

Decision Making for Protective Measures

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1. Why Is There Limited Interest In Mitigation?

The decision on whether to adopt risk mitigation measures (RMMs) to reduce losses from catastrophic accidents or natural disasters can be framed in a very straightforward manner. There is an upfront cost of the mitigation measure which will either reduce the probability of the accident or disaster occurring or the magnitude of the loss should the event take place. The benefits of the mitigation measure will be reaped for the length of time (T) that the entity is in place. In the case of homeowners adopting a loss-reduction measure, T is defined by how long the property is used as a residence. In the case of a firm facing technical risks, T is defined as the length of time that the business is in operation.

For simplicity, and without loss of generality, assume that there is a single type accident or disaster that can occur and that the probability of such an event and the resulting losses are constant over time. Using very simple notation to characterize the problem let us define the following terms:

C = upfront cost of mitigation measure

p = annual probability of disaster causing house to collapse without mitigation measure

(e.g. $p = .05$)

p^* = annual probability of disaster causing house to collapse with mitigation measure

$(p^* \leq p)$ (e.g., $p^* = .025$)

L = loss reduction from mitigation measure (e.g. $L = 20,000$)

r = annual discount rate (e.g. $r = .10$)

T = relevant time horizon (e.g. $T = 10$ years)

The decision as to whether or not to invest in an RMM is determined by comparing the cost of mitigation (C) with the expected benefits $[E(B)]$. Assume that if a disaster or accident occurs within the T year time horizon the house will be restored to its pre-disaster condition and be functional again as it was prior to the disaster. Then $[E(B)]$ can be characterized as follows:

$$\sum_{t=1}^T (p-p^*)(L)/(1+r)^t \quad (1)$$

To illustrate with a simple example, consider the figures presented with the notation above. Equation (1) now becomes:

$$\sum_{t=1}^{T=10} (.05-.025) (20,000)/(1.10)^t \quad (2a)$$

$$\sum_{t=1}^{T=10} 500 / (1.10)^t = \$3,380. \quad (2b)$$

On the average the mitigation will yield \$500 worth of direct expected benefits each year so that over the 10 year time horizon it will yield total discounted expected benefits of \$3380. If the mitigation measure costs less than \$3380, then it is cost-effective for the business or homeowner to adopt it. This example and the discussion which follows

assumes that the value of the property will not be increased at all by the investment in the mitigation measure. To the extent that mitigation gets translated into a higher property value, then this provides an additional reason to make this investment.

In reality there are a number of reasons why a firm or individual will decide not to invest in such measures:

Underestimation of Probability Some individuals may perceive the probability of a disaster causing damage to their property as being sufficiently low that the investment in the protective measure will not be justified. For example they may relate their perceived probability of a disaster (p) to a threshold level (p^*), which they may unconsciously set, below which they do not worry about the consequences at all. If they estimate $p < p^*$, then they assume that the event "will not happen to me" and take no protective actions. This decision to ignore events where $p < p^*$ may be justified by individuals who claim that there is a limited amount of time available to worry about protecting oneself against hazards facing us. By setting a threshold level p^* , individuals can devote their attention to events that where p is sufficiently high to be a source of worry and concern. Such a rule is also easy to explain and justify to others because of its simplicity.

Short Term Horizons Individuals may have relatively short time horizons over which they want to recoup their investment in an RMM. Even if the expected life of the house is 25 or 30 years, the person may only look at the potential benefits from the mitigation measure over the next 3 to 5 years. They may reason that they will not be residing in the property for longer than this period of time and/or that they want a quick return on their investment.

The need for a quick return is also consistent with having a high discount rate regarding future payoffs. Loewenstein and Prelec (1992) propose a behavioral model of choice whereby the discount function is hyperbolic, rather than exponential. Their model appears to explain the reluctance of individuals to incur the high immediate cost of energy-efficient appliances in return for reduced electricity charges over time (Hausman, 1979; Kempton and Neiman, 1987).

Aversion to Upfront Costs If people have budget constraints then they will be averse to investing in the upfront costs associated with protective measures simply because they feel they cannot afford these measures. It is not unusual for one to hear the phrase “We live from payday to payday” when asked why a household has not invested in protective measures.

Truncated Loss Distribution Individuals may have little interest in investing in protective measures if they believe that they will be financially responsible for only a small portion of their losses should a disaster occur. If their assets are relatively limited in relation to the potential loss, then these individuals may feel they that they can walk away from their destroyed home without being financially responsible. Similarly if residents anticipate liberal disaster relief from the government should they suffer damage, then they would have less reason to invest in an RMM.

2. Empirical Studies on Adoption of Mitigation Measures

The empirical data on studies of mitigation adoption in hazard-prone areas of the United States suggest that individuals are not willing to invest in RMMs despite the rather large damage that either they and/or their friends and neighbors suffered from recent disasters. For example, after Hurricane Andrew in Florida in 1992 most residents in

hurricane-prone areas appear not to have made cost-effective improvements to existing dwellings that could reduce amount of damage from another storm at relatively low cost. A July 1994 telephone survey of 1241 residents in six hurricane-prone areas along the Atlantic and Gulf Coasts revealed that 62 percent indicated that they had not installed hurricane shutters, used laminated glass in windows, installed roof bracing and/or made sure that side walls were bolted to the foundation either before or after Hurricane Andrew. (Insurance Institute for Property Loss Reduction 1995).

