FACING NATURAL HAZARDS:

UNCERTAIN AND INTERTEMPORAL ELEMENTS

OF CHOOSING SHORE PROTECTION ALONG THE GREAT LAKES

by

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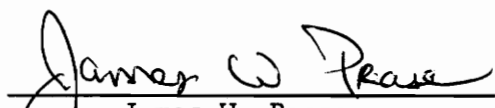
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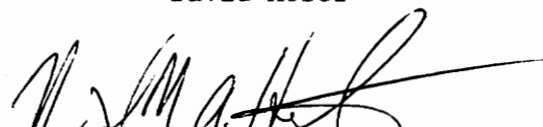Sandra S. Batie   David Moser

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(ABSTRACT)

One tool of the economic planner is Benefit Cost Analysis (BCA). This model's accuracy in describing human behavior has been criticized, particularly for uncertain and intertemporal choices. To the extent this holds, the model will be inaccurate in assessing benefits of shoreline protection measures and will provide reduced insight into policy choices.

From a review of economic, psychology and geography literature, three points of criticism are:

- when faced with losses, individuals tend not to be averse to risk,
- when faced with low probability hazards, individuals tend to ignore the hazard altogether (truncate low probability),
- when faced with choices over time, individuals have different rates at which they trade off benefits now versus later.

Typically, applications of BCA do not account for these observations.

The main objective of the study was to determine whether these criticisms are supported, and to draw conclusions regarding government policy for the flooding and erosion hazards on the Lakes.

A Benefit Cost model was formulated to describe the individual shoreline property owner's behavior with respect to undertaking structural measures to mitigate flooding and/or erosion. To test the model, property owners on Lakes Erie, Ontario and Michigan were surveyed by mail. Experimental questions, focussing on the intertemporal and uncertain nature of the hazard protection choice were developed.

The econometric analysis suggested that:
- individuals varied in their time preference rate,
- the probability of low chance events was truncated by many respondents,
- on average respondents were not risk averse, and
- the above phenomena helped explain the choice to take protective action.

Using a market rate for discounting in the BCA can provide inaccurate benefit estimates. Observed time preference rates may provide a better measure.

Subsidized hazard insurance has been suggested to encourage self protection. Disregard for low probabilities, coupled with a lack of risk aversion, suggest such a program would not be successful.

Subsidized loans for shore protection may be unsuccessful. Many people displayed a time preference rate above the market loan rate, yet they did not borrow.

Information programs may be useful in promoting a better understanding of the hazards which may be faced by residents.

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Chapter 1

Problem Statement

Natural disasters are not a thing of the past. It has been estimated that natural hazards have resulted, world wide, in the loss of three million lives and in property damage of 100 billion dollars in the last two decades (USDNDR, 1990) In 1976, an earthquake centered at Tangshan, China resulted in the loss of 242,000 lives (Cornell, 1982). In 1985, a wind driven storm surge led to extensive flooding and erosion along the shores of the North American Great Lakes. In 1989, the Loma Prieta Earthquake shook California and Hurricane Hugo devastated sections of Charleston, South Carolina.

Mitigation of the effects of natural disasters is of national and international concern, this concern increasing in recent decades. Most recently United Nations and its member countries have designated the

1990's as the Decade for Natural Disaster Reduction (UNDRO, 1990).
Several factors have lead to this increased interest: 1) the
introduction of television on a large scale increased awareness and
sympathy for victims of natural disasters, 2) the hypothesized
similarity between the devastation of natural hazards and nuclear attack
spurred an interest in the ability to respond to disasters, 3)
intolerance of the vagaries of nature increased as faith grew in the
ability of technology to provide protection from those vagaries, and 4)
increasing public expenditure to reduce the damage caused by natural
hazards brought pressure on the process and criteria of public decision
making (Russell, 1970; Burton, Kates and White, 1968; White, 1973).

In this social climate public decision makers face several issues in
designing policy. A case in point is the U.S. Army Corps of Engineers
(USACE), responsible in part, for public spending to mitigate flooding
and erosion hazards. The combination of high water levels and severe
storms, which led to considerable property damage on the shores of the
Great Lakes in the mid 1980's, has led to a public outcry for the USACE,
among others, to take some action to mitigate these adverse
consequences. Some of the policy design issues revolve about the types
of measures proposed as solutions to the adverse consequences. In the
broadest terms, five different types of measures have been identified
(Shabman et al, 1989): i) direct government expenditure on structural
mechanisms to modify lake levels and flows, ii) direct government
expenditure to modify the effects of the water levels and coastal

processes (e.g. shore protection, harbor dredging) but excluding actions to modify the levels and processes themselves , iii) direct government restriction of land and water use in the drainage basin (e.g. zoning controls on construction in hazard areas), iv) government programs to indirectly influence land and water use (e.g. insurance programs, disaster aid, subsidization of activities to protect the shoreline), and v) government planning for responses to emergency situations (e.g. advance storm warning).

Although all measures may be subject to some form of benefit cost analysis, the high cost of water level regulation measures in particular encourages an examination of methods of benefit assessment. Furthermore, changes in federal policy in the 1980's have altered the cost share rules for flood control projects. The Water Resources Development Act of 1986 will increase the costs to local beneficiaries such that they will be required to pay as much as 50 percent of project costs; the result is that there is increased pressure to examine methods for the assessment of benefits (Shabman, 1988).

1.1 Defining Natural Hazards

There is a certain vagueness to definitions of natural hazards. Some of the hazards which first come to mind are floods, tornadoes and earthquakes, although a broad definition could include such hazards as solar flares, malaria, typhus, poison ivy, locust infestations and

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venomous animal bites (Rowe, 1977 and Burton and Kates, 1964). Relying on the criterion of natural cause for defining natural hazards does not remove all ambiguity from any definitions. For example, a flood resulting from the destruction of a dam by an earthquake contains elements of both natural and man-made disasters. This distinction also relies on the implicit and arguable assumption that the outcome of human action is not natural, that man is in some way distinct from nature. Given the amorphous and ambiguous character of definitions of natural hazards, it may be useful in general to avoid overemphasis of their distinction as natural. However, this is not to say that the degree to which a hazard is perceived as natural is irrelevant to human reaction to that hazard. Indeed, people appear more willing to accept threats to life and livelihood that arise from sources perceived as natural as opposed to man-made (Kunreuther, 1985; Rowe, 1977).

Disasters of natural cause have been referred to as "acts of god" (Davids, 1983). Under closer inspection the notions of natural cause and "acts of god" are somewhat amorphous, reflecting changing social and cultural factors (Douglas and Wildavsky, 1982). In reference to "acts of god" Burton and Kates (1964) state:

> To judge by the volume of litigation, this concept is under constant challenge and is constantly undergoing redefinition. The "acts of God" today are often tomorrow's acts of criminal negligence. Such changes usually stem from a greater ability to control the environment.

Furthermore, natural hazards are typically appraised in an

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anthropocentric context, that is:

> A particular level or severity of natural event becomes a hazard only in relation to existing human adjustments. There are, then, no strictly physical definitions of what levels of severity of natural events constitute hazards (Russell, 1970).

Thus, what constitutes a natural hazard is defined by human activity, individual and collective. As such, our understanding of natural hazards reflects human knowledge and decisions about what is acceptable and what is not, about benefits to be gained in exchange for exposure to particular hazards.

1.2 Modeling Shore Protection Behavior

The model of human behavior forming the basis of neo-classical economics states that an individual ranks all possible choices using one dimension of measurement, utility, and chooses the option which yields maximum utility given the constraints of prices and income. In its most elemental form this model assumes a timeless and certain world. However, hazard reduction choices are characterized by the uncertainty associated with the frequency and magnitude of natural hazards and by the distribution of these events over time. To account for behavior involving uncertain, intertemporally distributed events, the economic elemental model has been modified yielding expected utility theory (EUT) and discounted utility theory (DUT). Each model weights choices by two dimensions, utility and the probability of event occurrence in EUT, and

utility and a time preference rate in DUT (Luce and Raiffa, 1957;
Koopmans, Diamond and Williamson, 1964). These models embody the
classical economic notion of rationality in decision making.

