm occurred.27

An in-depth analysis of the entire portfolio of the National Flood Insurance Program in the United States revealed that the median tenure of flood insurance was between two and four years while the average length of time in a residence was seven years. For example, of the 841 000 new policies bought in 2001, only 73 per cent were still in force one year later. After two years, only 49 per cent were in force and eight years later only 20 per cent. Similar patterns were found for each of the other years in which a flood insurance policy was first purchased.28

One reason that individuals cancel their policies is that they view insurance as an investment rather than a protective activity. Many purchase coverage after experiencing a loss from a disaster but feel they wasted their premiums if they have not made a claim over the next few years. They perceive the likelihood of a disaster as so low that they do not pay attention to its potential consequences and conclude they did not need insurance. A normative model of choice, such as expected utility theory, implies that risk averse consumers should value insurance as it protects them against large losses relative to their wealth. Individuals should celebrate not having suffered a loss over a period of time rather than cancelling their policy because they have not made a claim. A challenge facing insurers is how to convince their policyholders that *the best return on an insurance policy is no return at all*.

**IMPACT OF INTUITIVE THINKING ON INSURER BEHAVIOUR**

Two factors play an important role in insurers’ behaviour with respect to pricing and coverage decisions: the role of past experience and the role of ambiguous risk. We examine each of these features in turn.


Role of past experience on supply of insurance

When insurers have experienced significant losses from a particular extreme event, there is a tendency for them to focus on worst-case scenarios without adequately considering their likelihood. In some instances, due to extreme losses from hurricanes or floods, insurers determined that they could not continue to market coverage in the United States without involvement by the public sector. In these situations, either the state or federal government stepped in to fill the void.

Hurricane wind-related losses

Following catastrophic wind losses from hurricanes in Florida, insurers felt they had to significantly raise their homeowners’ premiums. Rather than using catastrophe models to justify rate increases, insurers pointed to their large losses following Hurricane Andrew in 1992 as a basis for demanding higher premiums without considering the likelihood of another disaster of this magnitude occurring. The insurers were denied these rate increases and reduced their supply of new homeowners’ policies.29

By the beginning of 2004, most insurers viewed their Florida rates as being close to adequate except in the highest-risk areas. However, after four major hurricanes battered Florida in 2004 and two more in 2005, many insurers again began to file for major premium increases and many of them were denied or approved at lower increases by the regulators. In 2007, the Florida Office of Insurance Regulation (FLOIR) took a position against any further rate increases of homeowners’ insurers and denied requests by all insurers. In December 2008, State Farm asked for a 67 per cent increase in premiums that was denied by the FLOIR, leading the insurer to announce that it would no longer offer homeowners’ coverage in Florida.30 Five years later (March 2014), State Farm announced that it would begin offering homeowners and renters insurance in the state on a limited basis.31

Flood insurance32

Following the severe Mississippi floods of 1927 and continuing through the 1960s there was a widespread belief among private insurance companies that the flood peril was uninsurable by the private sector for several reasons: adverse selection

would be a problem because only particular areas are subject to the risk, risk-based premiums would be so high that no one would be willing to pay them, and flood losses could be so catastrophic as to cause insolvencies or have a significant impact on surplus. This lack of coverage by the private sector triggered significant federal disaster relief to victims of Hurricane Betsy in 1965 and led to the creation of the National Flood Insurance Program (NFIP) in 1968.

The NFIP subsidized premiums to maintain property values on structures in flood-prone areas; new construction was charged premiums reflecting risk. Even though premiums on existing property were highly subsidized, relatively few homeowners purchased coverage, leading Congress to pass the Flood Protection Act (FDPA) of 1973. This bill required all properties receiving federally-backed mortgages to purchase flood insurance.

The NFIP has grown extensively in the past 40 years; as of January 2015 it had sold more than 5.2 million policies in 22,000 communities and provided almost $1.3 trillion in coverage. Insurance tends to be concentrated in coastal states, with Florida and Texas alone comprising nearly 40 per cent of the entire programme (in number of policies, premiums and coverage). After making claims payments from Hurricane Katrina in 2005, the NFIP found itself $18 billion in debt so that its borrowing authority had to be increased from $1.5 to $20.775 billion. To date, the programme has borrowed nearly $27 billion from the US Treasury to meet its claims obligations in the aftermath of the 2004, 2005, 2008 and 2012 hurricane seasons.

In July 2012 (three months before Hurricane Sandy), Congress passed and the President signed the Biggert-Waters Flood Insurance Reform Act of 2012 (BW12), which applied the tools of risk management to the increasingly frequent threat of flooding. Among its many provisions, the legislation required that the NFIP produce updated floodplain maps, strengthen local building code enforcement, remove insurance subsidies for certain properties, and move towards charging premiums that reflect flood risk.

Soon after becoming law, BW12 faced significant challenges from some homeowners who had reason to complain that the new flood maps overestimated their risk. These residents and other homeowners in flood-prone areas felt that their proposed premium increases were unjustified and that they could not afford the increased premiums that they would face. In March 2014, Congress passed the Homeowner Flood Insurance Affordability Act (HFIAA14), which required the Federal Emergency Management Agency (FEMA) that operates the NFIP to draft an affordability framework based on the recommendations of a National Academy of Sciences study that address the affordability of flood insurance premiums.