Measures, such as strapping a water heater with simple plumbers tape, can normally be undertaken by property owners at a cost of under \$5 in materials and one hour of their own time. (Levenson 1992). This RMM can reduce damage by preventing the heater from toppling during an earthquake, creating gas leaks and causing a fire. Yet these and other mitigation investments are not being adopted by residents in earthquake-prone areas in the United States. A 1989 survey of 3,500 homeowners in four California counties subject to the hazard reported that only between 5 and 9 percent of the respondents reported adopting any loss reduction measures (Palm et al. 1990). This behavior suggests that individuals do **not** believe that investing in the RMM will increase their residence's property value or that they have either short time horizons and/or severe budget constraints which either reduce their perceived net benefits from RMMs or simply prevent them from making the investment (Kunreuther 1996).

Turning to the relationship between insurance and mitigation some interesting findings emerge from recent surveys undertaken by Risa Palm and her colleagues. Palm and Carroll (1998) report that those who had adopted mitigation measures were also more likely to buy earthquake insurance than those who had not taken these loss

reduction measures. This raises the interesting question as to whether certain types of individuals and managers want protection for reasons that have less to do with their perception of the risk than their intrinsic worries and concerns.

To determine individual decision processes with respect to RMMs and how much an individual is willing to pay for investing in such a measures, a set of controlled experiments were conducted in Pennsylvania and California (Kunreuther, Onculer, and Slovic 1998). One example of a question posed to individuals participating in this survey was to specify their maximum willingness to pay (WTP) for bolting the structure to its foundation if they planned to reside in their house for exactly 5 years given that the expected annual reduction in damage from the RMM was approximately \$500. They were then asked to specify their maximum WTP if they expected to live in the house for exactly 10 years. In other words their time horizon (T) for residing in their house was doubled but nothing else in the experiment was changed.¹

Table 1 presents the distribution of these WTP figures for 84 students at the University of Pennsylvania. Half of these students were not told what the RMM cost to install and the other half were told that the price of installing the RMM was \$1500. As shown in the illustrative example presented in Section 3 [see equation (2b)], a risk-neutral person should be willing to pay as much as \$3380 if their annual discount rate was 10% and they expected to live in their house for 10 years.² Yet only 7% of the subjects who were **not** given the price chose to spend more than \$3,000; the percentage increases to 17% for this

¹No statement was made about the impact that mitigation would have on the value of the property. From informal discussions with subjects participating in the experiment, there was no indication that anyone even considered that mitigation would increase their property values.

² A person who is averse to risk should want to pay even more than \$3380.

group when the price was specified to be \$1,500. Almost half of the individuals participating in the experiment did not change their maximum WTP when the time horizon was doubled from 5 to 10 years. These results suggest that individuals have extremely high discount rates and/or use a decision process that differ from those suggested by cost-benefit analysis. RMMs may need to be very cost effective indeed if they are to be adopted voluntarily by individuals residing in hazard-prone areas.

INSERT TABLE 1 HERE

These general conclusions were reinforced in a follow-up survey of 252 individuals visiting the Exploratorium Museum in San Francisco who were more likely to face the earthquake hazard than those participating in the Pennsylvania survey. Now three different time horizons (T) for residing in the house were utilized: 5 years, 10 years and 20 years for obtaining the maximum WTP when the price of the quake RMM was given at \$1500. As in the earlier experiment, a significant proportion of the respondents had either high annual discount rates (the mean value varied between 67% and 74% depending on the values of T) or did not change their maximum WTP as the time horizon for residing in the house was increased. For the case where the length of time in the house was extended from 5 to 10 years, 45% of the subjects did not change their expressed WTP for the protective measure (Kunreuther, Onculer and Slovic, 1998).

In summary, many property owners are reluctant to invest in cost-effective RMMs because they do not make the implied tradeoffs between spending money now in return for potential benefits over time. Such non-adoption behavior may be further exacerbated by developers who may believe (perhaps correctly) that they are unable to recover the costs of RMMs in increased selling prices for the structures.

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TABLE 1**DISTRIBUTION OF MAX WILLINGNESS TO PAY (WTP)**

% Individuals in Each Category

	Price Not Given		Price Given=\$1,500	
	5 Years	10 Years	5 Years	10 Years
\$0-\$500	5%	5%	7%	4%
\$501-\$1,000	7%	7%	16%	16%
\$1,001-\$1,500	45%	17%	43%	44%
\$1,501-\$2,000	31%	36%	16%	19%
\$2,001-\$2,500	5%	14%	3%	0%
\$2,501-\$3,000	5%	14%	3%	0%
\$3,000 up	2%	7%	12%	17%
Number of Subjects = 42			Number of Subjects = 42	

Source: Kunreuther, Onculer and Slovic (1998)