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Introduction

In May of 2008 a storm surge triggered by Cyclone Nargis swept through low-lying coastal areas of Myanmar without warning, killing an estimated 138,000 residents (Fritz et al. 2009). As staggering as this loss of life was, it was dwarfed by the estimated 230,000 who died four years earlier in eleven countries in Southeast Asia from a major earthquake and accompanying tsunami (*http://www.tsunami2004.net).* Even wealthy countries that have the resources to invest in risk-reducing (i.e. mitigation) measures and warning systems have recently witnessed significant losses from natural hazards, such as the $150 billion in total economic damages and 1,300 deaths caused by Hurricane Katrina in Louisiana and Mississippi in 2005 (Knabb et al. 2006). Perhaps most disturbingly, if these events taught lessons about the potency of natural hazards, they were not widely absorbed by those at risk. Just three years after Katrina, many residents of the Bolivar Peninsula in Texas refused to heed urgent evacuation warnings as Hurricane Ike approached, a reluctance that led to the deaths of over 100 and forced a major airlifting of survivors after the storm (Berg 2009).

While these events provide perhaps the most vivid examples of recent disasters, they are but part of a trend of escalating losses from natural hazards that has been observed over the past 20 years. If one considers the 25 most costly insured catastrophes anywhere in the world between 1970 and 2008, all of them occurred after 1987. (Kunreuther and Michel-Kerjan 2009). Furthermore, two thirds of them occurred since 2001. This series of unprecedented catastrophes raises questions: Why is this happening? Will the coming years be even worse? If so, how are individuals –residents and policymakers alike– likely to behave in this new environment? And, finally, what might be done to reduce future losses?

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The goal of this chapter is to explore these questions. Our central thesis is that escalating losses from natural hazards are the result of a dynamic interplay between two central forces, one economic, the other behavioral. The economic driver of catastrophic losses are the increasing levels of material and human assets that have been placed in harm's way without adequate compensating investments in mitigation —most notably in coastal areas adjacent to the world's oceans. These location decisions, in turn, arise from a tendency among residents and policy makers to under-attend to low-probability, high-consequence risks. While decision makers are quick to see the potential short-run gains that can be obtained from investing in development in such areas, they display less skill at comprehending the long-term risks of such development, or seeing the benefits of long-term investments in protection. Moreover, the rarity of natural disasters in a given location provides few opportunities to correct such mistaken beliefs—until, of course, catastrophes occur. The result is an accelerating spiral of risk-taking, where the rate of economic development in high-risk areas increasingly outpaces technological gains in how to protect these assets, as well as the willingness of residents and policy makers to invest in these technologies.

We divide our discussion of the basis—and possible solutions—to the catastrophic risk problem into three phases. We first set the stage by reviewing evidence for the most immediate driver of catastrophes, the increasing global mismatch that exists between assets-at-risk and investments in risk reducing measures. We then explore the underlying behavioral drivers of this mismatch, noting that failures to invest in mitigation are often due to fundamental biases in how we make decisions under uncertainty and plan for the future—biases that can have disastrous consequences when applied to problems involving infrequent natural hazards. We conclude with a discussion of how knowledge of these human tendencies might suggest decision architectures that could help individuals and societies better manage the risk of future catastrophic losses. We focus on the specific example of how myopia biases can be overcome by offering residents and businesses long-term insurance policies coupled with long-term home improvement loans to induce individuals to invest in cost-effective mitigation measures. We show that this proposal, coupled with well-enforced building codes, significantly improves both individual and social welfare.

The Investment-Mitigation Gap

For evidence of why losses from natural disasters have increased so rapidly in recent years one needs to look no further than the state of Florida. The 1,200 miles of coastline that make it an attractive destination for tourists and retirees also make it vulnerable to impacts by hurricanes from the Atlantic, Gulf of Mexico, and Caribbean. While omnipresent threat of such hurricanes has long been a part of life in the state, their economic impact was historically limited by the sparseness of the population. As late as 1950 the state was only the 20th largest in the United States with a population of 2.8 million. But the years since then have witnessed a migration boom, with the state now being the country's fourth largest with a projected 2010 population of 19.3 million (a 600 percent increase since 1950). The consequence is clear: storms that were previously sources of inconvenience are now potential sources of catastrophe. It has been conjectured, for example, that if the same strong hurricane that hit Miami in 1926 were to hit the same area today it would induce economic losses that would dwarf those the country recently saw from Hurricane Katrina (Pielke et. al 2008). But this increased exposure is hardly unique to Florida. As of December 2007, Florida and New York each had nearly $2.5 trillion of insured values located directly on the coast. The coastal insured value for the top 10 states combined (ranked by that variable) accounts for more than $8.3 trillion (Kunreuther and Michel-Kerjan, 2009). Such huge concentrations of insured value in highly exposed areas almost guarantees that any major storm that hits these regions will inflict billions if not hundreds of billion dollars of economic losses, unless the residential construction and infrastructures are properly protected by effective mitigation measures.

How well protected are properties in hazard-prone areas? The empirical evidence is disturbing. A 1974 survey of more than 1,000 California homeowners in earthquake-prone areas, for example, revealed that only 12 percent of the respondents had adopted any protective measures (Kunreuther et al*.* 1978). Fifteen years later, there was little change despite the increased public awareness of the earthquake hazard. In a 1989 survey of 3,500 homeowners in four California counties at risk from earthquakes, only 5 to 9 percent of the respondents in these areas reported adopting any loss reduction measures (Palm et al. 1990). Burby et al. (1988) and Laska (1991) have found a similar reluctance by residents in flood-prone areas to invest in mitigation measures.

Likewise, even after hurricanes caused extensive damage to large parts of the U.S. Atlantic and Gulf coastlines during the 2004 and 2005 hurricane seasons a large number of residents had still not invested in relatively inexpensive loss reduction measures with respect to their property, nor had they undertaken emergency preparedness measures. A survey of 1,100 adults living along the Atlantic and Gulf Coasts undertaken in May 2006 revealed that 83 percent of the responders had taken no steps to fortify their home, 68 percent had no hurricane survival kit and 60 percent had no family disaster plan (Goodnough 2006).

The lack of interest in mitigation measures, even after the most devastating hurricane in the history of the country, is very much puzzling because we know that risk-reduction measures are effective. An analysis of the reduction in damage from future hurricanes in four states (Florida, New York, South Carolina and Texas) if current building codes were applied to all residential property in harm's way is revealing. The reductions range from 61 percent in Florida for a hundred-year return-period loss to 31 percent in New York for a five-hundred-year return-period loss. In Florida alone, mitigation reduces losses by $51 billion for a hundred-year event and $83 billion for a five-hundred-year event (Kunreuther and Michel-Kerjan 2009).