In practice, due to the abstractness of the concept, utility is
difficult to measure. As such, the discounted expected net benefits
model can be used as a means to evaluate an individual's investment in
shore protection. The decision to adopt hazard protection can be seen
as a non marginal choice. That is, the individual chooses between two
states, "with protection" and "without protection". Thus, the
discounted expected net benefits (DENB) model for the protection choice
decision can be formulated:

$$
\text{DENB} = \sum_{t=0}^{T} \frac{\alpha\, c_{wot} - \delta\, c_{wt}}{(1+r)^t} - \sum_{t=0}^{T} \frac{K_t}{(1+r)^t} + \frac{V_T}{(1+r)^T} \qquad [1.1]
$$

where

DENB = discounted expected net benefits of hazard reduction,

c   = the cost of flooding/erosion damage in time period t, t = (0, 1,
        2,..., T), with (w) and without (wo) mitigative action,

T   = the time period in which the property is sold,

K   = the cost of mitigation over time,

V   = the salvage value of protection works at the time of sale of the
        property,

r   = the time preference rate (discount rate),

α   = the probability density function associated with the damage cost
       when no protective action is taken, and

δ   = the probability density function associated with the damage cost
       when protective action is taken.

It is important to note that α and δ represent probability distributions
of damage frequency. That is, there is a range of possible damage
levels, and probabilities of damage can be associated with each damage
level. These distributions may be based upon erosion processes, water
levels and storm intensity. By taking protective action, a property
owner shifts the probability of damage for a given level of water levels
or storm intensity.

The public planner is faced with the problem of evaluating the various
measures which offer hazard reduction possibilities. One project
evaluation tool, a mainstay of planners for several decades, is the
damages avoided model (DA). This tool is simply an estimate, made by
the public planner, of the property damage that is avoided by
undertaking the hazard reduction measure in question (Herfindahl and
Kneese, 1974; USWRC, 1983; Davis et al, 1988). With respect to
flooding, the damages avoided refer to the repair and replacement cost
of property which would be affected. With respect to erosion, as eroded
soil may not be replaceable, damages avoided refers to the loss of
property value. The DA model is somewhat simpler than the DENB model of

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[1.1] in that the DA model does not include the last term of [1.1]; DA assumes an infinite time horizon, hence, salvage value is inapplicable.

In addition to being tools for accounting for peoples' preferences, both the damages avoided model (DA) and the more general DENB model, are implicitly behavioral models; their accounting accuracy is linked to their capacity to describe behavior. There are several assumptions which are needed to justify these models as a measure of preferences (utility). It is assumed that the property owner uses the same discount rate and has the same knowledge of the probability and effects of a hazard as does the public planner computing damages avoided. Furthermore, it is assumed the property owner is risk neutral. The validity of these assumptions has drawn criticism from a variety of sources. Additionally, criticism has been leveled against the economic notion of rationality defined by expected and discounted utility theories, and which underlie the DA and DENB models.

1.3 Critical Assessment of the Economic Model

Investigation of the human response to natural hazards has been a concern at both the applied policy level and at a more theoretical level. In the middle of this century there emerged an identifiable research effort, led by geographers, directed at investigating the human response to natural hazards (Bertness, 1986; Mileti, 1980). One of the questions plaguing the geographers was why people would continue to live

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and rebuild in areas recently devastated by environmental extremes (Kates, 1962). These geographers drew on the disciplines of economics and psychology for insights to explain the observed human behavior. Although the geographers were primarily interested in policy applications, their investigations raised theoretical issues for economists and psychologists.

The geographers of the 1950's and 1960's were not satisfied with the ability of the economic model to explain persistent floodplain occupation in the face of established hazards (White, 1973). It is surmised that their informal observations of floodplain residents suggested to them that such behavior did not accord with the rational economic model. As such, they began to focus on the human perception of natural hazards, hypothesizing that perceptions were the key to understanding human responses to hazards (Bertness, 1986). Although much of the early hazard perception work focused on floodplain occupants, many other natural hazards soon received attention (Saarinen, 1976). Summarizing the results of several field studies involving interviews with hazard zone occupants, Burton and Kates (1964) report four common responses to the uncertainty of natural hazards. Some people eliminate the sense of uncertainty regarding the occurrence of a hazard by placing the hazard occurrence in a deterministic cycle. That is, hazards are perceived as occurring at fixed intervals. This reaction was most common among floodplain occupants. Other people eliminate uncertainty by transferring it to a higher power; there is no

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need to worry about uncertainty as "its in God's hands." Another
response to the uncertainty of natural hazards is to deny or denigrate
the possible reoccurrence of the hazard, that is, a hazard may be seen
as a "freak", incapable of repetition. Although not frequently
observed, one method of eliminating the hazard was to simply deny its
existence. That is, past occurrences are not considered a hazard
(despite obvious damage), and future occurrences are considered
impossible.

As the geographers' hazard perception research program progressed, a
large number of variables were hypothesized to affect human adjustments
to hazards (Bertness, 1986). Some of the variables reflected the manner
in which individuals perceived the characteristics of the hazard event,
in particular the magnitude and frequency of the event. Other variables
accounted for the personal experience of an event, its recency,
frequency and severity. Additionally, a wide variety of variables were
hypothesized to have explanatory power: risk taking propensity,
susceptibility to panic, attitudes toward nature, age, sex, education
and income. Conflicting evidence regarding the importance of these
variables has led some geographers to search for other theoretical
models to describe and predict the observed behavior (Bertness, 1986).
One of the popular theoretical approaches, borrowed from economics and
psychology, was the bounded rationality model of Herbert Simon, the
Nobel Prize winner in economics in 1978. This model meshed well with
the work of psychologists concerned with the effects of cognitive

limitations on human judgement processes (Kates, 1967; Slovic, Kunreuther and White, 1974; Kunreuther, 1974; Kunreuther et al, 1978; Burton, Kates and White, 1978). This model suggested that human decision making is bounded by limitations on memory, organizational ability and computational capacity. What may appear as a rational decision given those bounds may not appear rational if the bounds did not exist.

Consistent with the geography research program and Simon's model cognitive psychological research, focusing on human limitations in decision making, suggests that people have difficulty in perceiving and combining the three dimensions of discounted expected utility theory (utility, probability and time preference) in the simple manner described by the model above. Much of the concern surrounds the descriptive accuracy of the axioms of discounted expected utility theory, individually and/or collectively, although as a normative model of choice, discounted expected utility theory receives much greater support (Schoemaker, 1982). In terms of the Discounted Expected Net Benefits model (DENB) the criticism can be organized about three elements of the model, 1) the individual's rate of time preference, 2) the individual's time horizon and 3) the individual's ability to compute and assess probability. These elements receive cursory attention by most economists. The applied economist, typically chooses a single time preference rate which is tied in some manner to market forces or to some notion of a social rate of time preference; the time horizon is tied to

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the expected life of the project in question.

1.4 Research Challenge

Describing human behavior in response to natural hazards has presented a challenge to both applied policy analysts and to theoreticians. From a review of the literature it can be seen that the discounted expected utility model has been challenged as a descriptive model of uncertain and intertemporal decision making. This presents a challenge to federal agencies such as the USACE. That is, how can the DENB model be applied to the evaluation of publicly funded projects such that the model captures more of the complexities of human behavior? To the extent this can be achieved, the model can provide a better indication of peoples' preferences and can improve the accuracy of the evaluation tools available to the policy maker. With respect to the issue of Great Lakes levels fluctuation, such a model can aid in the assessment of project benefits potentially achievable by the variety of measures considered, from structural levels regulation to shore protection, development of hazard insurance policies and the communication of hazard information.

