

Long-Term Insurance and Climate Change

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ABSTRACT

This paper examines the role that long-term insurance (LTI) policies coupled with mitigation measures can play in reducing losses from natural disasters. Two principles—*Premiums Reflecting Risk*; and *Dealing with Equity and Affordability Issues*—are advocated for developing LTI. A long-term policy encourages homeowners to invest in cost-effective mitigation by spreading the upfront costs of these measures over time through long-term loans while paying lower premiums due to the reduced claims costs that insurers will incur in the future. The paper proposes modifying the National Flood Insurance Program so it provides long-term policies given the large number of homeowners who cancel their annual insurance policies after several years of not making any claims. For private insurers to price LTI, there is a need to simulate alternative scenarios reflecting the uncertainties in losses over time due to climate change and sea level rise. The paper proposes the types of scenarios that need to be examined and notes a series of open issues that require further discussion by researchers and key stakeholders before LTI can be offered.

The Long Term Insurance and Climate Change¹

Howard Kunreuther²

1. Introduction

It has been well-documented in both controlled experiments, field studies and real world data that individuals have short-time horizons and are somewhat myopic with respect to their decisions. For example, taxi cab drivers focus on the next day's activity, set an earnings target and quit when their goal is reached. (Camerer et al. 1997). Individuals appear to demand a much higher return from stocks than bonds because investors focus on a short time horizon over which stocks are more likely to lose money than bonds. (Benartzi and Thaler 1995). Homeowners fail to invest in cost-effective measures to reduce losses from future disasters in large part because they only focus on the expected benefits over the next several years rather than over the life of the property. (Kunreuther, Meyer and Michel-Kerjan 2009).

More generally, individuals are often rewarded based on short-run performance as evidenced by end of the year bonuses and annual salary increases. Behavior, which may be viewed in hindsight as foolhardy, is often justified by assuming that it will not happen to me on my watch. The acronym NIMTOF---Not in My Term of Office---characterizes such decisions as highlighted by the many actions that have come to light during the current financial crisis. The social welfare losses from such behavior can be extraordinarily high as we are now discovering. In fact, perceiving that the government will come to the rescue if there is a large disaster is an additional reason why individuals may decide not to invest in risk-reducing measures. If they believe they'll be bailed out should a major disaster occur, then their perceived downside risk is truncated.

There are also institutional reasons that may justify not investing in protective measures particularly if one is dealing with low probability events that are unlikely to occur next year. If I am planning on changing jobs in a few years or anticipate being promoted to a new position, why undertake a costly investment if I may not be around to reap some of its expected future benefits? If I am concerned with being re-elected to public office two years from now, why support protective measures if it requires a high

¹ Prepared for the International Seminar at the University of Innsbruck, "Adaptation to Climate Change: The Role of Insurance," March 6-7, 2009, this paper incorporates material from Kunreuther and Michel-Kerjan (2009). It reflects many helpful discussions with my colleagues on the project – Neil Doherty, Martin Grace, Patricia Grossi, Robert Klein, Paul Kleindorfer, Erwann Michel-Kerjan, Mark Pauly, Paul Raschky and Robert Muir-Wood. Funding from the Wharton Risk Management and Decision Processes Center's *Managing and Financing Extreme Events* project, the Climate Decision Making Center (CDMC) located in the Department of Engineering and Public Policy (cooperative agreement between the NSF (SES-0345798) and Carnegie Mellon University), and a grant from the Federal Emergency Management Agency Preparedness Policy, Planning and Analysis Division in the National Preparedness Directorate, U.S. Department of Homeland Security (Grant # 2008-GA-T8-K004) is gratefully acknowledged. The views and opinions expressed are those of the authors and should not be interpreted as representing the United States Government or FEMA.

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upfront cost and the expected benefits in the near future are low and uncertain? If I expect to move from my home in the next few years, why invest in mitigation measures if the discounted expected benefits of the measure are not reflected in the house's property value? Why should I buy insurance now if the risk is so small that I believe the disaster will not happen to me?

It often takes a crisis or disaster for specific actions to be proposed and implemented to redress this balance. Even then these measures are often relatively short-lived unless there are formal institutional changes that are well enforced. One relevant example for this paper is the adoption of stricter building codes in Florida in the 1990s that were well-enforced after it was discovered that twenty-five percent of the damage from Hurricane Andrew could have been averted if existing codes had been adhered to, and that there was an opportunity to reduce damage from these hurricanes even further if stronger ones were put in place. [Insurance Services Office (1994)] Another example triggered by the Bhopal, India explosion of 1988 was the requirement by the United States Environmental Protection Agency (EPA) that facilities containing large quantities of highly hazardous chemicals perform a hazard assessment, estimate consequences from accidents and submit a summary report to EPA. (Kleindorfer et al. 2003).

This paper addresses the need for long-term contracts for dealing with the individual and social costs of myopia by proposing long-term insurance for protection against catastrophic losses from natural disasters where the premiums charged by insurers reflect their best estimates of the risk at the time they market the policy. There are challenges in implementing this concept particularly given the uncertainties associated with future risks due to climate change. The call for long-term programs stimulated by the current financial crisis provides an opportunity for having a constructive dialog as to what is required to overcome these obstacles

The paper proceeds as follows. The next section discusses the importance of having risk-based insurance premiums to encourage property owners to adopt cost-effective loss-reducing measures. Section 3 proposes long-term insurance (LTI) with risk-based premiums to provide stability to policyholders, reduce transaction costs and encourage individuals to invest in mitigation measures. Section 4 discusses the challenges in pricing LTI policies. The concluding section raises a set of open questions for future research.