**Role of ambiguity**

Empirical evidence based on surveys of underwriters reveals that insurers will set higher premiums when faced with ambiguous probabilities and uncertain losses than for a well-specified risk. Underwriters of primary insurance companies and reinsurance firms were surveyed about the prices they would charge to insure a factory

against property damage from a severe earthquake when probabilities and losses were well specified and when the probabilities and losses were ambiguous. The premiums the underwriters charged for the ambiguous case were 1.43 to 1.77 times higher than if underwriters priced a precise risk.34

A recent web-based experiment provided actuaries and underwriters in insurance companies with scenarios in which they seek advice and request probability forecasts from different groups of experts and then must determine what price to charge for coverage for flood damage and wind damage from hurricanes. The average premium that insurers would charge was approximately 30 per cent higher for coverage against either of these risks if the probability of damage was ambiguous rather than well-specified and if the experts were conflicted over their estimates. The data reveal that they would likely charge more in the case of conflict ambiguity (that is, experts disagree on point estimates) than imprecise ambiguity (that is, experts agree on a range of probability, recognizing that they cannot estimate the probability of the event precisely).35

IMPACT OF INTUITIVE THINKING ON REGULATOR BEHAVIOUR

Rate regulation and restriction on coverage has had more impact on property insurance than on any other line of coverage, particularly in states that are subject to potentially catastrophic losses from natural disasters.

Homeowners insurance in Florida

Following Hurricane Andrew in August 1992, Florida regulators imposed a moratorium on the cancellation and non-renewal of homeowners’ insurance policies during the upcoming hurricane season for insurers that wanted to continue to do any business in Florida. In November of 1993, the state legislature enacted a bill that these insurers could not cancel more than 10 per cent of their homeowners’ policies in any county in Florida in one year and not cancel more than 5 per cent of their property owners’ policies state-wide for each of the next three years. During the 1996 legislative session, this phase-out provision was extended until 1 June 1999.36

Early in 2007, Florida enacted legislation that sought to increase regulatory control over rates and roll them back based on new legislation that expanded the reinsurance coverage provided by the Florida Hurricane Catastrophe Fund (FHC). Insurers were required to reduce their rates to reflect this expansion of coverage, which was priced below private reinsurance market rates. This requirement applies to every licensed insurer, even if an insurer does not purchase reinsurance from the FHC.

The Citizens Property Insurance Corporation, Florida’s state-funded company, was formed in 2002 and has experienced a significant increase in market share of the residential property market in recent years. Consumers are allowed to purchase a policy from Citizens if a comparable policy would cost 15 per cent more in the private market. The most serious defect of such a system is that it encourages individuals to locate in high-hazard areas, thus putting more property at risk than would occur under a market system. This is the principal reason not to introduce such a system in the first place. Since 2005 there have been no hurricanes causing severe damage in Florida. But should there be a serious disaster that depletes Citizens’ reserves, the additional claims are likely to be paid from assessments (taxes) charged to all homeowners in Florida.

GUIDING PRINCIPLES FOR INSURANCE

The following two guiding principles should enable insurance to play a more significant role in the management and financing of catastrophic risks.37

Principle 1 – premiums should reflect risk

Insurance premiums should be based on risk to provide individuals with accurate signals as to the nature of the hazards they face and to encourage them to engage in cost-effective mitigation measures to reduce their vulnerability. Risk-based premiums should also reflect the cost of capital that insurers need to integrate into their pricing to assure an adequate return to their investors.

Catastrophe models have been developed and improved over the past 25 years to more accurately assess the likelihood and damages resulting from disasters of different magnitudes and intensities. Today, insurers and reinsurers utilize the estimates from these models to determine risk-based premiums and how much coverage to offer in hazard-prone areas.38

If Principle 1 is applied to risks where premiums are currently subsidized, some residents will be faced with large price increases. This concern leads to the second guiding principle.

Principle 2 – dealing with equity and affordability issues

Any special treatment given to low-income individuals currently residing in hazard-prone areas should come from general public funding and not through insurance premium subsidies. Funding could be obtained from several different sources, such as general taxpayer revenue, state government or taxing insurance policyholders, depending on the response to the question ‘Who should pay?’ It is important to note that Principle 2 applies only to those individuals who currently reside in

37. These principles are discussed in more detail in Kunreuther and Michel-Kerjan (n 29) and Kunreuther, Pauly and McMorrow (n 25).
hazard-prone areas. Those who decide to locate in these regions in the future would be charged premiums that reflect the risk.