This research neglected the broad question posed by geographers as to peoples' choice of location; the focus was directed toward the choice of action individuals may take to mitigate the effects of flooding and/or erosion at a particular location. Although continuing in an interdisciplinary vein, this research was ultimately rooted in the

economic optimization model of rational choice. Insights were drawn

from the applied research of psychologists in a attempt to improve the

descriptive capacity of the economic model. This study was somewhat

unique as the analysis of individual time preference rates and of an

individual's reaction to low probability events, typically analyzed in a

laboratory setting, were examined in a field setting.

This study focussed on the hazards of flooding and erosion in a lake

setting, specifically the Great Lakes. In this setting the incidence of

flooding and erosion is usually associated with storms characterized by

high winds and rain. However, erosion can occur through wave action

unassociated with extreme water levels or winds, while flooding may

result from increased precipitation unrelated to storm activity.

1.5 Objectives

The objectives were to:
1) integrate economic and psychological literature into a descriptive
   model of individual investment choice in adopting protection
   against the effects of flooding and/or erosion,
2) use the model framework to address the general question: is
   behavior boundedly rational? To this end, several more specific
   questions will be addressed:
   i) do hazard zone occupants differ from each other in the time
   preference rates they apply to evaluating shore protection

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investments?

ii) is an individual property owner's rate of time preference a function of socio-economic characteristics of that individual?

iii) does the individual time preference rate affect the probability that a property owner will take protective action?

iv) do hazard zone occupants ignore the possibility that they will face low probability/severe damage events?

v) is an individual property owner's treatment of low probabilities a function of socio-economic characteristics of that individual?

vi) does any such truncation of low probabilities affect the likelihood that the property owner will take protective action?

vii) do individual property owners have planning horizons of different length?

viii) is an individual property owner's time horizon a function of socio-economic characteristics of that individual?

ix) does the individual's planning horizon affect the probability they will adopt shore protection measures?

3) based upon the findings of the field survey questions conclusions will be presented regarding:

i) the degree to which the survey data supports previous research conducted in a laboratory setting,

ii) the implications for the use of the Damages Avoided technique as a measure of preference for hazard reduction, and

iii) the implications with respect to policy tools available to encourage self protective behavior.

1.6 Procedures

To achieve the objectives mentioned above the following procedures followed:

1) literature from economics, psychology and geography was examined with reference to decision making especially in context of natural hazard protection, and,

2) a survey instrument was developed and implemented to elicit data about hazard zone occupants and to empirically test the hypotheses derived from the choice model. A group of shoreline property owners along the Great Lakes was chosen as the focus of the study.

Chapter 2

Theoretical Model of Shore

Protection Behavior

In modelling choice under uncertainty and over time, economists have come to rely, respectively, on expected and discounted utility theories. These theories have been formalized as sets of axioms of behavior and are elegant in their simplicity (Hirshleifer, 1965; Arrow, 1971). However, in recent decades these theories have come under criticism for an alleged inability to describe human behavior; the normative usefulness of these models has received little challenge (Schoemaker, 1982). To the extent that economics can be considered a positive science, criticism of the descriptive capacity of its theories threatens this claim. Much, although not all, of the criticism has come from psychologists.

The goal of this research is to better describe the choice individuals make, in terms of taking protective action, when facing potential flood or erosion damage to their property. Although the structure of the economic optimization model will be maintained throughout this analysis, insights will be drawn from the applied research of psychologists in a attempt to improve the descriptive capacity of the economic model. This chapter presents a model, based on discounted expected utility theory, of an individual's decision to adopt shoreline protection. Some of the salient elements of the criticism of economic choice models will then be presented. This provides some insight into specific behavioral patterns not captured by expected and discounted utility models. However, this does not represent a seamless merging of economics and psychology. Fundamental differences between the disciplines, as discussed in the last sections of this chapter, are a barrier to such a merger.

2.1 A Model of Shore Protection Behavior

The economic model of rational choice behavior holds that, given the constraints of prices and income, an individual ranks all possible choices using one dimension of measurement, utility, and chooses the option yielding maximum utility. To account for behavior involving uncertain events distributed over time, salient characteristics of the choice to adopt shore protection, the model has been embellished to yield expected utility theory (EUT) and discounted utility theory (DUT). Each model weights choices by two dimensions, utility and the

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probability of event occurrence in EUT, and utility and a time preference rate in DUT. Both EUT and DUT have been formalized as sets of axioms (behavioral assumptions); these axioms are presented in Appendix A.

In addition to its uncertain and intertemporal nature, the decision to adopt shoreline protection can be characterized as a non-marginal choice; the individual chooses between two states, "with hazard protection" and "without hazard protection", such that discounted expected utility is maximized. That function can be characterized as:

$$DEU = \left[DEU_w \left(\alpha d_{wi} , \frac{\delta d_{wj}}{(1+r)^{i-j}} \right) - DEU_{wo} \left(\gamma d_{woi} , \frac{\lambda d_{woj}}{(1+r)^{i-j}} \right) \right]$$

where DEU is the discounted expected utility associated with the protection choice, d is the physical property damage due to erosion and/or flooding, subscripts w and wo refer to the with and without protective action scenarios, respectively, subscripts i and j refer to time periods (years), r is the personal rate of time preference, and α, γ, δ, and λ are the probability density functions associated with each damage event.

In practice, the abstractness of the concept of utility renders the discounted expected utility model directly inapplicable to choice problems; utility is difficult to measure. As such, the discounted expected net benefits model (DENB) is used as measure of utility where

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the utility of benefits and costs are measured in monetary terms. For any individual the degree to which the DENB model will accurately reflect discounted expected utility depends upon the validity of several assumptions about the individual's preferences. The most recognized assumptions of the DENB model are that an individual is risk neutral and that the marginal utility of a dollar is constant over all dollars. For the individual, the DENB model can be formulated:

$$DENB = \sum_{t=0}^{T} \frac{\alpha\, C_{wot} - \delta\, C_{wt}}{(1+r)^t} - \sum_{t=0}^{T} \frac{K_t}{(1+r)^t} + \frac{V_w - V_{wo}}{(1+r)^s}$$

where

DENB = discounted expected net benefits of hazard reduction,

C_{wo} = cost of flooding and/or erosion damage without shore protection,

C_w = cost of flooding and/or erosion damage with shore protection,

K = cost of building and maintaining shore protection,

V_{wo} = expected price of the property, without shore protection, received at the time of sale,

V_w = expected price of the property, with shore protection, received at the time of sale,

α = the probability density function associated with the level of flooding and/or erosion damage occurring when no action is taken,

δ = the probability density function associated with the level of flooding and/or erosion damage occurring when action is taken,

r = rate of time preference (discount rate),

t   = annual time period, t = (1, 2, ... T), over which costs and

       benefits accrue,

T   = time horizon, the last time period for which the individual

       receives any benefits or experiences costs for the action, and

s   = the time period in which the property is sold, s ≤ T.

The difference between the hazard damage costs with and without taking

action represents the benefits of taking mitigative action in terms of

reduced property damage accruing to the owner. Note that there is no

probability associated with any of the other terms. It is assumed here,

for the sake of simplicity, that the elements in the other terms are

known with certainty. The last term represents the benefits of shore

protection which the owner expects to receive at the time of the sale of

the property. Economic theory states that, as long as the protective

structures continue to be effective, an efficient property market will

capture the future stream of protection benefits in the sale price.

2.2 Criticism of EUT and DUT

In the mid 1950's, Herbert Simon offered the notion of bounded

rationality as more descriptive of human behavior than the classical

models of rationality (March, 1978). That is, human decision making is

bounded by human limitations on memory, organizational ability and

computational capacity; what is rational within those bounds may not be

so if the bounds did not exist. Cognitive psychologists have isolated

several heuristics or "rules of thumb" that have been adopted by people
to reduce the complexity of decision making tasks (Sherman and Corty,
1984). The use of heuristics involves a less than exhaustive analysis
of all relevant information; some aspects of the data are emphasized and
others are ignored. This may result in decisions which are biased
relative to those derived from unbounded rational choice models. These
heuristics can be helpful in describing human choice bounded by
cognitive limitations, although it can be difficult, a priori, to
determine which heuristic or heuristics a person will apply to a choice
and whether any particular bias or biases will result.