2. Guiding Principles for LTI Policies³

Given the significant increase in damage from hurricanes and other natural disasters during the past fifteen years due to the growing population and assets in high-risk areas,⁴ we need a new approach to encourage property owners to undertake effective mitigation measures.

³ This section draws heavily on chapter 14 of Kunreuther and Michel-Kerjan (2009).

⁴ For details on the significant increase in losses from catastrophic risks, see chapter 1 of Kunreuther and Michel-Kerjan (2009).

Two Key Principles

Two principles should guide the development of insurance programs for reducing future losses and allocating the costs of disasters in an efficient and equitable manner.

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

This principle is important because its application provides a clear signal of relative damage to those currently residing in areas subject to natural disasters and those who are considering moving into these regions. Risk-based premiums also enable insurers to provide discounts to homeowners and businesses who invest in cost-effective loss-reduction mitigation measures. Today, regulations in the United States and many European countries keep premiums artificially low in many regions subject to damage from natural disasters. If insurers are prevented from charging adequate premiums, they have **no** economic incentive to offer price discounts for those investing in loss reduction measures. In fact, they prefer not to offer coverage to these property owners because it is a losing proposition in the long-run.

Principle 2 – Dealing with Equity and Affordability Issues: *Any special treatment given to residents in hazard-prone areas (e.g. low-income homeowners) should come from general public funding and not through insurance premium subsidies.*

This principle reflects a concern for some residents in hazard-prone areas who will be faced with large premium increases if insurers are permitted to adhere to Principle 1. To assist these individuals, some type of insurance voucher should be provided by government at the state or federal level. This type of in-kind assistance assures that the recipients use the funds for obtaining insurance. A family deserving of special treatment would pay an insurance premium that reflects risk, and then be reimbursed by the government for a portion of the increased cost of insurance over the prior year's policy. The amount of reimbursement could be determined by their income and the risk-based insurance premium that they are charged.

There are several existing programs in the United States that could serve as models for developing such a voucher system:

Food Stamp Program. Under the Food Stamp Program, a family is given vouchers to purchase food based on their annual income and size of the family. Food stamps are available to most low-income households regardless of age, disability status or family structure.⁵ The program is funded entirely by the federal government. As of June 2007, more than 26 million individuals benefit from this program. (Food Research and Action Center, 2007).⁶

⁵ More details on this program at http://www.frac.org/html/federal_food_programs/programs/fsp.html, as of September 2007.

⁶ Sources: *Food Research and Action Center.* http://www.frac.org/data/FSPparticipation/2007_06.pdf, Data available at as of September 2007.

Low Income Home Energy Assistance Program (LIHEAP). The mission of this program is to assist low-income households that pay a high proportion of their income for home energy in meeting their immediate energy needs. The funding is provided by the federal government but is administered by the states and federally recognized tribes or insular areas (e.g., Guam, Puerto Rico, Virgin Islands) to help eligible low-income homeowners and renters meet their heating or cooling needs (eligibility based on similar criteria than the food stamp program).⁷ The federal government became involved in awarding energy assistance funds to low-income households program as a result of the increase in oil prices resulting from the Organization of Petroleum Exporting Countries (OPEC) oil embargo in 1973. Over the past few years, the annual appropriation of this program has averaged \$2 billion.⁸

*Universal Service Fund (USF).*⁹ The USF was created by the Federal Communications Commission in 1997 to ensure that consumers in all regions of the United States have access to telecommunications services that are reasonably priced, relative to those in urban areas. To achieve this goal, the USF provides discounts to low-income individuals in high-cost rural areas, and to other special groups, such as rural health care providers, schools and libraries in these areas. All telecommunication carriers that provide service internationally and between states pay contributions into the USF. The carriers may build this factor into their billing systems if they choose to recoup this amount from their customers. The USF provides discounts that make basic, local telephone service affordable to more than 7 million low-income consumers. From 1998 to 2006, over \$50 billion has been disbursed by this fund.

Who Should Provide Insurance Subsidies?

The above programs use different methods to subsidize low-income families for specific goods and services. With respect to homeowners' insurance, there are several different ways that vouchers could be provided to those requiring special treatment which mirror these programs.

General taxpayer. If one takes the position that everyone in society is responsible for assisting those who reside in hazard-prone areas, then one could utilize general taxpayer revenue from the federal government to cover the costs of insurance vouchers. This is what is currently done by the Food Stamp Program and the Low Income Home Energy Assistance Program.

State government. An alternative (or complementary) source of funding would come from taxes on residents and/or commercial enterprises in the state exposed to natural disaster. One argument that could be made for this type of funding arrangement is that states obtain significant financial benefits from economic development in their jurisdictions through the collection of property taxes or other state revenue such as gasoline taxes, state income taxes and sales taxes. If residents in coastal areas receive

⁷ For instance, at the end of August 2007, Secretary of Health and Human Services (HHS) Mike Leavitt announced that \$50 million in emergency energy assistance will be given to 12 states that experienced much hotter than normal conditions during the summer.

⁸ For more details on this program, see *U.S. Department of Health and Human Services at <http://www.acf.hhs.gov/programs/liheap/>*

⁹ For more details on this program see <http://www.usac.org/about/universal-service> as of September 2007.

greater benefits from the economic development in these regions than others in the state, they should be taxed proportionately more than those residing inland.