DEVELOPING LONG-TERM STRATEGIES FOR DEALING WITH EXTREME EVENTS IN DEVELOPED ECONOMIES

Given the nature of intuitive thinking for LP-HC events, this section proposes strategies for applying the two guiding principles so that insurance in combination with other policy tools can reduce future losses from extreme events. The proposed risk management strategy involves:

- **Choice architecture** to frame the problem so that the risks are transparent and key interested parties recognize the importance of purchasing and maintaining insurance while also undertaking protective measures to reduce their losses from the next disaster
- **Public-private partnerships** to assist those who cannot afford to invest in protective measures and provide financial protection against catastrophic losses for risks that are considered uninsurable by the private sector alone
- **Multi-year insurance** to provide premium stability to policyholders, lower marketing costs to insurers and reduce the cancellation of coverage by those at risk.

Choice architecture

The term *choice architecture*, coined by Thaler and Sunstein, indicates that people’s decisions often depend in part on how different options are framed and presented. **Framing** in the context of LP-HC events typically refers to the way in which likelihoods and outcomes are characterized. One can also influence decisions by varying the reference point or by changing the order in which alternatives and/or their attributes are presented, or by setting one option as the no-choice default option.

Framing the risk

People are better able to evaluate low-probability risks when these are presented via a familiar concrete context. For example, individuals might not understand what a one-in-a-million risk means but can more accurately interpret this figure when it is compared to the risk of an automobile accident (1-in-20) or lightning striking your home on your birthday (less than one-in-a-billion).

Probability is more likely to be a consideration if it is presented using a longer time frame. People are more willing to wear seat belts if they are told they have a 1-in-3 chance of an accident over a 50-year lifetime of driving, rather than a 1-in-100 000 chance of an accident on each trip they take. Similarly, a homeowner or manager


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considering earthquake protection over the 25-year life of a home or factory, is far more likely to take the risk seriously if told that the chance of at least one severe earthquake occurring during this time period is greater than 1-in-5, rather than 1-in-100 in any given year.42

Studies have shown that even just multiplying the single-year risk so the numerator is larger – presenting it as 10-in-1000 or 100-in-10 000 instead of 1-in-100 – makes it more likely that people will pay attention to the event.43 Studies have also found that comparisons of risks – rather than just specifying the probability of a loss or an insurance premium – are much more effective in helping decision-makers assess the need for purchasing insurance.44

Another way to frame the risk so that individuals pay attention is to construct a worst-case scenario. Residents in hazard-prone areas who learn about the financial consequences of being uninsured if they were to suffer severe damage from a flood or earthquake would have an incentive to purchase insurance coverage and may refrain from cancelling their insurance if they have not made a claim for a few years. One could then provide them with information on the likelihood of the event occurring over the next 25 years rather than just next year.

Insurers could also construct worst-case scenarios and then estimate the likelihood of the event’s occurrence when pricing their insurance policies. They could then determine a premium that reflects their best estimate of their expected loss while at the same time factoring in the uncertainty surrounding the risk.

**Default options**

Field and controlled experiments in behavioural economics reveal that consumers are more likely to stick with the default option rather than going to the trouble of opting out in favour of some other alternative. Many examples of this behaviour are detailed in Thaler and Sunstein’s important book, *Nudge*.45 To date, this framing technique has been applied to situations where the outcome is either known with certainty or when the chosen option (such as a recommended 401(k) plan), has a higher expected return than the other options.46 It is not clear whether people who failed to purchase coverage would reverse course if having insurance against an extreme event was the default option, given the intuitive thinking that individuals employ for these types of risks. More empirical research is needed to more fully understand the role that default options can play with respect to encouraging insurance protection for LP-HC events.

45. Thaler and Sunstein (n 39).
Private-public partnerships

Individuals at risk may be reluctant to invest in cost-effective loss reduction measures when these involve a high upfront cash outlay. Given budgetary constraints and individuals’ focus on short time horizons, it is difficult to convince them that the expected discounted benefits of the investment over the expected life of the property exceeds the immediate upfront cost. Decision-makers’ resistance is likely to be compounded if they perceive the risk to be below their threshold level of concern. Residents in hazard-prone areas may also be concerned that if they move in the next few years, the property value of their home will not reflect the expected benefits from investing in loss reduction measures because the new owner will not be concerned about the risk of a disaster.47

Mitigation grants and loans

FEMA created the Flood Mitigation Assistance (FMA) programme in 1994 to reduce flood insurance claims. FMA is funded by premiums received by the NFIP to support loss reduction measures, such as the elevation or relocation of property, flood-proofing commercial structures or the demolition and rebuilding of property that has received significant damage from a severe flood.

In July 2014, Connecticut initiated its Shore Up CT programme designed to help residential or business property-owners elevate buildings, retrofit properties with additional flood protection, or assist with wind-proofing structures on property that is prone to coastal flooding. This state programme, the first in the United States, enables homeowners to obtain a 15-year loan ranging from $10 000 to $300 000 at an annual interest rate of 2¾ per cent.48

More generally, long-term loans to homes and businesses for mitigation would encourage individuals to invest in cost-effective risk-reduction measures. Consider a property owner who could pay $25 000 to elevate his coastal property from 3 feet below Base Flood Elevation (BFE) to one foot above BFE to reduce storm surge damage from hurricanes. If flood insurance is risk-based then the annual premium would decrease by $3480 from $4000 to $520. A 15-year loan for $25 000 at an annual interest rate of 2¾ per cent would result in annual payments of $2040, so the savings to the homeowner each year would be $1440 (that is, $3480 - $2040).