What makes matters worse is that this failure to prepare for future disasters has consequences that go beyond the losses suffered by the owners of unprotected structures. When homeowners, private businesses, and the public sector do not adopt cost-effective loss-reduction measures, large sections of coastline are left highly vulnerable to catastrophic losses that can have significant economic spill-over effects. These broader losses, in turn, often lead public sector agencies to provide disaster relief to victims and subsidies to the affected victims even if the government claimed it had no intention of doing so prior to the event. This combination of underinvestment in protection coupled with the general taxpayer financing losses after-the-fact has been termed the *natural disaster syndrome* (Kunreuther 1996).

Why We Under-Prepare: The Psychology of Hazard Prevention

Why do individuals and communities seem so reluctant to invest in mitigation when the long-term benefits are significant? To explore this issue it is useful to begin by reviewing how mitigation decisions *should* ideally be made by a homeowner who makes choices by maximizing expected-utility. With this as a benchmark, we will then explore how different psychological tendencies and simplified decision rules foster actions decisions that depart from economic rationality; we will call those *decision biases*.

Consider the Lowlands, a hypothetical family whose New Orleans home was destroyed by Hurricane Katrina. They have decided to rebuild their property in the same location but are unsure whether they want to invest in a flood reduction measure (e.g., by elevating their home, sealing the foundation of the structure, and waterproofing the walls).[3] If the flood-proofing measure costs $20,000, should they make the investment?

On the surface, the problem would seem a natural candidate for utilizing expected utility theory. The Lowlands could simplify their decision rule by determining where they should invest in mitigation if they were neutral with respect to risk. If the long-term expected benefits of protection, discounted appropriately to reflect the time value of money, exceeded the upfront costs of the measure, then they should undertake this action. The expected utility model implies that the Lowlands would be even more interested in investing in mitigation if they were averse to the risk of large losses from future disasters.

If the family were to attempt such an analysis they would quickly realize that they lack most of the critical information needed to make the relevant comparison of costs and benefits. For example, the future economic benefit of mitigation conditional on a flood is highly uncertain. It depends not only on the quality of implementation (which is unobservable) but also on future social and economic factors over which the Lowlands have little control, such as whether neighbors make similar investments that is likely to impact on the value of their property, or whether federal disaster relief will be made available following a disaster. The decision is further complicated by the *timing* of the choice; the optimal mitigation policy might be to postpone the investment until the above ambiguities are resolved.

In the absence of analytic guidance, how will the Lowlands make the decision? Central to this chapter is the hypothesis that individuals often utilize informal heuristics that have proven useful for guiding day-to-day decisions in more familiar contexts—but that are likely to be unsuccessful when applied to the kind of low-probability, high-stakes decisions they are now facing in a catastrophic environment. In the sub-sections below we review the range of informal mechanisms that are used to make mitigation decisions, and discuss how they might explain the widespread lack of investment illustrated above.

[3] A discussion of alternative flood reduction measures can be found in Laska (1991) and Federal Emergency Management Agency (FEMA) (1998).

Budgeting Heuristics

The simplest explanation as to why individuals fail to mitigate in the face of transparent risks is affordability. If the Lowland family focuses on the upfront cost of flood-proofing their house and they have limited disposable income after purchasing necessities, there would be little point in undertaking a comparison of expected benefits and costs regardless of its recommendation. Residents in hazard-prone areas have used this argument explicitly as to why they have limited interest in buying insurance voluntarily. In focus group interviews to determine factors influencing decisions on whether to buy flood or earthquake coverage, one uninsured worker responded to the question "How does one decide how much to pay for insurance?" by responding as follows:

> A blue-collar worker doesn't just run up there with $200 [the insurance premium] and buy a policy. The world knows that 90 percent of us live from payday to payday….He can't come up with that much cash all of a sudden and turn around and meet all his other obligations." (Kunreuther et al. 1978, p. 113)

A similar argument is likely to be made by individuals when it comes to investing in protective measures such as elevating ones house. In fact, such a budget constraint may extend to higher income individuals if they set up separate mental accounts for different expenditures (Thaler 1999). Under such a heuristic, a homeowner who is uncertain about the cost-effectiveness of mitigation might simply compare the price of the measure to what is typically paid for comparable home improvements. Hence, the $20,000 investment may be seen as affordable by those who frame it as a large improvement similar to installing a new roof, but unaffordable to those who frame it as a repair similar to fixing a leaky faucet.

Making mitigation decisions in this manner does not conform to guidelines implied by expected utility theory or cost-benefit analysis, but there is evidence from controlled laboratory experiments that it may not be uncommon. For example, in a study that asked individuals why they were willing to pay only a fixed amount for a dead bolt lock when the lease for the apartment was extended from 1 to 5 years, one respondent said, "$20 is all the dollars I have in the short-run to spend on a lock. If I had more, I would spend more—-maybe up to $50." (Kunreuther, Onculer and Slovic 1998 p. 284). Similarly, we suspect that some residents in coastal zones are discouraged from buying and installing storm shutters because the cost exceeds that of the window itself—a logical benchmark expenditure.

Biases in Temporal Planning

While individuals' decisions about mitigation are undoubtedly constrained by considerations of affordability, trade-offs between costs and benefits invariably arise at some level. Are people skilled at making these comparisons? The empirical evidence on how individuals make inter-temporal judgments is not encouraging. Although decisions often follow the directional advice of normative theory (such as by valuing temporally distant events less than immediate ones), they frequently depart from those prescribed by rational theories of inter-temporal choice. Moreover, they depart in a way that collectively discourages far-sighted investments in mitigation.

To see this, consider the investment problem faced by the Lowlands. For simplicity, suppose that that the family knows that they will be living in their new home for *T* years, that each year there is a probability p_t of a Katrina-like flood in year *t*, and that should such an event occur the mitigation measures will reduce losses by an amount *B*. In this case, the decision to mitigate could be made by observing whether the disutility associated with the upfront cost (C) of mitigation is less than the positive utility associated with the discounted stream of benefits; i.e., if

$$u(C) < \sum_{t=1}^{T} p_t u(B)\beta^t \qquad (1)$$

where β is the consumer's discount rate, and *u(x)* is the consumer's utility associated with the benefit *(B)* or cost *(C)*.

While simple in its structure, implicit in (1) are a series of rather strong assumptions about how the Lowlands will value costs and benefits over time. Specifically:

1) all future benefits are evaluated vis-à-vis a constant rate of discounting;
2) individuals can estimate future probabilities of flooding in year *t* accurately;
3) the utility function is time-invariant.

There is ample evidence that violations of these assumptions will be common. In particular, homeowners are likely to overweight short-term cash expenditures, have distorted beliefs about probabilities, and value common outcomes differently over time. The implications of these tendencies in the context of mitigation decisions are now reviewed in turn.

Under-weighing the future. A fundamental feature of human cognition is that we are influenced more by cues that are concrete and immediate than those that are abstract and delayed. To some extent, of course, rational inter-temporal choice theory prescribes that we *should* give less weight to distant future outcomes, and this prescription is captured by the constant discount rate β in (1). There is extensive experimental evidence, however, showing that human temporal discounting tends to be *hyperbolic*, where temporally distant events are disproportionately discounted relative to immediate ones. As an example, people are willing to pay more to have the timing of the receipt of a cash prize accelerated from tomorrow to today than from two days from now to tomorrow (in both cases a one-day difference) (Loewenstein and Prelec 1992). The implication of hyperbolic discounting for mitigation decisions is that residents are asked to invest a tangible fixed sum now to achieve a benefit later that they instinctively undervalue—and one that they, paradoxically, hope never to see at all.