Insurance policyholders. A special tax could be levied on all insurance policyholders for covering the costs of these vouchers. The rationale for this type of tax would be that all homeowners (as opposed to all taxpayers) should be responsible for helping to protect those who cannot afford protection or should be subsidized for other reasons. The justification for such a program would be similar to the rationale for establishing the USF for telecommunication service: providing affordable telephone service to all residents in the country.

3. The Need for Long-term Homeowners Insurance¹⁰

Based on the principle of risk-based rates, insurers should consider marketing long-term insurance contracts on residential property as a way of providing stability to homeowners and encouraging adoption of cost-effective mitigation measures. There is precedent for long-term insurance contracts in the United States. Benjamin Franklin created the *Philadelphia Contributionship for the Insuring of Houses from Fire* in 1752. It eventually became the *Green Tree Mutual Assurance Company*, which closed its doors in 2004.¹¹

Short-term insurance policies create significant social costs. Evidence from recent disasters in the U.S. reveals that many consumers fail to adequately protect their homes or even insure at all, creating a welfare cost to themselves and a possible cost to all taxpayers in the form of government disaster assistance. The Department of Housing and Urban Development (HUD) reported that 41 percent of damaged homes from the 2005 hurricanes were uninsured or underinsured. Of the 60,196 owner-occupied homes with severe wind damage from these hurricanes, 23,000 (38 percent) did not have insurance against wind loss. (U.S. Government Accountability Office 2007). Under the current U.S. system, the Governor of the state(s) can request that the President declare a “major disaster” and offer special assistance if the damage is severe enough. The number of Presidential disaster declarations has dramatically increased over the past 50 years: there had been 162 over the period 1955-1965, 282 over 1966-1975, 319 over the period 1986-1995 and 545 during 1996-2005 (Michel-Kerjan, 2008).

The absence of long-term insurance also results in direct private costs to both the insurer and the insured. The private value of the LTI over a period of N years is higher than the sum of N one-year insurance contracts if the risk remains constant over time, for two reasons: (1) LTI reduces the transaction costs to consumers should their annual homeowners policy not be renewed, and to insurers should homeowners cancel their policy; and (2) LTI reduces the uncertainty to homeowners as to whether their premiums will be significantly increased following a severe disaster.

¹⁰ The material in this section is based on Jaffe, Kunreuther and Michel-Kerjan (2008) and Kunreuther and Michel-Kerjan (2009a).

¹¹ The Philadelphia Contributionship and other perpetual insurance companies require a large fixed payment at the time that one purchases insurance. The interest earned on this “insurance investment” covers the annual premiums on the property. We thank Felix Kloman for calling attention to this type of long-term insurance relationship. Kloman has favored long-term commitments and partnerships between the insurer and insured for many years, having written columns on the topic in his publication, *Risk Management Reports* in September 1994 and October 1995.

For a long-term insurance policy (say, 5, 10 or 20 years) to be feasible, insurers would have to be able to charge a rate that reflects their best estimate of the risk over that time period (*Principle 1*). The uncertainty surrounding these estimates could be reflected in the premium as a function of the length of the insurance contract, in much the same way that the interest rate on fixed-rate mortgages varies between 15, 25 and 30 year loans. Insurance vouchers could be provided to homeowners who cannot afford coverage at risk-based rates (*Principle 2*).

The obvious advantage of a long-term insurance contract from the point of view of policyholders is that it provides them with stability and an assurance that their property is protected for as long as they own it. This has been a major concern in hazard-prone areas where insurers have cancelled policies following severe disasters such as those that occurred during the 2005 hurricane season. More recently State Farm announced that it would be phasing out its homeowners insurance in Florida over the next two years. The principal reason for doing this was because the company was not permitted to charge rates that reflected risks in hurricane-prone areas of the state. (Diamond, 2009).

Encouraging Adoption of Mitigation Measures

Long-term insurance also provides economic incentives for investing in mitigation where current annual insurance policies (even if they are risk-based) are unlikely to convince property owners to incur the upfront costs of these measures due to their focus on short-term horizons as noted above (see Section 1).

How effective can mitigation be in reducing exposure to future disasters? To shed some light on this question, the Wharton Risk Center in conjunction with Georgia State University undertook an analysis of the impact that mitigation would have on reducing losses from hurricanes that would occur in four states: Florida, New York, South Carolina and Texas (Kunreuther and Michel-Kerjan, 2009). Two extreme cases were examined: (1) no one has invested in mitigation, and (2) everyone has invested in predefined mitigation measures.

From the U.S. Hurricane Model developed by the catastrophe modeling firm Risk Management Solutions (RMS), losses were calculated on a ground up and gross basis, assuming an appropriate mitigation measure across the insured portfolio. The mitigation measures were based on various assumptions for the different regions. For example, in Florida, the requirements as defined by the Institute for Business and Home Safety's (IBHS) *The Fortified ... for Safer Living* program was used to incorporate mitigation. Of course, this program is only for new construction. So, an analysis using these recommendations aligns the retrofit techniques with the features of the *Fortified* program. In New York, South Carolina and Texas, mitigation means the application of the latest building codes to the residential structures.¹²

Table 1 indicates the differences in losses and savings from adoption mitigation measures for hurricanes with return periods of 100, 250, and 500 years for each of the

¹² We are assuming that because these measures are incorporated in building codes they are cost-effective. In other words, the discounted long-term expected benefits from the mitigation measure over the projected life of the house is greater than its upfront costs. By obtaining detailed cost estimates for specific mitigation measures incorporated in building codes or Florida's *Fortified ... for Safer Living* program one could rank their relative cost-effectiveness.