Means-tested vouchers

One way to maintain risk-based premiums while at the same time addressing issues of affordability is to offer means-tested vouchers that cover part of the cost of insurance. Several existing programmes could serve as models for developing such a voucher system: the Food Stamp Program, the Low Income Home Energy Assistance Program (LIHEAP) and the Universal Service Fund (USF).49 The amount of the voucher would

49. For more details on these programmes see Kunreuther and Michel-Kerjan (n 29).
be based on current income and determined by a specific set of criteria as outlined in National Research Council (2015). If the property owners were offered a multi-year loan to invest in mitigation measure(s), the voucher could cover not only a portion of the resulting risk-based insurance premium, but also the annual loan cost to make the package affordable. As a condition for the voucher, the property owner could be required to invest in mitigation.

An empirical study of homeowners in Ocean County, NJ reveals that the amount of the voucher is likely to be reduced significantly from what it would have been had the structure not been mitigated, as shown in Figure 2 for property in a high hazard flood area (the V Zone) and a lower hazard area (the A Zone).50


**Figure 2 Cost of programme to the federal government and a hypothetical homeowner**

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**Catastrophe coverage**

As indicated above, insurers’ withdrawal from certain markets due to lack of sufficient reinsurance capacity and other risk transfer instruments (for example, catastrophe bonds) led to the establishment of government-backed programmes such as the California Earthquake Authority, the National Flood Insurance Program (NFIP) and the Terrorism Risk Insurance Act (TRIA).

If insurers were permitted to charge risk-based premiums they would very likely want to market coverage against earthquakes and floods as long as they were protected against catastrophic losses. State reinsurance facilities could play an important role in this regard if premiums were risk-based using data provided by catastrophe

models. One such facility exists today – the Florida Hurricane Catastrophe Fund. It was established in 1993 following Hurricane Andrew to supplement private reinsurance and reimburse all insurers for a portion of their losses from catastrophic hurricanes.

TRIA provides protection to insurers against catastrophic losses from future terrorist attacks. Insurance companies provide coverage for all losses in excess of their policy deductibles and the federal government reinsures the insurer’s terrorism loss in excess of a TRIA deductible percentage by covering 80 per cent of these losses. American taxpayers will not be responsible for any payments until the total commercial losses from a terrorist attack exceed $60 billion. In other words, insurers will cover the entire losses from future terrorist attacks that are not catastrophic.\(^51\)

Lewis and Murdock\(^52\) proposed that the federal government offer catastrophe reinsurance contracts that would be auctioned annually to private insurers in order to provide them with more capacity to handle truly extreme events. The design of such contracts would have to be specified, and a more detailed analysis would have to be undertaken to determine the potential impact of such an auction mechanism on the relevant stakeholders.

**Well-enforced regulations and standards**

Given the reluctance of individuals to voluntarily purchase insurance, one should consider requiring catastrophic coverage for all individuals who face risk. Social welfare is likely to be improved under the assumption that individuals would have wanted insurance protection had they perceived the risk correctly, and not exhibited systematic biases and utilized simplified decision rules that characterize intuitive thinking. If the public sector were providing protection against catastrophic losses from these extreme events they could pass a regulation requiring insurance coverage for individuals at risk.

Risk-based insurance premiums could be coupled with building codes so that those residing in hazard-prone areas adopt cost-effective loss reduction measures. Following Hurricane Andrew in 1992, Florida re-evaluated its building code standards, and coastal areas of the state began to enforce high-wind design provisions for residential housing. As depicted in Figure 3, homes that met the wind-resistant standards enforced in 1996 had a claim frequency that was 60 percent less than homes that were built prior to that year. The average reduction in claims from Hurricane Charley to each damaged home in Charlotte County built according to the newer code was approximately $20,000.\(^53\)

Homeowners who adopt cost-effective mitigation measures could receive a seal of approval from a certified inspector that the structure meets or exceeds building code standards. A seal of approval could increase the property value of the home by

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\(^51\) For more details on the renewal of TRIA see Howard Kunreuther et al., *TRIA After 2014: Examining Risk Sharing under Current and Alternative Designs* (Wharton Risk Management Center, University of Pennsylvania 2014).


informing potential buyers that damage from future disasters is likely to be reduced because the mitigation measure is in place. Evidence from a July 1994 telephone survey of 1241 residents in six hurricane-prone areas on the Atlantic and Gulf Coasts provides supporting evidence for some type of seal of approval. Over 90 per cent of the respondents felt that local home builders should be required to adhere to building codes, and 85 per cent considered it very important that local building departments conduct inspections of new residential construction.54

Multi-year insurance

As a complement to property improvement loans, insurers could consider designing multi-year insurance (MYI) contracts of three to five years. The insurance policy would be tied to the structure rather than the property owner, and carry an annual premium reflecting risk that would remain stable over the length of the contract. Property owners who cancel their insurance policy early would incur a penalty cost in the same way that those who refinance a mortgage have to pay a cancellation cost to the bank issuing the mortgage. With an MYI contract, insurers would have an incentive to inspect the property over time to make sure that building codes are enforced, something they would be less likely to do with annual contracts.