The effect of placing too much weight on immediate considerations is that the upfront costs of mitigation will loom disproportionately large relative to the delayed expected benefits in losses over time. A homeowner might recognize the need for mitigation, and see it as a worthwhile investment when it is framed as something to be undertaken a few years from now when both upfront costs and delayed benefits are equally discounted. However, when the time arrives to actually make the investment, a homeowner subject to hyperbolic discounting might well get cold feet.

This tendency to shy away from undertaking investments that abstractly seem worthwhile is exacerbated if individuals have the ability to *postpone* investments—something that would almost always be the case with respect to mitigation. A case in point is the relative lack of preparedness demonstrated by the city of New Orleans and FEMA in advance of Hurricane Katrina in 2005. In this case, the consequences of failing to invest in mitigation—such as developing a workable evacuation plan—could not have been more salient or more temporally proximate. Just two months prior to the storm, the city engaged in a full-scale simulation that graphically demonstrated what would happen should a hurricane of Katrina's strength hit the city, and the city was moving into the heart of an active hurricane season (Brinkley 2006). Yet, little was done to remedy known flaws in their preparedness plans.

What explains the inaction? The explanation, we suggest, is simple: while emergency planners and the New Orleans Mayor's office were fully aware of the risks the city faced and understood the need for investments in preparedness, there was inherent ambiguity about just *what* these investments should be and *when* they should be undertaken. Faced with this uncertainty, planners did what decision makers tend to do when faced with a complex discretionary choice: they opted to defer it to the future, in the (usually false) hope that the correct choices would become clearer and/or more resources would then be available (Tversky and Shafir 1992).

To see this effect more formally, imagine the Lowlands view the future benefits of mitigation not in terms of a constant discounting schedule, but rather by the hyperbolic discounting function

$$f(t) = \begin{cases} 1/k & for\ t = 0 \\ \beta^t & for\ t > 0 \end{cases} \qquad (2)$$

where $0<k<1$ is a constant that reflects the degree to which immediate costs and benefits are given disproportionately more weight than delayed ones (Laibson 1997; Meyer, Zhao, and Han 2007). Expression (2) has an intriguing implication. Suppose that it is January ($t=0$) and the Lowlands are considering whether it is worthwhile to invest in a mitigation project that would start the next June (t=1). As long as costs remain temporally distant, the value of the project will be assessed via the rational inter-temporal discounting model in (1); i.e., the expected net value of the mitigation project, next January is:

$$V(I \mid January)) = [\sum_{t=1}^{T} p_t k \beta^t u(B)] - \beta u(C) \qquad (3)$$

Suppose the Lowlands conclude that the project is minimally worthwhile a year from now, that is, $V(I|January)=\varepsilon$, where ε is a small positive valuation. Hyperbolic discounting carries a curious implication for how the Lowlands will value the project come July; when the prospect of the expenditure C is immediate. In June, the project will look decidedly less attractive, since it value will now be:

$$V(I \mid June) = [\sum_{t=1}^{T} p_t u(B) k \beta^t] - u(C)/k \qquad (4)$$

Hence, if $(1/k-\beta)C>\varepsilon$, it will no longer seem worthwhile to invest. So will the Lowlands abandon their interest in mitigation? Paradoxically, we suggest no; if the builder gives them the option to restart the project the *following* January, it will once again seem worthwhile, since its valuation would be given by the standard model in (3). Hence, the Lowlands would be trapped in an endless cycle of procrastination; when viewed from a temporal distance the investment will always seem worthwhile, but when it comes time to undertaking the work the prospect of a slight delay always seems more attractive.

We should add that other, less formal, psychological mechanisms could also produce perpetual postponements of investments in mitigation. The most salient is the observed tendency for individuals to defer ambiguous choices; the less certain one is about a correct course of positive action, the more likely one is to choose inaction (Tversky and Shafir 1992). This ambiguity would seem particularly acute in the context of mitigation decisions where the question of whether it is optimal to mitigate is often unknowable for a single household, and there is infinite flexibility as to *when* one can undertake the investment. Finally, when viewed locally, the risk of a short delay in the start of mitigation is typically negligible. While seismologists are reasonably certain that there will be a major quake along the San Andreas Fault in southern California at some point over the next century, odds are strongly against it happening tomorrow. As such, residents who postpone the decision from day-to-day will rarely be punished for their inaction.

We should emphasize that the concept of hyperbolic discounting discussed above is distinct from that of *planning myopia,* or the tendency to consider consequences over too short a finite time horizon. For example, if the Lowlands' beliefs about the length of time they would live in their home were biased downward, they would underestimate the benefits of mitigation by using equation (1). While we are not aware of work that has examined whether there are systematic tendencies to misjudge homeownership tenure, the fact that the vast majority (72 percent) of U.S. homeowners prefer 30-year fixed (as opposed to adjustable) mortgages has been taken by some economists as evidence that homeowners, if anything, *over*estimate the length of time they will likely live in their homes (Campbell 2006). It is thus paradoxical, then, that homeowners would display acute concern for minimizing long-term risk when securing mortgages, but display little comparable concern when making decisions about investing in mitigating potential damage to their home.

*Underestimation of risk***.** Another factor that could suppress investments in mitigation is under-estimation of the likelihood of a hazard—formally, under-estimation of p_t in (1). Although underestimation of risk is perhaps the simplest explanation as to why people fail to mitigate, the empirical evidence in the domain of natural hazards is far from complex.

On the one hand, we do know that decisions about mitigation are rarely based on formal beliefs about probabilities. Magat, Viscusi and Huber (1987) and Camerer and Kunreuther (1989), for example, provide considerable empirical evidence that individuals do not seek out information on probabilities in making their decisions. Huber, Wider and Huber (1997) showed that only 22 percent of subjects sought out probability information when evaluating risk managerial decisions. When consumers are asked to justify their decisions on purchasing warranties for products that may need repair, they rarely use probability as a rationale for purchasing this protection (Hogarth and Kunreuther, 1995).

Even though individuals do not find statistical probability to be a useful construct in making risky decisions, they are able to provide estimates of their subjective beliefs about relative risk. But these beliefs are not well-calibrated. When directly asked to express an opinion about the odds of being personally affected by different hazards, people consistently respond with numbers that, perhaps surprisingly, are far *too high* relative to actuarial base rates. For example, in a study of risk perception Lerner et al. (2003) found that when people were asked to provide an estimate of the probability that they will be the victim of a violent crime over the coming year, the mean estimate was 43 percent -- an estimate that was far too high compared to actuarial base rates, and comparable to that which they expressed when asked to estimate the odds of getting the flu (47 percent). If these estimates actually reflected heightened fears about being exposed to hazards, it would strongly argue against the idea that people fail to mitigate simply because they assume that they will be immune. But these results may be speaking more to individuals' lack of familiarity with statistical constructs than real evidence that people are pessimistic.