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

TABLE 1. MONEY SAVED IN REDUCED LOSSES FROM FULL MITIGATION FOR DIFFERENT RETURN PERIODS

State	100-Year Event			250-Year Event			500-Year Event		
	Unmitigated Losses	Savings in Reduced Losses from Mitigation (\$)	Savings in Reduced Losses from Mitigation (%)	Unmitigated Losses	Savings in Reduced Losses from Mitigation (\$)	Savings in Reduced Losses from Mitigation (%)	Unmitigated Losses	Savings in Reduced Losses from Mitigation (\$)	Savings in Reduced Losses from Mitigation (%)
FL	\$84 billion	\$51 billion	61%	\$126 billion	\$69 billion	55%	\$160 billion	\$83 billion	52%
NY	\$6 billion	\$2 billion	39%	\$13 billion	\$5 billion	37%	\$19 billion	\$7 billion	35%
SC	\$4 Billion	\$2 billion	44%	\$7 billion	\$3 billion	41%	\$9 billion	\$4 billion	39%
TX	\$17 billion	\$6 billion	34%	\$27 billion	\$9 billion	32%	\$37 billion	\$12 billion	31%

To highlight how LTI can encourage investment in mitigation, consider the following simple example. Suppose a family could invest \$1,500 to strengthen the roof of its house so as to reduce the damage by \$30,000 from a future hurricane with an annual probability of 1/100. An insurer charging a risk-based premium would be willing to reduce the annual charge by \$300 (i.e. 1/100 x \$30,000) to reflect the lower expected losses that would occur if a hurricane hit the area in which the policyholder was residing. If the house was expected to last for 10 or more years, the net present value of the expected benefit of investing in this measure would exceed the upfront cost at an annual discount rate as high as 15 percent.

Under current annual insurance contracts, many property owners would be reluctant to incur the \$1,500 because they would get only \$300 back next year. If they underweight the future, the expected discounted benefits would likely be less than their \$1,500 upfront costs. In addition, budget constraints could discourage them from investing in the mitigation measure. Other considerations would also play a role in a family's decision not to invest in these measures: The family may be uncertain as to how long they will reside in the area and/or whether their insurer would reward them again with a premium discount if their policy is renewed next year.

A 20-year LTI policy ties the contract to the property rather than to the individual. In fact, the insurer could provide the homeowner with a \$1,500 home improvement loan at an annual interest rate of 10 percent, resulting in payments of \$145 per year. If the insurance premium were reduced by \$300, the savings to the homeowner each year would be \$155. A bank would benefit from this arrangement by being more fully protected against a catastrophic loss to the property, and the insurer's potential loss from

a major disaster would be reduced. Moreover, the general public will now be less likely to have large amounts of their tax dollars going for disaster relief. A win-win-win situation for all!

There is an additional benefit to insurers in incentivizing individuals to invest in cost-effective mitigation measures. The costs of reinsurance should now decrease. If reinsurers know that they are less likely to make large payments to insurers because each piece of property in a region now has a lower chance of experiencing a large loss, then they will reduce their premiums to the insurer for the same reason that the insurer is reducing its premium to the property owner.

Suppose that an insurer had 1,000 identical insurance policies in the area in which the above family lived, and each one would have a claims payment of \$40,000 following a hurricane if homes had not strengthened their roofs. The insurer's loss from such a disaster would be \$40 million. Suppose that the insurer wants to have \$25 million in coverage from a reinsurer to protect its surplus. If a hurricane has a 1 in 100 chance of hitting the region where these families reside, the expected loss to a reinsurer would be \$250,000 and the premium charged to the insurer would reflect this. If all 1,000 homes have their roofs fortified to meet the local building code and each homeowner's loss were reduced to \$10,000, then the insurer's total loss would be \$10 million should all 1,000 homes be affected, and it would **not** require reinsurance. This savings would be passed on by the insurer in the form of a lower premium.

Why Does a Market for Long-Term Insurance Not Exist Today?

In his seminal work on uncertainty and welfare economics, Kenneth Arrow defined "the absence of marketability for an action which is identifiable, technologically possible and capable of influencing some individuals' welfare (...) as a failure of the existing market to provide a means whereby the services can be both offered and demanded upon the payment of a price." (Arrow, 1963). Several factors on the supply and demand side have contributed to the non-marketability of LTI for protecting homeowners' property against losses from fire, theft and large-scale natural disasters.

Supply Side Today, due to political pressure, insurance rates are frequently restricted to be artificially low in hazard-prone areas. The result is that the risks most subject to catastrophic losses also become the most unattractive for insurers to market. A second stumbling block, derived from premium regulation, is that insurers are unclear as to how much they will be allowed to charge in the future. Uncertainty regarding costs of capital and changes in risk over time may also deter insurers from providing long-term insurance.

In principle, of course, insurers could add a component in their premiums to account for the costs created by these factors. The problem is that the insurance regulator presumed to be representing consumers interests, may not allow these costs to be embedded in the approved premiums. Furthermore, it is unclear what the voluntary demand for coverage will be, given the resulting premiums. In a real sense, a new and less intrusive format for government regulation of insurance markets may be required if the private sector is to be successful in dealing with time-varying risks and capital costs.