To compare the expected benefits of annual versus multi-year contracts, Jaffee, Kunreuther and Michel-Kerjan55 developed a two-period model where premiums reflect risk in a competitive market setting. They show that a MYI policy reduces the marketing costs for insurers over 1-period policies and also eliminates the search costs to policyholders should their insurer decide to cancel their coverage at the end of period 1. Should the policyholder learn that the cost of a 1-period policy is sufficiently

low to justify paying a cancellation cost, it is always optimal for the insurer to sell a MYI policy and for a consumer to purchase it. The insurer will set the cancellation cost at a level that enables it to break even on those policies that the insured decides to let lapse before the maturity date.

Several factors have contributed to the non-marketability of MYI for protecting homeowners’ properties against losses from fire, theft and large-scale natural disasters. Under the current state-regulated arrangements in which many insurance commissioners have limited insurers’ ability to charge risk-based premiums in hazard-prone areas, no insurance company would even entertain the possibility of marketing a homeowner’s policy that was longer than one year. Insurers would be concerned about the regulator clamping down on them now or in the future regarding what price they could charge. Uncertainty regarding costs of capital and changes in risk over time may also deter insurers from providing multi-year insurance.

For the private sector to want to market coverage if the above issues are addressed, there needs to be a sufficient demand to cover the fixed and administrative costs of developing and marketing the product. To empirically test the demand for multi-year insurance, a web-based experiment was undertaken with adults in the United States; most were older than 30 so they were likely to have experience purchasing insurance. The individuals participating in the experiment were offered a choice between 1-year and 2-year contracts against losses from hurricane-related damage. A large majority of the responders preferred the 2-year contract over the 1-year contract, even when it was priced at a higher level than the actuarially fair price. Introducing a 2-year insurance policy into the menu of contracts also increased the aggregate demand for disaster insurance.

MODIFYING THE NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program provides a target of opportunity to implement a long-term strategy for reducing risk that could eventually be extended to other extreme events. The two guiding principles for insurance would be utilized in re-designing the rate structure for the programme:

- Premiums would reflect risk based on updated flood maps so that private insurers would have an incentive to market coverage.
- Means-tested vouchers would be provided by the public sector to those who undertook cost-effective mitigation measures. This would address the affordability issue. This proposal for risk-based premiums and means-tested vouchers are part of BW12 that was modified in March 2014. The new legislation (HIFIAA14) delayed the implementation of risk-based premiums until issues of affordability of the NFIP were addressed. The National Research Council undertook this study and issued its first report in March 2015 (National Research Council, Affordability of National Flood Insurance Program Premiums – Report 1.
be given a premium discount to reflect the reduction in expected losses from
floods. Long-term loans for mitigation would encourage investments in cost-
effective mitigation measures. Well-enforced building codes and seals of
approval would provide an additional rationale for undertaking these loss
reduction measures.

- A multi-year insurance (MYI) policy tied to the property would prevent policy-
holders from cancelling their policies if they did not suffer losses for several
years. Property owners would be provided with stable annual premiums over
this period and would also have knowledge that they were protected against
water damage from floods and hurricanes.
- Reinsurance and risk-transfer instruments marketed by the private sector could
cover a significant portion of the catastrophic losses from future floods. Some
type of federal reinsurance would provide insurers with protection against
extreme losses.

The social welfare benefits of this proposed programme would be significant: less
damage to property, lower costs to insurers for protecting against catastrophic
losses, more secure mortgages, and lower costs to the government for disaster
assistance.

FLOOD RE: A PUBLIC-PRIVATE PARTNERSHIP CASE STUDY

Following catastrophic flooding in 2000 in the United Kingdom, and mindful of the
2014 Winter Floods, a public-private partnership (Flood Re), under development
for over a decade, has been finalized between the British government and the Asso-
ciation of British Insurers (ABI). It has been given statutory authority under Part 4
of the Water Act 201459 and will operate for 25 years, expiring in 2039. The Prud-
ential Regulatory Authority and Financial Conduct Authority have authorized
Flood Re with effect from 1 April 2016 and the scheme commenced on 4 April
2016.60 This highly innovative insurance scheme provides insights and inspiration
for other jurisdictions searching for a balance between government and private
insurance in the face of climate change and weather-related disasters.

The key elements of the agreement are:

- A commitment by the industry to offer insurance in high-risk areas at affordable
prices;
- The establishment of the Flood Reinsurance Scheme (Flood Re) run by the
industry that provides reinsurance to relevant insurers for the purposes of:
  o Promoting the availability and affordability of flood insurance for
households

accessed 10 April 2016.
(60) See Flood Re <http://www.floodre.co.uk/industry/> accessed 10 April 2016.
Managing the transition to risk-related pricing\textsuperscript{61} of flood insurance over a 25-year period for households, as was envisaged by the US’s BW12;\textsuperscript{62}

- A guarantee that the government would be primarily responsible for losses from ‘a catastrophic event’ that Flood Re could not cover; and
- Increased government spending on flood defences.\textsuperscript{63}

This will protect approximately 350 000 households over the course of the decade, providing a total of £2.3 billion in insurance.\textsuperscript{64} There is concern, however, that the scheme is not adequate to cover the estimated 825 000 homes considered to be at significant flood risk during the 2020s.