On the other hand, there is also evidence that people tend to ignore risks whose subjective odds are seen as falling below some threshold. In a laboratory experiment on purchasing insurance, many individuals bid zero for coverage, apparently viewing the probability of a loss as sufficiently small that they were not interested in protecting themselves against it (McClelland et al. 1993). Similarly, many homeowners residing in communities that are potential sites for nuclear waste facilities have a tendency to dismiss the risk as negligible (Oberholzer-Gee 1998). Prior to the Bhopal chemical accident in 1984, firms in the industry estimated the chances of such an accident as sufficiently low that it was not on their radar screen (Bowman and Kunreuther 1988). Similarly, even experts in risk disregard some hazards. For instance, even after the first terrorist attack against the World Trade Center in 1993, terrorism risk continued to be included as an unnamed peril in most commercial insurance policies in the United States, so insurers were liable for losses from a terrorist attack without their ever receiving a penny for this coverage. (Kunreuther and Pauly 2005). Because insurers had not integrated the threat into their portfolio management, the September 11, 2001 attacks obligated them to pay over $35 billion in claims.

Levees or other flood control projects are likely to give residents a false sense of security with respect to suffering damage from floods or hurricanes. In fact, Gilbert White pointed out many years ago that when these projects are constructed, there is increased development in these "protected" areas. Should a catastrophic disaster occur so that residents of the area are flooded, the damage is likely to be considerably greater than before the flood-control project was initiated. This behavior and its resulting consequences have been termed the *levee effect.* Evidence along these lines has recently been offered by Burby (2006), who argues that actions taken by the federal government, such as building levees, make residents feel safe when, in fact, they are still targets for catastrophes should the levee be breached or overtopped.

Affective forecasting errors. A final assumption of normative theories of inter-temporal choice that is worth scrutinizing is the assumption that utility functions are temporally invariant. In our example, the Lowlands would be assumed to value benefits from mitigation realized in the distant future in the same way that they would be valued if realized now. How likely is this assumption to be empirically valid? There are extensive bodies of work showing that individuals tend to be both poor forecasters of future affective states (e.g., Wilson and Gilbert 2003), and focus on different features of alternatives when they are viewed in the distant future versus today (e.g., Trope and Lieberman 2003.

Probably the most problematic of these biases for mitigation decisions is the tendency for affective forecasts to be subject to what Loewenstein, O'Donoghue, and Rabin (2003) term the *projection bias*—a tendency to anchor beliefs about how we will feel in the future on what is being felt in the present. Because mitigation decisions are ideally made in docile times long before (rather than just after) a disaster occurs, the projection bias predicts a tendency for decision makers to both underestimate the likelihood of future hazards and the feelings of trauma that such events can induce—a bias that would, in turn, lead to undervaluation of investments in protection. After Hurricane Katrina, a common theme heard from survivors trapped in the floods was, "had I known it would be this bad, I would have left." The reality, of course, was that they were *told* that it would be that bad; the storm was preceded by warnings of the most dire sort, that Katrina was "the big one" that New Orleans' residents had been warned to fear for years (Brinkley 2006). But it is one thing to imagine being in a large-scale flood, quite another to actually be in one. Judgments of the severity of the experienced were unavoidably biased downward by the relative tranquility of life before the storm.

We might add that while the dominant likely effect of affective forecasting errors is to undervalue future protection, it is possible that protection could be *over*valued if prior valuations are subject to a different bias that has also been observed in intuitive forecasts, that of *duration neglect*, the tendency to over-estimate the length of time it takes to recover from negative life events, such as being fired from a job (Wilson and Gilbert 2003). Under such a bias, a homeowner might well underestimate the initial impact of damage suffered from a hazard due to the projection biases, but still *over*-invest in protection out of a belief that it will take an excessively long time to physically and emotionally recover from that damage. As an example, in the days immediately following Katrina there were dire warnings that it would likely be months before flooded sections of the city could be drained, and that the city would never be able to recover—predictions that later proved too pessimistic.[4]

Finally, the tendency to value costs and benefits differently depending on temporal perspective is another mechanism that could result in procrastination. Trope and Lieberman (2003) offer a wide array of evidence showing that when making choices for the distant future we tend to focus on the abstract benefits of options, whereas when making immediate choices we tend to focus on concrete costs. Hence, similar to the predictions made by hyperbolic discounting, it would not be uncommon to hear politicians pledge their deep commitment to building safer societies at election-time (when costs loom small relative to abstract benefits), but then back away from this pledge when the time comes to actually make the investment—when it is the concrete costs that loom larger.

[4] Still, the US Census Bureau estimates indicate that almost two years after the storm, by July 1, 2007, nearly half of these evacuees had yet to return to New Orleans (Vigdor 2008).

Learning Failures

The above discussion makes a clear argument that if individuals make mitigation decisions by performing intuitive comparisons of upfront costs with long-term benefits, they will likely underinvest by virtue of focusing too much on upfront costs, undervaluing long-term benefits and/or underestimating the likelihood that the disaster will happen to them. But this begs a conjecture: while an individual (or institution) making a one-time mitigation decision might well err by underinvesting, such errors would likely be transient. Once the consequences of under-mitigation are observed, intuition suggests that there would be a natural tendency to correct the biases that led to the initial error. Indeed, there is some evidence that mitigation errors are naturally correcting; early Mayans learned (no doubt by experience) that it was safer to build cities inland than on the hurricane-prone coasts of the Yucatan. The loss of 6,000 lives in Galveston in 1900 taught the city that it needed a seawall to protect against future storms, and it took the disaster of Katrina for New Orleans to finally put in place a comprehensive evacuation plan (Brinkley 2006).

The problem, however, is not that we do not learn, but rather that we do not seem to learn *enough* from the experiences of disaster. As an illustration, when Hurricane Wilma hit south Florida in October of 2005, just a few weeks after Hurricane Katrina, thousands of residents failed to take such simple preparatory measures as securing bottled water and filling their cars up with gas—oversights that greatly added to the challenges of recovery. What was surprising about this lack of preparation was that the region had ample warning of the storm's approach (the impact was forecast up to four days in advance), and it came at the end of the most destructive hurricane season on record, one where the news media were constantly filled with graphic illustrations of the destructive power of such storms (such as the flooding in New Orleans). Other familiar examples exist as well—such as the tendency to re-settle in flood plains after major floods, and become increasingly lax in earthquake preparedness as the time since the last quake lengthens.

What explains the seeming lack of learning by residents? The reason, we suggest, is that we instinctively learn to protect ourselves against hazards by relying on the same trial-and error heuristics that have proven successful in other walks of life: heuristics that encourage us to repeat those behaviors that yield positive rewards and avoid those behaviors that yield negative outcomes. But while reinforcement learning is a highly efficient way to learn to perform such repeated tasks as walking, speaking, and playing tennis, it is particularly ill-suited for learning how best to respond to low-probability, high-consequence hazards. The reason is simple: most protective behaviors will be negatively reinforced far more often than they will be positively reinforced.