Combining the findings of the critics of expected utility theory (EUT)
and discounted utility theory (DUT) with the standard economic theory is
not readily manageable. The deductive reasoning and formality of EUT
and DUT provide elegant and simple models of human behavior, while the
critical research offers piecemeal modifications based on observation.
Incorporation of the piecemeal modifications can result in relatively
minor aggravations which reduce the simplicity of EUT and DUT, or the
modifications may represent a threat to the fundamental reasoning of EUT
and DUT.

With respect to expected utility theory (EUT) much of the criticism
arose in the late 1940's and early 1950's immediately after its
axiomatic formalization (Appendix A). Discounted utility theory (DUT)
has received less attention from the critics until recent years

(Loewenstein and Thaler, 1989). Much of the criticism, but by no means all, has come from psychologists concerned with the descriptive accuracy of axioms, individually and/or collectively. Cognitive psychological research, focusing on human limitations in decision making, suggests that people have difficulty in perceiving and combining the three dimensions of EUT and DUT, utility, probability and time preference.

The research findings representing criticism of the descriptive capacity of classical models of rationality are "organized in a set of conceptual vignettes rather than a single coherent structure; and the connections among the vignettes are tenuous (March, 1978)." However, it is possible to categorize some research findings according to the manner in which they might affect elements of the economic optimization model. The following sections address the issues of decision framing, risk attitude, availability of information, and the manner in which probability, the personal rate of time preference, and personal time horizon enter the net benefits model.

2.2.1 Intertemporal Choice

Time enters the Discounted Expected Net Benefits (DENB) model in two ways, through the rate of time preference and by way of the time horizon. An individual's personal time horizon is the length of time over which the benefits and costs of an action are relevant to that decision maker. The personal rate of time preference is the rate at

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which an individual is indifferent between receiving a benefit (cost) at
one point in time or another benefit (cost) at another point in time.
An individual placing a relatively high (low) importance on a distant
future event may be seen as having a low (high) rate of time preference
and/or a long (short) time horizon. Without closer inspection, it is
not clear the degree to which each element, time preference rate or time
horizon, leads to a particular observed level of concern placed on a
future event.

2.2.1.1 Time Horizon

There is next to no literature available regarding individual time
horizons as distinct from individual time preference rates. However, in
a recent study Svenson and Karlsson (1989) found that the length of an
individual's planning horizon varied with the issue requiring planning.
Furthermore, they found that planning horizons, for a particular issue,
varied across subjects (high school and university students (engineering
and psychology), nuclear fuel experts, retired people). Unfortunately,
economic theorists have devoted little attention to the time horizon.
Assuming that well functioning markets will capitalize the value of an
investment (say, shore protection) into the value of the property,
implies that the time horizon is infinite. However, as the effect of
the time preference rate is compounded with time there will exist, for
practical purposes, an effective time horizon; that is the point at
which a future event makes an insignificant contribution to the present

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decision. Thus, by focussing on the time preference rate the issue of the time horizon begins to dissolve for the theoretical economist.

Applied economists, typically, in the evaluation of public projects choose the time horizon as the length of time the project is expected to provide its intended service. In the case of major structural works such as levees, breakwaters, bridges or dams the time horizon may be as high as 25 to 50 years.

It is not clear that the economists' choice of time horizon is descriptive of the actual time horizon considered relevant by individuals. Particularly to the extent that an individual has a shorter time horizon than that utilized by the public analyst, costs and benefits will be overestimated. Additionally, the shorter an individual's time horizon, the less time for the benefits of an improvement to be capitalized into the property value, reducing the perceived benefit of undertaking protective action.

2.2.1.2 Rate of Time Preference

The economists' focus on market forces has led economists to assume that individual time preference rates are dictated by those forces, that is, the rate is determined by solving an intertemporal utility maximizing problem. However, in the evaluation of public projects, there has been considerable debate about the appropriate rate to employ for discounting

(Mikesell, 1977; Prest and Turvey, 1965). The opportunity cost of capital and various measures of the market rate of interest are offered as appropriate. Alternatively, arguments are made for some rate lower than these rates to reflect long term social planning. Despite this debate, the range of rates considered theoretically appropriate is relatively narrow, whereas it has been observed that the time preference rates implied by peoples' choices may be as high as several hundred percent (Hausman, 1979; Gately, 1980; Houston, 1983). These authors drew their conclusions from actual observed purchases of electricity using durable goods. Based on observed differences between peoples' marginal propensities to consume from permanent or current income and their marginal propensity to consume from windfall receipts, Landsberger (1971) estimated that the time preference rate over a variety of consumer goods is about thirty percent. Furthermore, based on observed purchases, it has been shown that implied time preference rates vary considerably with the decision in question (Ruderman, Levine and McMahon, 1987). Because it is often assumed that the individual uses the market rate of time preference as a constraint, little effort has been directed toward estimating rates at an individual level and toward investigating their determinants.

In the following discussion, the assumption of a market dictated rate of time preference will be set aside so as to focus on the individual rate. As formulated in Section 2.1, discounted expected utility (DEU) is a function of flooding/erosion damages today and in future periods (with

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or without mitigative action). In making the choice as to the optimal level of flooding/erosion damage in each time period, the individual displays a personal rate of time preference. This rate is a function of the marginal utilities associated with the damages in the two time periods:

$$\frac{MUd_i}{MUd_j} \; = \; MRS_{ij} \; = \; \frac{1}{1 + r}$$

where

i,j = time periods, $i \neq j$,

MUd = the marginal utilities of the flooding and/or erosion damage,

MRS = the marginal rate of substitution between the damages in each time
      period, and

r = the personal rate of time preference.

In general, the individual rate of time preference is a function of the variables in the utility function. The level of damage is one of the variables included in the utility function; research suggests that the time preference rate falls with an increase in the absolute value of the consequence of an event (Loewenstein and Thaler, 1989). Discounted utility theory (DUT) assumes that the time preference rate is constant over time. However, research suggests it is a function of the delay time expected in experiencing an event. Benzion, Rapoport and Yagil (1989) and Thaler (1981) found that the time preference rates implied by experimental choice decisions tended to fall the more temporally distant a future event.

There are three general and robust observations with respect to how an individual's implied time preference rate tends to vary; rates tend to be higher for gains than losses, decline with a decrease in the size of the consumption bundle and, decline with an increase in the length of time until consumption can occur (Loewenstein and Thaler, 1989).

2.2.2 Probability

Economists, to the extent they draw a distinction, employ two different views of probability in developing models of uncertainty. Loosely defined, these are the subjective and objective views (Barnett, 1982). Objective probability is defined in terms of the frequency of occurrence of a particular event in repeatable situations (e.g. coin toss), while definitions of subjective probability reflect the view that individuals employ their own "degrees of belief" as a basis for decision making under uncertainty. Economists, among others, have developed techniques for eliciting subjective probabilities from individuals (Norris and Kramer, forthcoming).

Aside from the discussion as to the appropriate basis of probability, there is little research into how the difference between the two views is manifested. Some laboratory research suggests that people weight outcomes using "decision weights" which are not probabilities but are a function of probabilities (Kahneman and Tversky, 1979). The result is that utility may be over or under weighted relative to what would result

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if probabilities were used as weights. There is some evidence that natural hazards are perceived as less aversive than man-made hazards (Rowe, 1977). This may arise because of because of a phenomenon outlined by Kunreuther (1985): individuals will focus on the catastrophic nature of technological hazards, but will tend to "focus on the low probability aspect of a natural disaster, claiming 'it won't happen to me.'" The only available applied research on natural hazards suggests that low probabilities, at some point, are truncated to zero, ignoring altogether the objective probability of the loss (Slovic et al, 1977; Schoemaker and Kunreuther, 1979). This research was conducted in a controlled laboratory setting where subjects were presented with hypothetical choice problems.