Insurers might also be concerned about possible changes in the level of risk over time. For example, global warming could trigger more intense weather-related disasters, and/or local environmental degradation might change the risk landscape in the next several decades. One way to address this concern would be to have renegotiable contracts every X years based on new information validated by the scientific community in much the same way that there are renegotiable loans with adjustable rates.

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

Long-Term Flood Insurance through the National Flood Insurance Program

Given the reluctance of many state regulators in the U.S. to allow insurers to charge premiums reflecting risk on homeowners' coverage in hurricane prone areas, it appears more appropriate to introduce LTI by focusing on flood insurance since this coverage is provided by the federal government.¹³ Created in 1968 as a result of the refusal by insurers to cover this risk because they viewed it as uninsurable, the National Flood Insurance Program (NFIP) sold over 5.5 million policies in 2007 (compared to 2.5 million in 1992) and covered over \$1.1 trillion in asset (compared to only \$237 billion in 1992). These figures were stable in 2008. Given that the NFIP is up for renewal in Congress in 2009, there may be a window of opportunity for change in the coming months.

More specifically, one could propose making flood insurance policies long-term by tying them to mortgages. By instituting such a program, insurance would be connected directly with the property rather than to the homeowner. One might also consider having everyone in flood prone areas ***required*** to take out the insurance just as those who own a car are required to take out automobile insurance today whether or not they are financing the purchase of their car. If a homeowner moved to another location, the flood insurance policy would remain with the property.

A long-term flood insurance program would offer homeowners currently residing in flood-prone areas a fixed rate for a fixed period of time (e.g. 5, 10 or 20 years). If the homeowner moved away from the area before the end of the policy period, then the insurance policy would automatically be transferred to the new property owner at the same rate. For those homeowners who were being charged subsidized rates because their homes were constructed prior to the time that their community joined the NFIP, these rates would be maintained for the length of the policy period. For homeowners who constructed homes after the date that their community joined the program, their rates would be actuarially based.

¹³ For more details on the National Flood Insurance Program see chapter 4 of Kunreuther and Michel-Kerjan (2009).

There are a number of reasons why such a long-term flood insurance policy would be a significant improvement over the current annual policies from the perspective of the relevant stakeholders: homeowners, the Federal Emergency Management Agency (FEMA) and the general taxpayer. By fixing flood insurance rates, homeowners would be provided with financial stability. They would also have knowledge that they are protected against water damage from floods and hurricanes. This would reduce the legal problems that have plagued recent hurricanes (Florida hurricanes of 2004, Katrina, Ike). Homeowners would not have to argue that the losses were due to wind in order to be able to collect on their homeowners' policy. There would still be a question as to whether the government would be paying for some of the loss because it was caused by water or whether private insurers would be responsible because it was wind-related damage.

Long term flood insurance would also assure the spread of risk within the program since most homeowners in flood prone areas would be covered. If flood insurance were required for all homeowners residing in hazard-prone areas, then there would be even a larger spread of risk. This would provide much needed financial revenue for the program over time by having a much larger policy base than is currently available.

Long-term policies would prevent individuals from cancelling their policies after they have not experienced a flood for several years, a practice even among those who are required to purchase the policy as a condition for a federally insured mortgage. The banks and financial institutions have often not enforced this regulation: Few homeowners have been fined and/or have had their mortgages transferred to banks in non-flood prone regions of the country that have not focused on either the flood hazard risk or the requirement that homeowners purchase this coverage. Consider the flood in August 1998 that damaged property in northern Vermont. Of the 1549 victims of this disaster, FEMA found 84 percent of the homeowners in Special Flood Hazard Areas (SFHAs) did not have insurance, even though 45 percent of these individuals were required to purchase this coverage. (Tobin and Calfee, 2005)

If long-term loans for mitigation were offered by the NFIP or banks, individuals with long-term flood insurance policies would be encouraged to invest in cost-effective risk reduction measures. These mitigation measures would likely increase property values of homes, capitalizing benefits of mitigation with reduced insurance premiums. Furthermore, the general public will now be less likely to have large amounts of their tax dollars going for disaster relief. Indeed, prior to the 2005 hurricane season which inflicted nearly \$18 billion in flood claims, the NFIP had a cumulative deficit of about \$3 billion after 37 years of operation (Michel-Kerjan and Kousky, 2008).

4. Challenges in Pricing LTI Policies

The ambiguities associated with both the probability of an extreme event occurring and with the outcomes of such an event raise a number of challenges for insurers with respect to pricing LTI policies. As shown by a series of empirical studies stimulated by the classic study on ambiguity by Ellsberg (1961), actuaries and underwriters are averse to ambiguity and want to charge much higher premiums when the likelihood and/or consequences of a risk are highly uncertain than if these components of risk are well specified.

Surveys of Actuaries and Underwriters

Building on a study by Cabantous (2007) the Wharton Risk Center launched a web-based survey of U.S. actuaries and underwriters' decision making under risk and ambiguity. Survey data are still being collected, but the first set of results on seventy-eight responses are summarized here.

In this survey, nine different scenarios were developed by crossing three different types of natural hazards (fire, flood, and hurricane) with three types of information about the probability of a disaster (precise probability, imprecise probability, and conflicting probability) with a loss of \$100,000. When there was no ambiguity, the probability of the loss was 1 in 100 so the expected loss is \$1,000. In the two ambiguous cases, 1 in 200 and 1 in 50 were the minimum and maximum estimates of the probability of the \$1,000 loss. The expected loss for the two ambiguous cases was \$500 and \$2,000 respectively – a geometric mean of \$1000.