As an example, when Hurricane Wilma approached south Florida in 2005, the vivid news depictions of suffering Katrina survivors were counterbalanced by a different, and more salient source of information: residents' recollections of the seven false-alarms that the area had received during the previous two years. For many, the hurricane warnings posted for Wilma triggered memories of rushing to secure supplies of water and gas before a storm, only later to find out that their efforts were unnecessary. For everyone else, it was memories of how gambling paid off; their decisions *not* to prepare for all the *previous* storms had turned out to be the right ones (in hindsight).

A more recent example of the potentially dysfunctionalities of learning from experience arose in a different context too: the 2007 shootings at Virginia Tech University. In a report that was highly critical of the University's slow response to the incident, an investigatory committee suggested that the failure to react quickly was partially due to bad publicity the university administration received the previous year when they were accused of *over*reacting to the threat of an escaped convict who was involved in a shooting near campus. The threat proved a false alarm, but there was nevertheless damage; administrators became wary of moving too quickly in response to the next threat.

This same tendency to ignore warning information because of its perceived unreliability may also be inflamed in the context of natural hazards by the tendency for news sources to over-hype threats—such as warnings of a coming blizzard, ice storm, or hurricane. While occasionally the events measure up to the billing advertised on the 11 p.m. news, more often they will not—causing viewers to discount future warnings of dire threats.

A second major impediment to learning is the inherent ambiguity of feedback about what constitutes optimal mitigation. In the course of disasters, one can rarely observe the counterfactuals critical to learning: what damage would have occurred had certain mitigation steps been taken (or not taken). As noted by Meyer (2006), one consequence of this feedback property is that it supports the persistence of superstitious beliefs about mitigation strategies. A good example is the old adage that one should open windows in advance of a tornado so as to equalize pressure. It took structural engineers years to discover that open windows were more likely to be the *cause* of building failures than the cure (entering wind exerts upward pressure on roofs); yet the myth is still widely held. The reason, of course, is that it is impossible to infer from observing a destroyed house whether it would still be standing had the windows been closed—or indeed whether they were open or closed to begin with.

We should emphasize that it is not the rarity of hazardous events *per se* that limits learning. While individuals may encounter a major earthquake or hurricane only once in their lives (or, more likely, never), there are ample opportunities to learn by observing the experiences of others. Indeed, the plethora of books describing great disasters of the past (from Noah's flood onward) and the intense new attention that is given to disasters suggests that we have deeply-ingrained instincts (however morbid) for trying to learn from others' misfortunes. There is suggestive evidence, however, that people often learn much less from vicarious feedback than one might hope. As an example, in a laboratory study designed to measure peoples' abilities to learn optimal levels of investment to protect against hurricanes, Meyer (2006) found that decisions to increase investment were driven almost exclusively by whether the decision maker personally suffered losses in the previous period; in contrast, losses suffered by others did not have such a triggering effect.

Finally, we should note that if the government comes to the rescue with liberal disaster assistance, then one may conclude from media reports or personal experience that it may not be necessary to invest in costly protective measures. In fact, those who have taken steps to protect themselves financially against losses may conclude that they would be better off not having purchased coverage. A graphic example comes from the Alaska earthquake of 1964, when the federal government provided low-interest loans to aid the recovery and retire debts from existing mortgages for those who were uninsured. It was not uncommon to hear the few homeowners who did purchase earthquake insurance bemoan their decision because they discovered they would have been better off financially had they not purchased this coverage. (Dacy and Kunreuther 1968).

Social Norms and Interdependencies

Let us return again to the dilemma faced by the Lowland family, who have now narrowed their mitigation option to elevating their house on piles so as to reduce flood losses from a future hurricane. If none of their neighbors have taken this step, their house would look like an oddity in a sea of homes at ground level. Should the Lowlands choose to move, they would be concerned that the resale value of their home would be lower because the house was different from all the others. Likewise, the effectiveness of mitigation might itself depend on the number of other residents who elect to elevate their homes. If the Lowlands decide to elevate their home but their neighbors do not take this action, then one of these non-elevated homes could be washed away during a flood or hurricane and cause damage to the Lowlands' home which would otherwise have been spared. Note that these—very real—considerations would not be easily captured in a traditional expected utility analysis of their problem (such as expression (1)), which assumes a decision is made in social isolation. In contrast, mitigation decisions often take the form of coordination games, where the value of mitigation depends on whether neighbors choose to mitigate.

Decisions made by neighbors also carry information value—or at least are likely to be perceived as such. As in an information cascade (Sunstein 2006), if a large number of neighbors have already decided to put their house up on piles, the Lowlands might plausibly conclude that that the investment must be cost-effective. Of course, such inferences could be wildly mistaken if their neighbors' decisions were also based on imitation; much like a fad, one might observe communities collectively adopting mitigation measures that have little actuarial or engineering basis.

To illustrate such effects, we recently conducted a laboratory study of social network effects in earthquake mitigation. In the study, participants were told that they would be living in an area prone to periodic earthquakes, and that they could purchase structural improvements in their homes that potentially mitigated the effects of quakes should one arise. The task was to make these decisions as efficiently as possible in the following sense: at the end of the simulation they would be paid an amount that was tied to the difference between their home value and interest earning minus the cost of mitigation plus damage repairs. Throughout the simulation they could observe the investment decisions being made by others in their virtual community, as well as damage they suffered from quakes. The key source of uncertainty in the simulation was whether the mitigation was cost effective or not; half of the participants were placed in a world where mitigation was not cost effective (hence the optimal investment was 0%), and the other half were placed in a world where it was long-term effective (hence the optimal investment was 100%). Our interest was in observing whether communities could discover the optimal level of mitigation over repeated plays of the game.

The basic result was that they could not determine how much to invest in mitigation. Consistent with the findings on learning discussed above, there was little evidence of either community naturally discovering the optimal level of mitigation (the investment level in both worlds averaged 40%). There was, however, a social norm effect: the major driver of individual decisions about how much to invest was the average level of investment made by neighbors.

Would learning have been enhanced had the communities been populated with a few opinion leaders who had knowledge of mitigation's true effectiveness? To investigate this, we ran a new set of studies where, prior to the simulation, one player in each community was privately informed of the true effectiveness of mitigation. Other players knew that one among them had this information, but that person's identity was not revealed—but could likely be inferred by observing players' investment behavior. For example, a player who is told that investments are ineffective would, presumably, invest 0% from the start. Did this "knowledge seeding" help communities learn? It did, but—quite surprisingly—only in the case where investments were ineffective. In these communities, players seemed to immediately recognize the informed player (who was not investing), and after two rounds of the game almost all investments in mitigation had vanished, as it should have.