2.2.3 Framing

An issue raised by the critics of expected utility theory (EUT) is that of framing. The decision frame refers to "the decision-makers conception of the acts, outcomes, and contingencies associated with a particular choice" and that frame is "controlled partly by the formulation of the problem and partly by the norms, habits, and personal characteristics of the decision-maker" (Tversky and Kahneman, 1981). There is considerable evidence that individuals deciding between alternatives may reverse their preferences with slight changes in the way a problem is presented to them even though the options are identical in terms of the rational choice model. Tversky and Kahneman (1987),

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referring to a study by McNeil et al, present the following example of
research portraying preference reversal arising from framing. Two
groups of respondents were isolated and provided the same statistical
information regarding the success of treating lung cancer by radiation
and by surgery. One group received information in terms of survival,
the other in terms of mortality. One group's task was to choose the
preferred option from the survival frame:

> Surgery: Of 100 people having surgery 90 live through the
> post-operative period, 68 are alive at the end of the first year
> and 34 are alive at the end of five years.

> Radiation Therapy: Of 100 people having radiation therapy all live
> through the treatment, 77 are alive at the end of one year and 22
> are alive at the end of five years.

The other group chose from the mortality frame:

> Surgery: Of 100 people having surgery 10 die during surgery or the
> post-operative period, 32 die by the end of the first year and 66
> die by the end of five years.

> Radiation Therapy: Of 100 people having radiation therapy, none
> die during treatment, 23 die by the end of year one and 78 die by
> the end of five years.

Despite the fact the evidence provided to the respondents contained the
same statistical information, the number of people preferring radiation
therapy in the mortality frame (18%) was more than double the number
preferring radiation therapy in the survival frame (44%). These results
were consistent across trials with business students, cancer clinic
patients, and experienced physicians. The authors suggest that the
relative advantage of radiation therapy appears larger when it displays
a reduction of the risk of immediate death. Although the example above

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refers to uncertain choice, Loewenstein (1988) found that intertemporal choice is also sensitive to the framing of a problem.

2.2.4 Risk Attitude

Discounted expected net benefits models embody the assumption of risk neutral behavior on the part of the decision maker. That is, no utility (or disutility) is assigned to the benefits or costs on the basis of a decision maker's preferences regarding risk; benefits and costs are weighted only by their respective probabilities (Pratt, 1964).

Expected utility theory assumes that individuals are able to integrate all elements of a risky decision into some final level of wealth on which the decision is ultimately based. However, there is a body of evidence gleaned from controlled laboratory studies which suggests that individuals react to changes in wealth relative to some reference point and not to the final level of wealth; gains and losses become the focus of the decision (Kahneman and Tversky, 1979). In addition to the incorporation of a reference point, these authors present evidence that individuals tend to be risk seeking when faced with a choice between losses, and risk averse when faced with a choice among gains. A field study of individuals living in flood and earthquake hazard zones supports the notion of risk taking behavior in the domain of losses, although there is some conflicting evidence (Kunreuther et al, 1978; Brookshire et al, 1985). Recent laboratory evidence suggests that the

reference point phenomenon observed in risky choices also plays a role in intertemporal choice, violating the assumption of discounted utility theory (DUT) that the final level of wealth is the carrier of utility (Loewenstein, 1988).

2.2.5 Availability

Availability is a term for a particular decision heuristic (rule of thumb). It refers to the ease with which specific information can be brought to mind when judging the frequency or relative frequency of one or more events (Sherman and Corty, 1984). This rule may be useful and appropriate as more frequent events and events of a higher probability tend to be more readily available to a decision maker. The essence of the availability heuristic lies in the notion of sampling. Faced with a decision and limited information, the decision maker typically generates a sample of evidence to use as basis for the decision. Systematic biases will arise when the sample is not representative of the population of possible outcomes. For example, an individual may assess the national divorce rate by the number of divorced people with which that person is acquainted; that individual may overstate the national rate if a large proportion of his/her acquaintances are divorced. Evidence from both laboratory and field studies indicates that the availability of events stored in memory is related to such factors as the salience and vividness of the events (Combs and Slovic, 1979; Sherman and Corty, 1984). Direct experience with an event and the

shorter the interval since its occurrence tend to make memories more available. In a field study of hazard zone occupants, Kunreuther et al (1978) found that individuals were more likely to purchase hazard insurance if their acquaintances also held such policies.

2.3 Perspectives on the Criticism: Economics vs. Psychology

In this section an outline of the methodological differences between economics and psychology will be presented with the purpose of drawing some implications for the blending of their respective insights into human behavior. The discussion will focus on several dimensions of comparison including the appropriate role of choice models, notions of rationality, logic preference and legitimacy of observation. To highlight some of the main points of the methodological differences, reference will be made to stylized economists and psychologists.

As social sciences, economics and psychology concern themselves with the study of human behavior, individual and aggregate. However, fundamental methodological differences have kept the disciplines separate over time despite their shared interests. These differences have led the two disciplines, at times, to passively ignore each other, and at other times to denigrate the other's legitimacy and/or relevance in specific areas of inquiry (Coats, 1976). There also been times when the two disciplines have been close to reconciling some of their differences and trading insights. Most recently there has been an upsurge in the

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conciliatory mood among some elements of the two disciplines reflected

by developments in Psychological Economics (Earl, 1987), Economic

Psychology (MacFadyen and MacFadyen, 1986; Lea, Tarpy and Webley, 1987)

and Behavioral Economics (Gilad and Kaish, 1986). However, this

conciliatory mood is not widely shared by the mainstream of economists

or psychologists.

2.3.1 The Role of Models Of Choice

Economists and psychologists employ models in seeking to explain choice

behavior but differ considerably with regard to notions of the

appropriate scope and content of the models as well as the criteria

governing model choice within each discipline. Indeed, the "differences

between the concepts or models of rationality used in different areas of

inquiry will correspond to the different tasks for which the theories

themselves are designed" (Benn and Mortimore, 1976, p.1).

Controversy between the disciplines arises from a tension between the

normative and descriptive roles to which choice models may be applied.

A fundamental premise of neo-classical economics is:

> models that characterize rational, optimizing behavior also
> characterize actual human behavior. The same model is used as a
> normative definition of rational choice and as a descriptive
> predictor of observed choice (Thaler, 1987b, p. 1).

Although psychologists may accept the dual role of models of choice,

they display more of a tendency to avoid imputing normative stature to

any model, preferring to describe observed behavior.

2.3.2 Notions of Rationality

A key element of the quote above (Thaler) is the word rational. This word, in general, conjures up notions of reasoning, sanity, sense and intelligence, a definition with which few would disagree. However, focusing on a more specific definition is useful in sorting out the methodological differences between the disciplines. In the broadest of terms, rationality may refer to rationality in action or rationality in belief. Concerns regarding rationality in belief revolve about inquiries and explanations of individual or cultural differences in belief. This notion of rationality is also concerned with how beliefs are adapted given new information and how beliefs may persist in the face of conflicting experience. Rationality in belief can be thought of as the degree to which it is practical to hold and/or modify certain beliefs (Mortimore and Maund, 1976). The anthropologist and psychologist encompass these concerns as part of their disciplines.

The notion of rationality in action is used in two ways: "as a conceptual tool for picking out and characterizing a phenomenon to be explained and understood" and in "explaining and predicting the acts and practices of agents to whom some degree of rationality can be imputed (Mortimore, 1976, p. 93)." Rationality in action is of interest to both

the psychologist and the economist.

One classification of rationality that more directly serves to highlight
the differences between the economist and the psychologist is the
distinction between substantive and procedural rationality. Herbert
Simon defines substantive rationality:

> Behavior is substantively rational when it is appropriate to the
> achievement of given goals within the limits imposed by given
> conditions and constraints ... The rationality of behavior
> depends upon the actor in only a single respect - his goals.
> Given these goals, the rational behavior is determined entirely by
> the characteristics of the environment in which it takes place
> (1976, pp. 130-1).