The preliminary results reveal that the type of hazard does not have a significant effect on mean premiums. However the quality of the probabilistic information can change the premium significantly as shown in Figure 1.

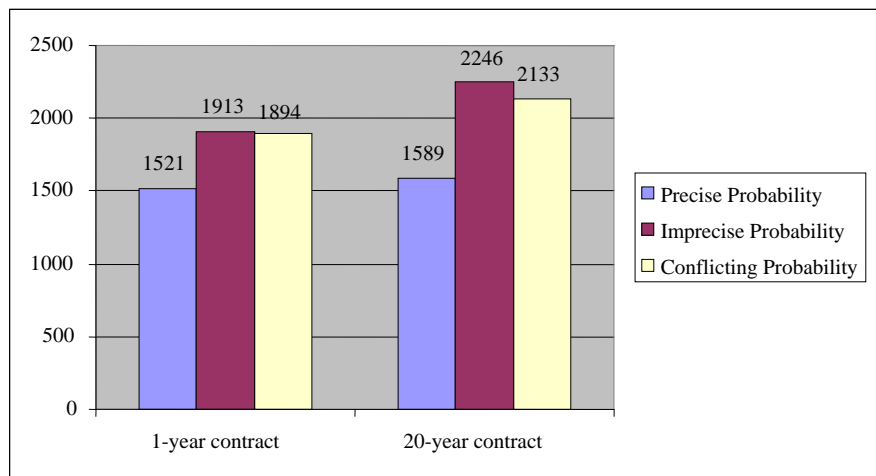


FIGURE 1. MEAN ANNUAL PREMIUMS IN DOLLARS, ACROSS NATURAL HAZARDS (N=78)

Under a one-year contract, insurers would charge on average \$1,521, which reflects their estimate of the expected loss plus a loading factor (administrative cost and cost of capital). Under a 20-year contract, the premium with precise probability is \$1,589 or about 5 percent above the amount which insurers would charge for a one-year contract with precise probability. When ambiguity is introduced, the mean annual premiums for 1-year contracts are approximately 25 percent higher than when the probability of a loss is given precisely. There is no significant difference between the premium under conflict and those under imprecision. For a 20-year insurance policy with an imprecise probability of a loss, the mean annual premiums are 34 percent higher than when there is no ambiguity. There is a 41 percent increase for mean annual premiums in a 20 year contract when the ambiguity is due to conflict in estimates of the probability of a loss.

Simulating Alternative Long-term Scenarios

The above analysis suggests that even if insurers are permitted to charge premiums that reflect risk, they will be reluctant to offer fixed premium LTI policies unless they charge rates that are considerably higher than annual contracts. Their principal concern is that they will suffer a catastrophic loss in future years that they did not anticipate when they marketed a long-term policy. The risks associated with losses from hurricanes and flooding may be higher than current estimates if there is an unexpected increase in the intensity of hurricanes and/or there is a higher than anticipated sea level rise caused by climate change during the next 10 or 20 years.

What impact will these uncertainties have on the pricing of long-term insurance against risks with catastrophic potential? To answer this question there is a need to simulate a variety of long-term scenarios based on different estimates of the likelihood and magnitude of losses that an insurer would face with a given portfolio of LTI policies. To illustrate the nature of such a simulation, first consider a homeowner who is being offered an LTI policy against flood damage by an insurer who is unsure how climate change will impact on sea level rise (SLR). One can then generalize the simulation to analysis a portfolio of risks.

To keep the analysis simple, assume that there is only one flood that can occur in a given year, and that the severity of the losses over time will be determined by the projected increase in SLR. The following proposition needs to be confirmed through simulations.

Proposition 1: *The key driver of an insurer's performance is the magnitude of the catastrophic loss rather than the increase in premiums necessary to cope with the loss.*

The premium increase per structure will be relatively small in comparison to the loss that will be incurred due to the relatively low probability of a flood occurring. To illustrate this point consider the following simple example where premiums reflect expected losses. Suppose the probability of a flood in any given year is p and that sea level is expected to rise 3.5 millimeters (0.14 inches) each year.¹⁴ Should a flood occur in year t the loss would be L_t where $L_{t+1} > L_t$. If we disregard tax, administrative cost and the cost of capital and we consider that premiums equals expected loss, then the annual premium P for a T year policy that would cover the losses for this scenario would be:

$$P = (p \sum_{i=1}^T L_i) / T$$

¹⁴ A report issued by the Environmental Protection Agency on January 15, 2009 estimated that the annual SLR on the East Coast of the U.S. from New York to North Carolina will be between 2.4 and 4.4 millimeters. For more details go to <http://www.epa.gov/climatechange/effects/coastal/front.pdf>

If $p=1/100$, $L_1=1000$ and the losses remained stationary over time, then the annual actuarially fair premium would be $P=10$. Should there be an increase in SLR over time so that $L_{t+1} = L_t + a$ where $a>0$ then

$$P = \{p L_1 \sum_{i=1}^T [1+(i-1)a]\} / T$$

Suppose $a = .02$ and $T=20$. Then $P=11.9$, a 19% increase over what the premium would be if there was no SLR during the 20 year period when LTI was in place. If $T=10$ then the premium increase required for the insurer to break even over a 10 year period would be $P=10.9$ or a 9% increase caused by SLR. If the homeowner experienced a flood in period t and the SLR was given by the above scenario then the insurer's loss would be $L_t = [1+(t-1)a] L_1$. Using the data for the above illustrative example, if $t=11$ then the loss would be 1200, 20 percent higher than if there were no SLR.