In contrast, in communities where mitigation was effective, rather than investments increasing over time, they *decreased.* For many of the reasons described earlier in this section, players who were told that mitigation was effective did not play the optimal strategy of investing 100% at the start—they procrastinated. The other players, seeing no one with a high level of investment, then mistakenly concluded that they must be in a world where mitigation was ineffective. Hence they invested only a small amount themselves. Then, bizarrely, the informed players—who should have been opinion leaders—became followers, reducing their own investments. After multiple plays of the game, few players were making any investments at all, even though it was optimal for them to do so in the long-run.

Of course, one might hope that in real-world settings, opinion leadership and tipping strategies might be more effective, and evidence along these lines has been presented by Schelling (1978) and popularized by Gladwell (2000). Heal and Kunreuther (2005) provide a game theoretic treatment of the impact of interdependency on the decision to invest in protective measures and suggest ways to coordinate actions of those at risk, ranging from subsidization or taxation to induce tipping or cascading to rules and regulations, such as well-enforced building codes.

The Samaritan's Dilemma

As eluded above, another of the arguments advanced as to why individuals do not adopt protective measures prior to a disaster is that they assume liberal aid from the government will be forthcoming should they suffer losses from an earthquake, hurricane or flood. Federal disaster assistance may create a type of Samaritan's dilemma: providing assistance *ex post* (after hardship) reduces parties' incentives to manage risk *ex ante* (before hardship occurs) (Buchanan 1975). If the Lowland family expects to receive government relief after a loss, it will have less economic incentive to invest in mitigation measures and purchase insurance prior to a hurricane. The increased loss due to the lack of protection by residents in hazard-prone areas amplifies the government's incentive to provide assistance after a disaster to victims.

The empirical evidence on the role of disaster relief suggests, however, that individuals or communities have **not** based their decisions on whether or not to invest in mitigation measures by focusing on the expectation of future disaster relief. Kunreuther et al. (1978) found that most homeowners in earthquake- and hurricane-prone areas did not expect to receive aid from the federal government following a disaster. Burby et al. (1991) found that local governments that received disaster relief undertook more efforts to reduce losses from future disasters than those that did not. This behavior seems counter-intuitive and the reasons for it are not fully understood. It will be interesting to see whether Hurricane Katrina changes this view given the billions of dollars in disaster relief that have been sent to victims and affected states. In the same vein, the historical federal bailout of some of the largest financial institutions in 2008 and 2009, is likely to create strong moral hazard in the future.

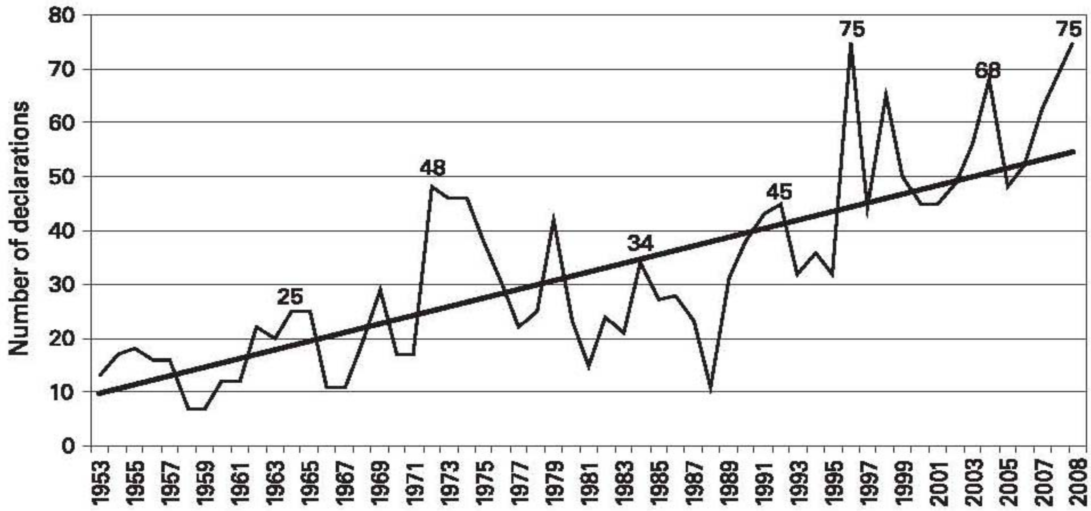
Whether or not individuals incorporate an expectation of disaster assistance in their pre-disaster planning process, a driving force with respect to the actual provision of government relief is the occurrence of disasters where the losses are large (Moss 2002). Under the current system the Governor of the State(s) can request that the President declare a "major disaster" and offer special assistance if the damage is severe enough. Although the President does not determine the amount of aid (the House and Senate do), he is responsible for a crucial step in the process. This obviously raises the question of what are the key drivers of such a decision and whether some states are more likely to benefit from this situation than others, and if so, when does this occur?

The Politician's Dilemma

Federal relief is not immune from behavioral bias – that is consistent with recent research that has shown that election years are a very active time for disaster assistance (all other things being equal). Figure 1 depicts the evolution of the number of Presidential declarations over the period 1953-2008. Overall, the number of these declarations has dramatically increased over that period of time: there were 162 during the period 1955-1965, 282 between 1966 and1975, 319 over the period 1986-1995 and 545 from 1996-2005 (Michel-Kerjan, 2008b). It is interesting to note that many of the peak years described in Figure 1 correspond to presidential election years.

Four salient examples are the Alaska earthquake in 1964, Tropical Storm Agnes in June 1972, Hurricane Andrew in September 1992 and the four hurricanes in 2004. For example, following the Alaska earthquake where relatively few homes and businesses had earthquake resistant measures and insurance protection, the U.S. Small Business Administration provided 1 percent loans for rebuilding structures and refinancing mortgages to those who required funds through its disaster loan program. As pointed out above, the uninsured victims in Alaska were financially better off after the earthquake than their insured counterparts (Dacy and Kunreuther 1968). More recently, it has also been shown that a battleground state with 20 electoral votes has received more than twice as many Presidential disaster declarations than a state with only three electoral votes (Reeves, 2004, 2005).

Figure 1. Disaster Presidential Declarations per Year (Peak-values on the graph correspond to some presidential election years)



Sources: Data from Michel-Kerjan (2008b)

In the case of Hurricane Katrina, Governor Kathleen Blanco declared a State of Emergency on August 26th, 2005, and requested disaster relief funds from the federal government on the 28th. President Bush declared a State of Emergency on the 28th, an action that frees federal government funds and puts emergency response activities, debris removal, and individual assistance and housing programs under federal control (CRS 2005). Under an emergency declaration, federal funds are capped at $5 million. On August 29th in response to Governor Blanco's request, the President declared a "major disaster," allotting more federal funds to aid in rescue and recovery. By September 8th, Congress had approved $52 billion in aid to victims of Hurricane Katrina. As of August 2007, the total federal relief allocated by Congress for the reconstruction of the areas devastated by the 2005 hurricane season is nearly $125 billion.