Flood Re will operate as follows:

- It will be run and financed by insurers as a not-for-profit fund which will cover the cost of flood claims from high-risk homes. However, if flooding exceeds a ‘1-in-200-year’ event the government will take primary responsibility for apportioning money to Flood Re policyholders,\textsuperscript{65} and will work with Flood Re to ensure that payments are distributed to them.\textsuperscript{66}
- Homeowners will continue to acquire the most suitable and cost-effective buildings and/or contents insurance. After a flood the homeowner will lodge a claim with the insurer.
- Flood Re allows insurers to place the flood risk element of domestic property insurance with Flood Re at a capped premium, based on the rates levied by local councils on the property if those households are deemed at high risk of flooding.\textsuperscript{67}
- As Flood Re will suffer a loss on every policy it holds, insurers will pay their share of an annual levy of £180m based on their share of the home insurance market, which equates to a levy of £10.50 on annual household premiums and represents the estimated level of cross-subsidy that already exists between lower and higher flood risk premiums. It is anticipated that in the future the primary levy will decrease, with corresponding increases in eligibility thresholds, so ensuring a smooth transition to risk-reflective prices.\textsuperscript{68}
- Flood Re will reimburse insurers for the costs resulting from any valid claims from policies which have been passed, or ceded, to Flood Re, subject to an excess per policy.
- The Secretary of State may make regulations prescribing a target number of properties to be insured for flood risk, as well as prescribing the relevant insurer’s share of insurance business for that type of risk.\textsuperscript{69} Enforcement action by the Financial Conduct Authority creates incentives for insurers to compete

\textsuperscript{61} For more information on the transition to risk-related premiums see Flood Re <http://www.floodre.co.uk/industry/flood-re-publishes-first-transition-plan-setting-out-how-home-insurance-market-will-return-risk> accessed 10 April 2016.
\textsuperscript{62} Water Act 2014 s 64(2).
\textsuperscript{64} Ibid 11.
\textsuperscript{65} Ibid.
\textsuperscript{66} Ibid 13.
\textsuperscript{67} Water Act (n 59) s 74.
\textsuperscript{68} Ibid s 66.
\textsuperscript{69} Ibid s 70.
with one another to ensure that they meet their quota requirements. Penalties apply to the non-performance of obligations.

- Any profits made by Flood Re will be retained by the scheme so as to create reserves that would cover any future shortfall. If there is a shortfall a top-up levy may be charged, but analysis suggests that this should only be required once or twice in the first ten years of the scheme.

PROBLEMS WITH DEVELOPING COUNTRIES AND INSURANCE

Developed countries’ governments have the capacity and resources to engage in large-scale prevention programmes, through land use and planning, building codes, land swaps, and resettlement and relocation, to reduce exposure to extreme weather events and slow-onset disasters; however, governments in developing countries generally lack these resources. Furthermore the post-disaster recovery programmes are fragile and unpredictable as low income developing countries face exhausted tax bases, depleted reserves and declining credit ratings, making external borrowing difficult. Governments attempt to raise post-disaster capital by diverting funds from other budgeted programmes, borrowing money domestically or taking out loans from international financial institutions. On average, international post-disaster assistance has covered approximately only 10 per cent of direct economic losses and in many cases much less. The result is that the uninsured and uncompensated climate disaster loss and damage is borne by individuals who are poor and vulnerable to future disasters. These individuals are forced to secure either emergency loans or remittances from family, micro-credit agencies or money-lenders, sell or mortgage assets and land, or rely on limited public post-disaster assistance and international aid. In many instances it is the NGOs, such as the UN Central Emergency Response Fund, Red Cross and Red Crescent, Care International and Oxfam who are the first responders, coordinating the efforts of various government bodies and charities to deliver medical assistance, food and temporary shelter.

The 2011 Thailand flood is a good case study for exposing the fragility of insurance solutions in developing countries, including those in the Asia Pacific. As was mentioned earlier in this article, Lloyd’s calculated the total damage from this flood as US$30 billion or 8.68 per cent of GDP. Insured losses were US$12 billion or 3.47 per cent of GDP, leaving an insurance gap of US$18 billion or 5.21 per cent of GDP. However, when the impact on international supply chains is included, the World Bank estimates the total loss to be US$45.7 billion, making this one of the top five costliest natural disaster events in modern history. The World Bank has

70. Bennett and Edmonds (n 63) 15.
71. Water Act (n 59) s 73.
72. Linnerooth-Bayer et al. (n 8) 385.
73. Ibid.
74. Ibid 384.
76. See Lloyd’s (n 9).
77. Aon Benfield (n 10) 3.
estimated that the recovery process will cost US$12 billion, with this figure including the expectation that rebuilding will be to a higher standard than was previously the case.79