One way for the insurer to protect itself against catastrophic losses is to purchase reinsurance or utilize an alternative risk transfer instrument such as a catastrophe bond to protect itself against a large loss. Today, reinsurance contracts are typically for one or two years. But alternative transfer instruments such as cat bonds are longer. In 2007 there were 20 catastrophe bonds (of the 29 issued that year) that covered a term of three years or more.¹⁵ There is thus a need to assess the constraints on the availability and volume and contract length of securities that diversify catastrophe risk, how the use of these vehicles could be expanded to augment reinsurance capacity, and the role that the government can play to promote this market.

Using the above example, suppose the insurer wanted to protect itself against losing more than 600 dollars from a flood that destroyed its insured home. The insurer could purchase *excess of loss* reinsurance for which a premium is paid to cover losses between two attachment points. If there were no projected SLR over the next 20 years the insurer would want a contract that specifies 400 in excess of 600 for flood losses so the reinsurer would be liable for claims between 600 and 1000. If the reinsurer were to provide an actuarially fair policy to cover this loss then the annual reinsurance cost to the insurer for such a policy would be $R=1/100 (400)= 4$.

If there was a projected increase in annual losses so that $L_t = [1+(t-1).02] L_1$ where $L_1=1000$, then the insurer would want to have an increasing amount of excess of loss reinsurance coverage each year beginning at 400 in excess of 600 for year 1 and ending with 780 in excess of 600 in year 20. The annual cost for this policy for the reinsurer to break even would be 5.9, a 47.5 percent increase over what it would be charging should there be no increase in SLR.

Of course, if premiums were actuarially fair, the insurer would be charging the same total premium to the policyholder whether or not it had reinsurance. In reality both insurers and reinsurers attach a loading cost to cover their expenses and their need to hold

¹⁵ The only catastrophe bond issued for longer than 5 years was a 10-year cat bond issued in 1997. For more details on the trends in cat bonds and other insurance-linked securities, see Michel-Kerjan and Morlaye (2008).

additional capital in a more liquid form than normal to cover catastrophic losses. (Doherty 2000). Although the premiums charged to the homeowner will reflect these costs, the percentage differences between the cases where there is and is not SLR would be the same as in the above illustrative example if the loading cost was a fixed percentage of expected claims payments.

A complementary strategy for the insurer to follow is to diversify its portfolio so it does not have too many policies subject to a specific risk in one region of the country. To the extent that the insurer is able to issue sufficient policies in a large number of regions where the risks are independent of each other, then its concern with catastrophic loss will diminish. For example an insurer that issued 100 policies in each of 50 different regions of the country will have a much smaller probability of a large loss than an insurer who wrote 500 policies in 10 different hazard-prone areas. The insurer also knows that it has the option of modifying its long-term premium each year as new customers enter the system so that it is diversifying its policies over time.

One of the principal reasons for advocating long-term insurance would be to encourage property owners to invest in cost-effective mitigation measures. To the extent that these investments sufficiently reduced the losses suffered by a homeowner, the actual cost of insurance could be lower with SLR than if the homeowner did not invest in mitigation and there was no rise in sea level. To highlight this point in the context of the above example, suppose that a homeowner would invest in a mitigation measure that reduced the expected losses in each of the 20 years by 3 at an upfront cost of 8. Even if there was projected to be an increase in SLR, the homeowner would have his annual premium for LTI reduced from 11.9 to 8.9. If the insurer issued a 20 year loan to cover the mitigation expense of 8 at a 10% interest rate, it would cost the homeowner .77 per year so that his total annual expenditure for insurance and the mitigation loan would be 9.67, which is less than the 10 it would be paying if there was no increase in SLR.

Constructing Realistic Long-Term Scenarios

In order to understand more fully how uncertainty about the future affects insurers' pricing decisions there is a need to construct a set of realistic scenarios with respect to losses from floods and hurricane that reflect scientists best estimates regarding climate change as well as characteristics of insurers' portfolio of coverage with respect to these risks.

To be of maximum utility to insurers today, catastrophe models must be informed by answers from scientific experts regarding the following questions: How much will sea level rise over the next half-century in 5-year intervals, and what effect will this have on storm surges from hurricanes? How many storms (Category 3 or greater) are estimated to make landfall in the next 6 to 18 months? How far inland is damage likely to extend, and how closely can the storm tracks be predicted? Will climate change alter the number and types of storms that strike land? Do today's topological maps accurately reflect risk of inundation?

The simulations that one could undertake would characterize the likelihood of losses of different magnitudes at each time period t by constructing exceedance probability (EP) curves for an insurer's portfolio of risks. In other words there would be

an EP curve for periods 1 through 20 if one was evaluating a 20 year LTI policy. The EP curve would be constructed by making specific assumptions regarding the degree of correlation of the risks at any point in time as well as the correlation of risks across time as illustrated by the above hypothetical scenario. One could also construct EP curves that reflect the impact of alternative mitigation measures on projected losses. A more sophisticated analysis would incorporate the issuance of new policies each year that had an updated estimate of the risk for an LTI policy.

Based on these EP curves one could examine the role that alternative risk transfer (ART) instruments such as reinsurance and cat bonds could play in reducing the insurer's losses from catastrophic risks. By estimating the variance and expected losses from these ART instruments one could determine what the private sector would have to charge for protection against these catastrophic losses and compare these prices with a government program for protection against large-scale disasters. At the same time one would be able to evaluate the impact that mitigation measures would have on reducing the losses in the tail of the distribution and its impact on the price of insurance.