The fact that politicians can benefit from their generous actions following a disaster, raises basic questions as to the capacity of elected representatives at the local, state and federal levels to induce people to adopt protection measures before the next disaster. The difficulty in enforcing these mitigation measures has been characterized as the *politician's dilemma* (Michel-Kerjan 2008a).

Imagine an elected representative at the city or state level. Should s/he push for people and firms in her district to invest in cost-effective mitigation measures to prevent or limit the occurrence of a disaster? From a long-term perspective, the answer should be *yes*. But given short-term re-election considerations (another form of myopia), the representative is likely to vote for measures that allocate taxpayers' money elsewhere that yield more political capital. It is another example where little consideration is given to supporting mitigation measures prior to a disaster (*ex ante*) because their constituencies are not worried about these events occurring and there is likely to be a groundswell of support for generous assistance to victims from the public sector after a disaster (*ex post)* to aid their recovery. The one silver lining to this behavior is that following a natural disaster when residents and the media focus on the magnitude of the losses, politicians are likely to respond by favoring stronger building codes and other loss reduction measures, but only when there is a consensus among her/his constituencies that this is a good thing to do.

Strategies for overcoming decision biases

How might we build more resilient communities in areas prone to natural hazards? The biases discussed above suggest that the task is not an easy one. Communities face a difficult choice: either find ways to de-bias decision makers so as to foster voluntary investments in mitigation, or restrict voluntary choice, such as imposing well-enforced building codes and land-use regulations. To date, public officials have turned to regulations as the only effective means of insuring mitigation: if residents are unable to make wise choices about where to live and how much to invest in protection, it is the role of government to impose these choices.

A compelling illustration of this argument is provided by Kydland and Prescott (1977), who, in their Nobel Prize winning contribution, show that a policy that allows freedom of choice may be socially optimal in the short run but socially suboptimal from a long-term perspective. As a specific example, the authors note that unless individuals are initially prohibited from locating in a flood plain, it will be very difficult politically to force these people to leave their homes. In making their decisions to locate in flood plains, Kydland and Prescott argue that these individuals believe that the Corps of Engineers will subsequently build dams and levees if enough people choose to build homes in flood-prone areas and hence decide to locate there.

Kunreuther and Pauly (2006) extend the Kydland-Prescott argument by introducing behavioral considerations into the picture. They contend that if individuals underestimate the likelihood of a future disaster, it may be important to require homeowners to purchase insurance and have well-enforced rules such as land-use regulations and building codes to avoid the large public sector expenditures following these events. To support this point, they provide empirical evidence that many individuals do not even think about the consequences of a disaster until after a catastrophe occurs, and hence do not invest in protective measures in advance of a disaster.

Yet, a policy of widespread government intervention in mitigation decisions carries its own risks. Specifically, the approach can be criticized as one that paradoxically, might in some cases actually exacerbate rather than reduce the long-term risk of catastrophes. Evidence along these lines has recently been offered by Burby (2006), who argues that actions taken by the federal government, such as building levees, make residents feel safe when, in fact, they are still targets for catastrophes should the levee be breached or overtopped. Likewise, Steinberg (2000) notes that beach restoration projects that are now widespread in coastal communities carry the same risk; while restoration lowers the potential damage from a single storm event, it also denies residents the visual cues that would inform perceptions of risk. This approach is also one whose viability assumes that the government planners who design and enforce codes are themselves immune from the biases that they are designed to overcome—a presumption that is unlikely to hold in practice. As an example, four decades of hurricanes from the

1920s through the 1950s persuaded South Florida to pass one of the country's strictest building codes in 1957, but enforcement of these codes gradually waned during the three quiet decades that followed—a lapse that contributed to the extreme property losses the area suffered during Hurricane Andrew in 1992 (Steinberg 2000).

In light of this dilemma, a long-term solution to managing catastrophe risks lies in decision architectures that *guide* residents to making more efficient protection decisions in a way that takes into account the behavioral biases noted above.

Long-term Insurance and Long-term Mitigation Loans

A major reason why individuals are reluctant to make major investments in mitigation is that they are unlikely to realize personal financial benefits in the short run. A key challenge with respect to encouraging mitigation, therefore, is to move the focal point from the *individual* to the *property,* so that individuals will focus on a longer time horizon when deciding whether to invest in risk-reducing measures. Mortgages can play an important role in this regard since they are typically long-term contracts.

In this spirit we have proposed as a market innovation that one moves from the traditional one-year insurance contracts as we know them today which encourages myopic thinking to multi-year insurance contracts with annual premiums coupled with long-term mitigation loans (Jaffee, Kunreuther and Michel-Kerjan 2008).

For a long-term insurance (LTI) policy to be feasible (say for 10 or 25 years), insurers would have to be able to charge a rate that reflects their best estimate of the risk over that time period. The uncertainty surrounding these estimates could be reflected in the annual premium being 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. The obvious advantage of an LTI 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 had cancelled policies before severe disasters occurred.[5] On a much broader scale, a recent study of flood insurance in Florida revealed that of the one million residential NFIP flood insurance policies in place in Florida in 2000, one third had been cancelled by 2002 and about two thirds had been cancelled by 2005 (Michel-Kerjan and Kousky, forthcoming).

Under the current state-regulated arrangements, where many insurance commissioners have limited insurers' ability to charge premiums that reflect the exposure and the cost of capital necessary to provide insurance in hazard-prone areas, no insurance company would even entertain the possibility of marketing an LTI policy. Insurers would be concerned about the regulator clamping down on them now or in the future regarding what price they could charge, so that LTI insurance would be infeasible from a financial point of view. Given the existing tension between state insurance regulators and the insurance industry, we feel that it would be best politically to introduce LTI by focusing

[5] Following a flood in August 1998 that damaged property in northern Vermont, FEMA found that 84 percent of the 1,549 homeowners suffering damage resided in Special Flood Hazard Areas (SFHAs) but did not have insurance, even though 45 percent of these individuals were required to purchase this coverage (Tobin and Calfee 2005).

on flood insurance, which is provided nationwide by the federal government under the National Flood Insurance Program.[6]

We propose that the purchase of long-term flood insurance be required for all property owners residing in hazard-prone areas so as to reduce the likelihood of liberal disaster relief legislation following the next major catastrophe. There is precedent for such a requirement today in all states where motorists have to show proof of bodily injury and property damage liability or financial responsibility on the automobile insurance policy in order to register their car. With respect to property insurance, homeowners who have a mortgage are normally required by the bank which finances the loan to purchase coverage against wind damage for the length of the mortgage and this requirement is normally enforced.

A long-term flood insurance contract would also provide economic incentives for investing in mitigation where current annual insurance policies are unlikely to do the trick even if they were risk-based due to the behavioral considerations discussed in the previous section. To highlight this point, consider the following simple example. Suppose the Lowland family could invest $1,500 to flood-proof the foundation of its house so as to reduce the water damage by $30,000 from a future flood or hurricane that would occur with an annual probability of 1/100. If the insurance premium reflects the risk, then the annual premium would be reduced by $300 to reflect the lower expected losses to the property. 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 in the form of lower insurance premiums would exceed the upfront cost at an annual discount rate as high as 15 percent.