Procedural rationality is defined by Simon:

> Behavior is procedurally rational when it is the outcome of
> appropriate deliberation. Its procedural rationality depends upon
> the process that generated it ... Behavior tends to be described
> as 'irrational' in psychology when it represents impulsive
> response to affective mechanisms without an adequate intervention
> of thought (1976, p. 132).

These notions of substantive and procedural rationality are reflective
of the disciplinary cores of mainstream economics and of psychology,
respectively. In terms of the broad distinctions of rationality in
belief and in action, substantive rationality can be equated with
rationality in action while procedural rationality can reflect
rationality in action and in belief. That is, psychology addresses
itself to processes encompassing action and belief; economics concerns
itself with the outcomes of action.

Unlike economists who invoke the assumption of substantive rationality at every turn, psychologists display a wariness to imputing rationality to any given action. Abelson (1976) feels the wariness arises as the term is "too prescriptive, too presumptive and too pre-emptive." The criticism of too prescriptive reflects the normative element in notions of rationality. Standards of rationality can color an analysis of human behavior causing the treatment of prescription as description and psychologists are "sceptical of ideological characterizations of human nature which might impute ubiquity to things seen as good or bad" (Abelson, p. 59). Notions of rationality can be too presumptive in that cognitive ability to carry out tasks required for rationality is presumed to exist contrary to what much evidence suggests. As a pre-emptive concept Abelson states:

> It is easy to talk about rationality, but hard to do anything to advance our understanding of it directly. The trouble is that once one starts to talk about rationality, it pre-empts the way we organize our views of human thought and behavior. We tend to think always in terms of default from a standard - in such-and-such a situation, why do people not behave rationally? But searching for the idealization that isn't there is a less productive research strategy than finding out what is there. Rationality simply may not be a useful descriptive concept when we look carefully at what is going on psychologically (1976, p. 61).

The preceding discussion illuminates the difference between the economists' and the psychologists' models. The normative and goal oriented focus of economics is served by elegant axiomatic models of how an idealized decision maker would make choices. In contrast, the psychologist possesses no single model which unifies the discipline to

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the extent observed in economics.

2.3.3 Utility Maximization

A crucial and controversial element of economic models of rational

choice is the maintained hypothesis that individuals seek to maximize

utility. This objective is an integral part of the economist's notion

of what is rational and is central to the economists' models of choice.

Indeed, the goal oriented nature of substantive rationality is the

source of the normative content of economic models.

To the psychologist, utility maximization has little role to play in

studying human behavior. Where the economist readily invokes the

assumption of the substantively rational utility maximizer, the

psychologist looks elsewhere for explanation:

> For learning theorists, it is schedules of reinforcement; for
> Freudians, unconscious motivations; for developmentalists, the
> individual's stage of cognitive development; for social
> psychologists, the current social context and the way the
> individual represents it; even cognitive psychologists argue that
> the individual's particular information processing machinery will
> constrain his or her performance (Lea, Tarpy and Webley, 1987, p.
> 103).

Aside from being the source of normative content in economic models, one

of the psychologists' criticisms of the utility maximizing hypothesis is

that "utility-maximizing theory is reactive rather than predictive. It

accommodates the facts as they emerge rather than telling us what to

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expect in advance (Lea, Tarpy and Webley, 1987, p. 481). For this reason, psychologists see the hypothesis as untestable. Furthermore, the hypothesis is seen as unnecessary. That is, predictions arising from a utility maximizing model may not rely at all on the utility maximizing assumption but rather on the empirical content of the bolstering assumptions. Lea, Tarpy and Webley (1987) and Simon (1987) point to the work of Gary Becker as an example:

> The contribution of the utility maximizing framework to Becker's analysis is, in fact, rather slight; most of the work is done by economic general knowledge ... Neither the utility maximizing framework nor Becker's general knowledge persuades us to accept his analysis. What is persuasive is the statistical and econometric evidence that he assembles in support of his predictions (Lea, Tarpy and Webley, 1987, p. 510-1).

In another example, Eichner (1983) points out that recognition of a downward sloping demand curve does not require the acceptance of the utility maximizing assumption.

2.3.4 Protecting Normative Content

Central to economic analysis is the assumption that tastes and preferences do not change over the period in question; furthermore, the formation of tastes and preferences is not open to inquiry by the economist (Stigler and Becker, 1977). Both of these elements are very much a part of psychological analysis and can be viewed as a way of protecting the normative content of the economic model:

> It is possible, on considering this set of contrasts between decisionmaking as we think it ought to occur and decisionmaking as

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we think it does occur to trivialize the issue into a
"definitional problem". By suitable manipulating the concept of
tastes, one can save the classical theories of choice as
"explanations" in a formal sense, but probably at the expense of
stretching a good idea into a doubtful ideology (March, 1978, p.
597).

Furthermore, the avoidance of issues involving taste formation and

changes in tastes precludes much of the discussion of the effects of

class, culture, power and social institutions upon preferences. These

factors conflict with the assumption of consumer sovereignty which is

crucial to the particular view of liberty supported by neo-classical

economics; consumer sovereignty supports the status quo (Etzioni, 1988).

2.3.5 Approach to Empirical Work

Reliance on the notion of substantive rationality allows the economist

to employ deductive reasoning to a much greater extent than the

psychologist. The desire to avoid normative elements when constructing

theories leads the psychologist to employ inductive reasoning. This is

reflected in different approaches to empirical work (Hogarth and Reder,

1987). Given the elegant axiomatic model, economists are comfortable in

making predictions with little empirical evidence. In contrast, the

psychologist is less willing to make predictions outside the observed

data. Additionally, by placing more emphasis on deductive reasoning,

the economist chooses explanatory variables that are compatible with the

deductive model; the psychologists' choice of variables is neither bound

nor directed to such an extent by their models.

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Economists and psychologists differ considerably in what they will accept as legitimate empirical evidence. Economists devote their efforts to behavior which is subject to market forces; psychologists do not accept this restriction. As such, economists are sceptical of experimental data, the mainstay of the psychology discipline. Economists feel this evidence lacks legitimacy as the observed behavior may not reflect market forces; market forces would weed out irrational behavior (Hogarth and Reder, 1987; Thaler, 1987a; Jungermann, 1983). Unlike the theoretical firm, consumers do not simply disappear if they are inefficient or irrational. This position of economists reflects the strong prior they place on their model and their unwillingness to accept anomalous observations. In contrast, psychologists are less troubled by anomalies. Research by Russell and Thaler (1985) suggests that irrational behavior can persist in competitive market situations.

Economists defending the descriptive capacity of their models are likely to argue that individuals will act consistently with their model if provided the correct incentive. However, this is not readily supported by research (Slovic and Lichtenstein, 1983). Furthermore, psychologists counter that it is not always clear what behavior should be rewarded in the experimental situation.

Some critics hold that the experimental settings do not allow people to learn from past experience and that if learning were possible people would act more in accordance with the models of economic theory.

However, learning to "do it right" may not occur in non-experimental situations either:

> outcomes are commonly delayed and not easily attributable to a particular action ... variability in the environment degrades the reliability of the feedback ... there is often no information about what the outcome would have been if another decision had been taken ... and ... most important decisions are unique and therefore provide little opportunity for learning (Hogarth and Reder, 1987, p. 8).

Another criticism of anomalous experimental data is that deviations from the normative economic model will cancel each other when aggregated. However, psychological studies suggest that biased behavior is systematic and not random (Thaler, 1987a). Thus, cancellation of deviations would not occur in aggregate.