To determine the price that an insurer would charge for LTI policies versus annual policies one would want to incorporate the transaction costs associated with marketing policies each year in relation to a 20 year policy. If there are a significant number of cancellations of annual insurance policies, then an LTI policy will have more appeal than if the vast majority of homeowners automatically renew their policies each year. As pointed out above, the evidence with respect to flood insurance suggests that many policyholders cancel their policies after several years of not experiencing any damage. They view insurance as a poor investment and are not convinced that *the best return on a policy is no return at all*.

5. Open Questions and Future Research Issues¹⁶

A number of issues and questions associated with the development of a long-term insurance policy that have a direct impact on insurers and homeowners, and indirect effects on other stakeholders, require further research and analysis.

Nature of the Contract

Long-term insurance could be offered by insurers in the form of a fixed-price contract (FPC) for the full term of the policy (e.g., twenty years) or an adjustable premium contract (APC) at a variable premium with guaranteed renewal for the term of the policy. The annual premium would be reset based on an index that would have to be simple and transparent. Policyholders will want the option to terminate the contract; mortgage markets provide examples of both good and bad practices. On FPCs, formal arrangements to make the insurer whole through provisions such as yield maintenance and defeasance (the two most common methods for dealing with prepayment costs on commercial mortgages) may be necessary. On APCs, the borrower would want the right to terminate the contract without cost within a certain time period of a premium increase notification (e.g., three months).

¹⁶ This section draws on Kunreuther (2008).

Protection against Catastrophic Losses

One would also need to know how the rating agencies will view long-term FPC commitments since the insurer is now locked into the premium even if the expected losses rise. To protect itself against possible increases in the probability of catastrophic losses over time, insurers marketing FPCs would have to be able to invest in cat bonds or other forms of securitized risks. Some type of government guarantee might be necessary to deal with both insurers' and policyholders' concerns with respect to the ability to pay claims in the future following a catastrophic loss. As for the pricing of the product, FPC premiums would likely be somewhat higher than APC premiums to protect insurers against an increase in the risk during the contract period. This behavior would be similar to the pricing of fixed-rate mortgages relative to adjustable-rate mortgages.

One of the central issues will be how high the price of a long-term contract will be, given the ambiguities associated with the risk and the capital costs for covering catastrophic losses. Without some type of protection against large losses through long-term risk transfer instruments or a government reinsurance program at the state or federal level, the premiums for FPCs are likely to be extremely high, so that there would be little demand for this type of coverage.

Understanding the Contract

Those who purchase insurance policies often have a difficult time understanding the terms of the contract: what risks are covered, what risks are not, and the basis for being charged a specific rate. The problem is likely to be compounded for a long-term insurance contract. Insurers will be concerned with how the legal system interprets the long term contract in advance of court cases with respect to disputes regarding what losses are covered by the LTI policy.¹⁷

There is also an opportunity for insurers to educate consumers as to the basis for the premiums they charge by providing more detail on the types of risks covered and the amounts charged for different levels of protection. More specifically, insurers could break down the premium into coverage against fire, theft, wind damage, and other losses included in a homeowners' policy and explain how the premium varies with the length of the long-term contract.

It would be beneficial for insurers to reveal this information so that homeowners are able to make better decisions by understanding the nature of the contract and what alternative options cost them. They will then be able to make trade-offs between costs and expected benefits—something that is impossible for them to do today. Thaler and Sunstein (2008) argue for this type of information disclosure by proposing a form of government regulation termed RECAP: record, evaluate and compare alternative prices. They recommend that the government not regulate prices but require disclosure practices—not in a long, unintelligible document but in a spreadsheet-like format that includes all relevant formulas.

¹⁷ I appreciate Eric Nelson of Travelers pointing out the need for clarity from the courts on what the insurer is responsible for covering in a long-term policy.

Institutional Details

Some questions regarding institutional details require further analysis and discussion with key stakeholder:

- Under what circumstances could property owners change their insurance policy over time?
- What role would the modeling companies and the scientific community studying climate science play in providing estimates for developing risk-based premiums and suggesting a rationale for changes over time as new risk models become available?
- How would insurers deal with significant changes in risk estimates over time?
- What types of risk transfer instruments would have to emerge from the reinsurance market as well as from the capital markets to protect insurers against catastrophic losses and changes in risk estimates over time?
- What role would the public sector play in providing protection against catastrophic losses?
- How will the rating agencies view long-term insurance contracts?
- How concerned will consumers be at the possible insolvency of insurers providing long-term contracts, and what steps should be taken to protect homeowners should this occur?
- Should one equitably adjust premiums after periods during which wind-risk models become misaligned with actual loss results? For example, if actual flood losses over a multiyear period were less than anticipated, should premium credits be given to policyholders in future periods?¹⁸

Whether long-term insurance will be attractive to insurers, homeowners, regulators and other relevant stakeholders will certainly depends on the market conditions that come with it. What is clear today, however, is that we need innovative programs for reducing future losses from disasters that involve combined strengths of the public and private sectors. For insurance to play an important role in this regard, one needs to understand what a policy can and cannot do as a function of the nature of the risk, the type of coverage provided by the insurer and the premium structure.

¹⁸ This is part of a proposal by Travelers Companies, Inc. with respect to creating a Coastal Hurricane Zone along the Atlantic and Gulf Coasts from Texas to Maine. For more details see <http://coastalplan.com/>

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