Under the current annual flood insurance contract, many property owners would be reluctant to incur the $1,500 because they would only get $300 back next year. If they used hyperbolic discounting and/or they were myopic with respect to the time horizon, the expected discounted benefits would likely be less than the $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 the homeowners' decisions not to invest in these measures. They may not be clear how long they will reside in the area and/or whether they would be reward again with lower premiums next year when their policy is renewed.

With a 20-year flood insurance contract, the premium reduction would be viewed as a certainty. In fact, the property owner could take out a $1,500 home improvement loan tied to the mortgage at an annual interest rate of 10 percent, resulting in payments of $145 per year. If the annual insurance premium was reduced by $300, the savings to the homeowner each year would be $155.

A bank would have a financial incentive to provide this type of loan. By linking the expenditure in mitigation to the structure rather than to the property owner, the annual payments are lower and this would be a selling point to mortgagees. The bank will also feel that it is now better protected against a catastrophic loss to the property and the insurer knows that its potential loss from a major disaster is reduced. These mitigation

[6] For more details on the proposed long-term flood insurance policy see Kunreuther and Michel-Kerjan (in press).

loans would constitute a new financial product. 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-win situation for all! (Kunreuther 2006).

Seals of Approval

A complementary way of encouraging the adoption of cost-effective mitigation measures is to require that banks and other lenders condition their mortgages. Sellers or buyers of new or existing homes would have to obtain a seal of approval from a recognized inspector that the structure meets or exceeds building code standards. This requirement either could be legislated or imposed by the existing housing government sponsored enterprises (GSEs) (i.e., Fannie Mae, Freddie Mac, and the twelve Federal Home Loan Banks). Existing homeowners may want to seek such a seal of approval as well, if they knew that insurers would provide a premium discount (akin to the discounts that insurers now make available for smoke detectors or burglar alarms) and if home improvement loans for this purpose were generally available.

Evidence from a July 1994 telephone survey of 1,241 residents in six hurricane-prone areas on the Atlantic and Gulf Coasts provides supporting evidence for some type of seal of approval. Over 90 percent of the respondents felt that local home builders should be required to follow building codes, and 85 percent considered it very important that local building departments conduct inspections of new residential construction. We recommend the following procedure. The inspection required to establish a seal of approval must be undertaken by certified contractors. For new properties, the contractor must provide the buyer with this seal of approval. For existing properties, the buyer should pay for the inspection and satisfy the guidelines for a seal of approval. If the house does not satisfy the criteria, then banks and other mortgage lenders should roll into their mortgage loans the cost of such improvements. (Kunreuther and Michel-Kerjan 2006).

Tax Incentives

One way for communities to encourage residents to pursue mitigation measures is to provide them with tax incentives. For example, if a homeowner reduces the losses from a disaster by installing a mitigation measure, then this taxpayer would get a rebate on state taxes to reflect the lower costs of disaster relief. Alternatively, property taxes could be reduced. In practice, some communities often create a monetary disincentive to invest in mitigation. A property owner who improves a home by making it safer is likely to have the property reassessed at a higher value and, hence, have to pay higher taxes. California has recognized this problem, and in 1990 voters passed Proposition 127, which exempts seismic rehabilitation improvements to buildings from reassessments that would increase property taxes.

The city of Berkeley in California has taken an additional step to encourage home buyers to retrofit newly purchased homes by instituting a transfer tax rebate. The city has a 1.5 percent tax levied on property transfer transactions; up to one-third of this amount can be applied to seismic upgrades during the sale of property. Qualifying upgrades include foundation repairs or replacement, wall bracing in basements, shear wall installation, water heater anchoring, and securing of chimneys (Heinz Center 2000).

Zoning Ordinances that Better Communicate Risk

One of the more vexing problems facing policy makers after major catastrophes is whether to permit reconstruction in areas that have been damaged. As the response after Katrina demonstrated, there is usually strong political support for wanting to rebuild one's home in the same place where it was damaged or destroyed. Indeed, not to do so somehow seems a lack of empathy for those who have lived part, if not all their life, in the area and have family and social connections there; for many of them nowhere else could be home. (Vigdor 2008)

An unfortunate tendency after disasters is not only permitting homes to be rebuilt in hazard-prone areas, but rebuilding the structures so as to remove all signs that might communicate to new and prospective residents the inherent risks posed by the location. Visitors to the Mississippi Gulf coast today, for example, will find few cues that would be indicative of the complete devastation that the area suffered from Hurricane Katrina in 2005: attractive mansions are once again strung along Route 90, where sandy beaches give little clue that this is perhaps the most hazard-prone section of coastline in the United States.

While policies that prohibit residents from rebuilding destroyed residences may be politically unviable, policies that guide reconstruction in such a way that allows new residents to make informed decisions about the real risks they face would seem far less controversial. This notion is implicitly recognized in FEMA's flood maps, which the agency is in the process of updating. We urge that this education process be recognized more widely, not just for floods, but for hurricanes and earthquakes as well. (GAO 2008).

Conclusions

Recent disasters in the United States have provided empirical evidence supporting the *natural disaster syndrome*. Following Hurricane Katrina, many victims in Louisiana suffered severe losses from flooding because they had not mitigated their homes and did not have flood insurance to cover the resulting damage. As a result, there was an unprecedented level of federal disaster assistance to aid these victims.

There are many reasons why those in harm's way have not protected themselves against natural disasters. In this chapter we have highlighted behavioral considerations that include budgeting heuristics, short term horizons, underestimation of risk, optimism, affective forecasting errors, learning failures, social norms and interdependencies, the Samaritan dilemma, and the politician's dilemma. All these effects limit people's interest and ability to invest in hazard mitigation measures.

The 2004, 2005 and 2008 hurricanes should have been a wakeup call in this regard but seemed to fall on deaf ears. The next series of major hurricanes, floods and/or earthquakes are likely to be devastating ones.

In the case of New Orleans, inhabitants may have simply felt that they were fully protected by flood control measures such as the levees. Unfortunately, it is very likely that we will discover after future catastrophes that there are actually many similar situations of false perceived security in other highly exposed areas (Pinter 2005). The question of the resiliency of our infrastructure to large-scale disasters is one that has not yet received the attention it deserves (Auerswald et al. 2006).

If we as a society are to commit ourselves to reducing future losses from natural disasters and limit government assistance after the event, then we need to engage the private and public sectors in creative partnerships. This requires well-enforced building codes and land-use regulations coupled with adequate insurance protection. Economic incentives, making these actions financially palatable to property owners, should be provided in the form of long-term insurance policies and mitigation loans.

One may also want to think more about the type of disaster insurance that should be provided to those in hazard-prone areas. It may be useful to consider the possibility of providing protection against all hazards under a long-term homeowner's insurance policy tied to the mortgage rather than continuing with high volatility inherent in annual insurance contracts. These and related issues form the basis for future behavioral studies that may help us to develop more effective policy recommendations for reducing losses from future natural disasters.

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