2.4 Summary and Implications

Although both economics and psychology concern themselves with the study of human behavior, there are fundamental differences between the disciplines. To some extent, the relationship between the disciplines could be characterized as one in which economics is a subset of psychology. For the most part, economics focuses on choice behavior circumscribed by the market place; psychology has a broader focus. Generally, economists do not concern themselves with the formation and ongoing modification of tastes and preferences; the psychologist is at home in this area. Furthermore, economists rely on the assumption of utility maximization as the motivating force behind choice;

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psychologists are less willing to grant this assumption such stature. This assumption provides economics with a normative component and reflects the economists' affinity for deductive reasoning. Psychologists view their models as descriptive, as opposed to normative, hence they rely more heavily, although not exclusively, on inductive reasoning.

The preceding pages suggest that it is difficult, at least on a methodological basis, to blend economic and psychological inquiry. Where there are common topics of interest, such as intertemporal choice under uncertainty, differences may still be found as to notions of rationality, the acceptability of working hypotheses, and the legitimacy of empirical observation. This does not suggest that, for any area of common interest, useful insights cannot be gained from both disciplines. To the extent that the economic model can be used to describe behavior its descriptive capacity may be improved using psychological insights.

Chapter 3

Empirical Models

A model of shore protection behavior, derived from discounted expected utility theory, was presented in the previous chapter. Criticism of the standard economic theory focussed on three elements of the discounted expected net benefits model: the rate of time preference, the probability of hazard occurrence, and the time horizon. In this chapter an empirical model of shore protection adoption behavior will be specified allowing for variation in these three elements. Additionally, in this chapter, each of these three factors will be modeled in their own right as functions of characteristics of the decision maker. These models will make reference to traditional economic theory and to research findings which either run counter to that traditional theory or offer insights where the traditional theory has little to say.

One objective of this study was to obtain data for the testing of hypotheses by surveying individuals faced with the hazards of flooding and/or erosion. The models defined below are expressed in terms of variables identified for empirical measurement and obtained from that survey. These models were not developed independently of the practical considerations required to insure the success of the survey.

Two of the variables included in the empirical model are the rate of time preference and the degree of probability truncation. In previous experimental research, estimates of these variables were elicited in a laboratory setting (Slovic et al,1977; Loewenstein, 1988). For the most part subjects were students although in one case the subjects were members of the League of Women Voters. Typically the experiments posed simple and abstract choices. The laboratory setting allowed the analysts a considerable degree of control; many elements of the choice problem could be held constant and varied as required. However, in eliciting these variables by way of a field setting there are several advantages over the laboratory experiments. In this field experiment the respondents were shoreline property owners; they were confronted with experimental choices designed to capture elements of the actual choice problem they may face. Thus, they can bring their direct experience and understanding of protection issues to bear on the experimental problem. Their responses can be expected to more closely represent their preferences than responses obtained in a laboratory situation where the subject and the decision setting are unrelated to

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the problem of shoreline hazards. Although typically the lab setting offers considerable experimental control, the responses to the field questions in this study can also be controlled given the many other variables available: socio-economic characteristics, risk attitude and degree of hazard faced.

3.1 Rate of Time Preference (TPR)

It was shown in the last chapter that, in general, the individual rate of time preference is a function of the variables in the utility function. For the purpose of empirically testing hypotheses the time preference rate will be estimated as the function:

$$TPR = g(INC, AGE, EXP, RATT, FLO, ERO, COA) \qquad [3.1]$$

where

TPR = the personal rate of time preference applying to shore protection
      decisions,

INC = the income of the landowner,

AGE = the age of the landowner,

EXP = the owners experience with flooding and/or erosion,

RATT = risk attitude of the landowner,

ERO = level of erosion activity,

FLO = level of flooding activity, and

COA = membership in a coalition.

3.1.1 Income

Hausman (1979) and Houston (1983) suggest that the time preference rate is negatively related to income; their empirical work supports this hypothesis. These authors reason that people with low incomes may have an uncertain income stream, a lack of savings, difficulty in obtaining credit, and less incentive to invest in consumer durables than individuals with a higher income.

3.1.2 Age of the Landowner (AGE)

There is little empirical evidence that the personal time preference rate is a function of age, although no explicit test of that hypothesis was presented in the reviewed literature. However, the findings of Svenson and Karlsson (1989) suggest that the personal time horizon is a function of a person's age. Given that it can be difficult to separate the effects of the time horizon and time preference rate on a decision in the present, it may be useful to control for any effect that age might have on the personal time preference rate.

3.1.3 Past Hazard Experience (EXP)

When focussing on the specific issue of flooding and erosion, an individual's previous experience with those hazards may play a role in the level of utility (disutility) assigned to a future hazard event.

This relationship may be captured in the attempt to elicit a person's time preference rate. As such, it is useful to control for the personal experience of flooding or erosion.

3.1.4 Risk Attitude (RATT)

In eliciting time preference rates, questions will be designed so that a respondent would make a choice between shore protection projects differing in costs and or protection benefits over time. The respondent's risk attitude may play a role in that choice (Jungermann and Fleischer, 1988). A risk averse individual may choose a project with benefits nearer the present than another project by imputing more uncertainty to the latter project even though there was nothing in the question to suggest any uncertainty in either project. To control for that possibility, the risk attitude variable was included in the estimation.

3.1.5 Hazard Levels (ERO & FLO)

It was hypothesized that respondents facing higher levels of flooding and erosion would be more likely to display an urgency in seeking shoreline protection. This urgency could be reflected as a higher time preference rate than for those owners facing less of a hazard.

3.1.6 Coalition Membership (COA)

In the mid 1980's, a combination of storms and higher than average water levels on the Great Lakes led to considerable shoreline property damage. This prompted some property owners to form organizations (or coalitions) with the goal of pressuring governments to take action to reduce the chance of such damage in the future. Property owner coalitions display an urgency in their petition for government action to reduce flooding and erosion damage. As such, coalition members may display a higher time preference rate than non members.

3.2 Probability Truncation

As pointed out in the last chapter, there is evidence to suggest that for low probability losses some people truncate that probability to zero, ignoring altogether the possibility of the loss. As such, this variable was included in the model explaining the adoption of shore protection. However, probability truncation itself may be a function of several factors. A model to be estimated empirically is:

$$PROB = h(\ EXP,\ EDUC,\ RATT,\ INC,\ ERO,\ FLO,\ COA,\ ) \qquad [3.2]$$

where

PROB = the degree to which a landowner truncates the probability of the occurrence of an hypothesized hazard event,

EXP = the owners experience with flooding and/or erosion, and

EDUC = the education of the landowner.

RATT = risk attitude of the landowner,

INC = the income of the landowner,

ERO = level of erosion activity,

FLO = level of flooding activity, and

COA = membership in a coalition.

3.2.1 Past Hazard Experience (EXP)

To the extent that a landowner has had the experience of flood and/or erosion damage that person may be more aware of the possibility of damage and less likely to truncate the probability. The salience and vividness of the event is stronger in the mind of the person with hazard experience.

3.2.2 Education of the Property Owner (EDUC)

In addition to experience, it is expected that increased landowner education will reduce probability truncation to the extent that increased education reflects a better understanding of probability.

3.2.3 Risk Attitude (RATT)

In eliciting the occurrence of probability truncation, questions will be

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designed so that a respondent would make a choice between options of equal expected value. The respondent's risk attitude may play a role in that choice (Pratt, 1964). A risk averse individual may choose an option with a lower possible loss than would a risk neutral or risk seeking individual. To control for that possibility, the risk attitude variable was included in the estimation.

3.2.4 Other Control Variables (INC, ERO, FLO & COA)

There is little available information regarding the phenomenon of probability truncation for a specific hazard. However, income, levels of flooding and erosion, and coalition membership were included in the analysis as they highlight a decision maker's income constraint, hazard potential and knowledge of possible mitigative measures.

3.3 Time Horizon (TH)

Another model to be considered is that of an individual's planning horizon. A property owner's time horizon is modeled as a function of several variables:

$$TH = f (AGE, EDUC, INC, ERO, FLO, COA) \qquad [3.3]$$

where:

TH   = time horizon,

AGE = age of the property owner,

EDUC = education of the property owner,

INC = income of the property owner,

ERO = level of erosion activity,

FLO = level of flooding activity, and

COA = membership in a coalition.