The Thai government’s response was to establish a National Disaster Fund of US$1.6 billion to support the provision of natural disaster risk coverage to households, small firms and industries intended to operate for three years until such time as reinsurers re-evaluate their exposure in Thailand.80 Meanwhile, many reinsurers responded to the 2011 Thai floods by limiting their exposure to flood risk through various measures, including imposing flood event limits on their liability or totally excluding natural catastrophe cover, with some reinsurers exiting the Thai market.81 The local Thai insurance industry has now also responded by excluding flood cover which had previously been offered almost free in association with fire insurance policies. Household insurance policy premiums are now expected to double, with several exclusions and conditions written into the policies. Thailand’s insurance regulator has also changed the New Risk-Based Capital rules to require insurers to have a minimum capital adequacy ratio of 140 per cent as from January 2013.82

EMERGING PRIVATE AND PUBLIC INSURANCE RESPONSES IN DEVELOPING COUNTRIES

Given the differences between developed and developing economies’ ability to respond in the face of climate disasters, it is to be expected that insurance responses will also differ. In developing countries, the two primary responses to disaster risk insurance are micro insurance and risk pooling.

Micro insurance

At the micro level, households and businesses in low- and middle-income countries are beginning to access new index-based insurance policies, although these are only feasible if they are accessible to the poor. These schemes can also reduce the danger of moral hazards (when guaranteed compensation for losses encourages risk-taking behaviour) and adverse selection (when only high-risk households sign up for the insurance).

Micro insurance can support disaster risk reduction in a variety of ways. One approach is to bundle the insurance with loans to promote investments in risk reduction. This can also promote productive investments that help the most vulnerable escape disaster-related poverty traps.83 Index-based micro insurance can also be linked not only to observed hazard events, but to forecasts, so funds for risk reduction activities can be provided before the disaster occurs. Faure and Wibisana provide the example of Indonesia which has developed a new earthquake insurance product known as Kartu Gempa. This product provides cover of US$225 whenever an

79. Ibid 34.
80. Ibid 25.
81. Ibid 23.
82. Ibid 25.
earthquake occurs and falls within pre-determined parameters. The insurance can be purchased as a voucher at retail outlets at a cost of US$11.84. However, in reality, micro insurance only reaches a small fraction of risk-prone households and reviews of micro insurance pilot initiatives reveal substantial obstacles to scaling up these initiatives.

### Pooling catastrophic insurance risk in developing countries

Given the challenges of climate disasters to the insurance industry in developing countries, innovative insurance solutions for risk pooling have recently emerged that involve:

- Parametric and index-based insurance, where the insurer agrees to make a pre-defined pay-out when a ‘trigger’ is reached. For example, weather derivatives are being used to insure agricultural activities where policyholders’ actions or losses are difficult or costly to monitor;
- Multi-crop peril insurance, which could be developed to insure against hazards that have historically been difficult to cover.

### Risk pooling in the Caribbean

The concept of risk pooling for catastrophic risk has already been adopted by the Caribbean Catastrophe Risk Insurance Facility (CCRIF). This mechanism was launched in 2007 following Hurricane Ivan, which caused losses in Grenada and the Cayman Islands of 200 per cent of annual national GDP, with donors providing US$67 million in start-up capital. It was developed with the assistance of the World Bank and a grant from the Japanese government, and was capitalized through donations via contributions to a Multi-Donor Trust Fund (MDTF) from Canada, the European Union, the United Kingdom, France, Ireland, Bermuda and the Caribbean Development Bank, as well as membership fees paid by participating governments. It was the first insurance instrument in the world to successfully develop parametric policies backed by both traditional and capital markets. In 2014, CCRIF was restructured into a segregated portfolio company to facilitate the offering of new products and its expansion into new geographic areas such as Panama, the Dominican Republic and Nicaragua. Since its inception, CCRIF has made 13 pay-outs for hurricanes, earthquakes and excess rainfall in the amount of US$38 million to eight member governments within one to two weeks of the event.

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85. United Nations International Strategy for Disaster Reduction (n 82) 125.
87. Ibid 301.
88. Swiss Re (n 4) 10.
Risk pooling in Africa

The African Union has established a Specialized Agency known as the African Risk Capacity (ARC) to assist Member States (MSs) to improve their capacities to plan and prepare for extreme weather events and natural disasters as well as to respond to them. The ARC uses risk pooling and risk transfer to create pan-African climate response systems. ARC transfers the risk away from governments and individuals to the ARC. It uses an advanced satellite weather surveillance and a software system Africa RiskView that combines existing rainfall-based early warning models on agricultural drought in Africa with data on vulnerable populations to provide a standardized approach across the continent for estimating food insecurity response costs. This information is critical for drought financial preparedness and provides the basis for establishing and managing a parametric risk pool and triggering early disbursements. Africa RiskView provides every first-level administrative district in every country in sub-Saharan Africa with maximum costs estimates of drought-related responses before an agricultural season begins and as the season progresses. In addition to providing a financial early warning tool, it identifies and quantifies risk to assist countries and their partners to direct appropriate drought response actions and target food security investments. At COP 21 in Paris, the US, Germany, France and the UK committed US$150 million to the ARC. By June 2020, the ARC intends to cover 30 African states with funds of up to US$1.5 billion in coverage against drought, floods and cyclones.

In June 2014, ARC launched the first catastrophe insurance pool for African nations to help MSs become more resilient to extreme weather events and to protect food-insecure populations. The pool enables parametric insurance policies to be sold to African countries, providing them with predictable post-disaster event financing which adopts a rapid pay-out mechanism. A specialist hybrid mutual insurance company, ARC Insurance Company Limited, was established to issue parametric disaster insurance policies to a group of African governments, starting with Kenya, Mauritania, Mozambique, Niger and Senegal. The initial capital for the company was provided by Germany and the UK, which are also founding members of the mutual. In its first year, the ARC paid out $26.3 million to Senegal, Niger and Mauritania to distribute food and to transfer cash to 1.3 million people affected by drought, as well as to subsidize animal feed for 570,000 livestock.

Asia Pacific Economic Cooperation (APEC) and risk pooling

In September 2015, APEC Finance Ministers announced that they are confident that resilience to extreme weather events and disasters in the region can be bolstered through the development of innovative disaster risk financing and insurance

mechanisms, and other risk transfer instruments available through the capital markets. They launched the Cebu Action Plan, which comprises four pillars: (i) promoting financial integration; (ii) advancing fiscal reforms and transparency; (iii) enhancing financial resilience; and (iv) accelerating infrastructure development and financing. Recourse to disaster risk financing and insurance mechanisms form part of the Member States’ commitment to enhancing financial resilience in the region.94

DIRECTIONS FOR FUTURE STUDIES AND RESEARCH

In theory, insurance rewards individuals should they undertake loss reduction measures by lowering their premiums. For insurance to play this role premiums have to reflect risk; otherwise insurers will have no financial incentive to offer coverage or will not want to reduce premiums when those at risk undertake protective measures. Charging risk-based premiums raises questions of affordability for those low-income residents in hazard-prone areas who are currently paying subsidized prices for coverage or have elected to be uninsured due to budget constraints or misperceptions of the risks. In addition, insurers may elect not to offer coverage if they are concerned about the impact that catastrophic losses will have on their balance sheet, as evidenced by the decisions by insurers not to offer flood, earthquake or terrorism insurance in the United States without some type of back-up from the state or federal government.

To determine the price of risk-based premiums there is a need for more accurate data. In the United States, FEMA is now updating their flood-risk maps as recommended by a Government Accountability Office (US GAO) study95 and by recent federal legislation on the National Flood Insurance Program. The impact of changing climate patterns on future damage from flooding due to potential sea level rise and more intense hurricanes also needs to be taken into account. There is evidence that federal agencies and other bodies have underestimated the risks of damage from extreme weather events due to climate change.96 Hurricane Sandy has stimulated studies on ways that communities can be more prepared for future disaster damage, as well as highlighting the need for a suite of policy tools, including insurance, to address the climate change problem.97

Studies are also needed on the ways that other policy tools, such as well-enforced building codes to encourage good construction practices, can complement insurance. Enforcing building codes for all residences in Florida could reduce by nearly half the risk-based prices of insurance under climate change projections with respect to hurricane damage in 2020 and 2040.98 In this regard, Chile serves an example for the

94. See APEC Finance Ministers (n 11).
United States to emulate. The country passed a law that requires the original construction company to compensate those who suffer any structural damage from earthquakes and other disasters if the building codes were not followed. Furthermore, the original owner of a building is held responsible for damage to the structure for a decade, and a court can sentence the owner to prison. Well-enforced building codes in Chile account for the relatively low death toll from the powerful earthquake (8.8 on the moment magnitude scale) that rocked the country on 27 February 2010.

The challenge facing the United States today is how to capitalize on the concerns raised by Hurricane Sandy and discussions for the renewal of the NFIP in 2017. The case for making communities more resilient to natural disasters by investing in loss reduction measures is critical today given economic development in hazard-prone areas. For risk-based insurance to be part of such a strategy there is a need for support from key interested parties. These include real estate agents, developers, banks and financial institution, and residents in hazard-prone areas, as well as public sector organizations at the local, state and federal levels.

The principle of risk-based premiums coupled with concerns regarding affordability and catastrophic losses apply to all countries that utilize insurance as a policy tool for dealing with risk. Studies on the role that the private and public sectors play with respect to risk sharing of these losses reveal significant differences between countries. Other countries face similar problems and would do well to consider how to develop long-term strategies that have a chance of being implemented because they address short-term concerns.

In developing countries, insurance is used less commonly as a risk-sharing instrument at present. Where insurance is adopted it is still desirable that it be consistent with the guiding principles for insurance described above. However, it is unlikely that the premiums can appropriately reflect the risk of extreme weather disasters, or that equity and affordability can be resolved in the near term. Rather, governments, multilateral agencies and even donor countries will be instrumental in establishing catastrophic risk pooling initiatives and small-scale micro insurance schemes. In the absence of insurance the victims of disasters will continue to rely on government post-disaster payments, donor countries and charities to make good their losses.