3.3.1 Age of the Property Owner (AGE)

Although Svenson and Karlsson (1989) did not explicitly consider age as a factor affecting time horizon, their results suggest, in general, that older respondents tended to feel that longer planning horizons were more appropriate for a variety of issues. It was hypothesized that the personal time horizon of the landowner is a positive function of age although there may come a point of increased age where the time horizon begins to decrease particularly if the individual is not concerned with the outcomes of their decisions beyond their expected life span.

3.3.2 Hazard Levels (ERO & FLO)

It was expected that the level of flooding and/or erosion experienced by a property owner could affect their time horizon for taking protective action. Higher levels of damage may present the need for longer term planning.

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3.3.3 Other Control Variables (INC, EDUC & COA)

With little available literature regarding the factors affecting planning horizons it is difficult to speculate how income, education and coalition membership might affect that horizon. However, these variables were included in the analysis as they highlight a decision maker's income constraint and knowledge of possible mitigative measures.

3.4 Adopting Shoreline Protection

A theoretical model of shore protection behavior was outlined in Chapter 2. The discounted expected net benefits arising from shore protection efforts were described as a function of several factors; in general:

$$DENB = h(Cwo, Cw, K, Vw, Vwo, r, T, \alpha) \qquad [3.4]$$

where

DENB = the discounted expected net benefits of shore protection,

Cwo = the property damage experienced without shore protection,

Cw = the property damage experienced with shore protection,

K = capital cost of shore protection,

Vw = the property sale price without shore protection,

Vwo = the property sale price with shore protection,

r = the rate of time preference,

T = the time frame over which costs and benefits accrue, and

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α = the probability density function of property damage occurring.

The decision to take action (or to not take action) to protect a shoreline property from flood and/or erosion damage depends on the discounted expected net benefits of the action; as DENB rises so does the likelihood that an individual will take protective action:

  Protect/Not Protect = f(DENB).

The decision to adopt shore protection may be expressed in terms of variables identified for empirical measurement. These variables will be presented in terms of [3.4]. The empirical model is as follows:

  Protect/Not Protect = g(TPR, PROB, TH, PRPR, PVAL, KSP, ERO,

                          FLO, INS, OCC, TEN, RESID, AID, CAP,

                          RATT, AGE, EDUC, EXP, COA, INC)   [3.5]

where

TPR   = landowner's personal time preference rate,

PROB   = probability of experiencing damage,

TH   = the landowner's personal time (planning) horizon,

PRPR   = shoreline protection taken by a previous owner,

PVAL   = the market value of the property,

KSP   = the perceived capital cost of shore protection,

ERO   = severity of erosion,

FLO   = existence of a flooding problem,

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INS   = commercial insurance to protect against flooding,

OCC   = the frequency of occupancy of the dwelling,

TEN   = the tenancy status of the property,

RESID = existence of a residence on the property.

AID   = expectation of government aid for protection,

CAP   = the degree that protection expenditure is expected to be
        capitalized into the market price of the property,

RATT = the property owner's risk attitude,

AGE   = age of the property owner,

EDUC = education of the property owner,

EXP   = past experience with flooding and erosion of property,

COA   = membership in a coalition, and

INC   = income.

The following sections will discuss the definitions of and state the
hypotheses associated with each of the variables identified above.
These variables were obtained from the survey questionnaire.

3.4.1 Time Preference Rate, Probability and Time Horizon

Three of the elements which are hypothesized to affect the decision to
take protective action are the time horizon, rate of time preference and
the probability of a disaster. These elements have received some
discussion in previous sections. An assumption regarding potential
protective action is required in order to hypothesize the direction of

the effect these variables as the time preference rate and time horizon effect both benefit and cost streams. It is assumed that the benefits of protective action accrue to the property owner for a period longer than the period over which costs accrue. This assumption does not appear unrealistic because structures such as levees, seawalls and shore protection are planned to have a life span of many years, longer than the repayment term of a loan to finance these structures (that is not to say that these structures necessarily meet expectations). Given this assumption, as the time horizon decreases (T in [3.4]) a property owner will be less likely to undertake protection because the benefit stream is being shortened. An increased time preference rate (r in [3.4]) will reduce the effect of the benefit stream reducing the net benefit to taking protective action. Truncating the probability of damage (α in [3.4]) will reduce the expected cost of any damages, thus, reducing the benefits to undertaking protective action.

3.4.2 Protection By a Previous Owner (PRPR)

In the case study region, it is expected that some of the present landowners will have purchased or inherited their property with existing shore protection. As such, they may face little or no damage from flooding and/or erosion (reducing the difference between Cwo and Cw in equation [3.4]). It is hypothesized that where this is the case there will be less protective action by the present owner.

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3.4.3 Market Value of the Property (PVAL)

Structural flood and erosion protection, for the most part, cannot be purchased in small increments. For example, stone shore protection may offer essentially no protection until a certain amount of stone has been properly placed. Too little stone may leave a weak point which threatens the effectiveness of the entire structure. Where the property to be protected is of a lower value (reducing Cwo relative to K in equation [3.4]) the cost of a minimum level of protection may be excessive. Thus, it is hypothesized that the likelihood that a property is protected will fall with the value of the property.

3.4.4 Cost of Shore Protection (KSP)

The capital cost of shore protection is an element of the DENB model (K in equation [3.4]). The length of shoreline, its physical configuration, and the wave and wind action can be expected to vary from property to property. Thus, the cost of protection can be expected to vary. The higher a landowner perceives this cost to be, the less likely the owner will take protective action.

3.4.5 Level of Erosion (ERO)

It was hypothesized that an increased level of property erosion would increase the probability that a property owner would take protective

action. Increased erosion would increase property damage and reduce the future sale price (Cwo and Vwo in [3.4]).

3.4.6 Level of Flooding (FLO)

As in the case of erosion levels, it is hypothesized that an increase in flooding will increase the likelihood that action will be taken.

3.4.7 Commercial Flood Insurance (INS)

Flood insurance is available for residents of floodplains. This insurance represents a substitute, albeit not perfect, for structural property protection. Damage costs of unprotected property (Cwo in equation [3.4]) are reduced where an insurance policy is held. To the extent that an individual faces a flood hazard, it is hypothesized that those individuals owning flood insurance will be less likely to take other protective action.

3.4.8 Frequency of Dwelling Occupancy (OCC)

Another aspect of the tenancy issue is the practice of some property owners who occupy the dwelling for a only part of the year, typically the summer vacation season. For part of the year these owners would not face the hardship of evacuating during a disaster, nor would they face personal injury or death. This reduces the cost of a hazard should it

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occur (Cwo in equation [3.4]). As such, it is hypothesized that those property owners for which the property is a second home would be less likely to take action to protect their property.

3.4.9 Tenancy Status of the Dwelling (TEN)

Tenancy characteristics of the property may be expected to affect the decision to undertake protection in a manner similar to the occupation status of the dwelling. Owners who rent to others do not have to face the possibility of evacuating during a disaster; nor do they face the possibility of death or injury (reducing Cwo in equation [3.4]). Furthermore, tenants typically own the personal effects and furnishings which are subject to the hazard. Thus, it is hypothesized that absentee owners will be less likely to undertake protective action. Based on a sample of owners of property in a river floodplain, Thunberg (1988) found that absentee owners were less willing to pay for flood protection.

3.4.10 Existence of a Residence (RESID)

Some shoreline properties may not have residences upon them. As such, there is no occupant subject to personal danger from natural hazards (reducing Cwo in equation [3.4]). Additionally, an owner of an unoccupied property may not be fully aware of the extent of any erosion or flooding damage. Thus, it was hypothesized that properties without

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residences would have a lower probability of being protected.

3.4.11   Expectation of Government Aid (AID)

Kunreuther (1973) makes a case that U.S. government policies in recent decades have increased aid to the victims of natural disasters either through direct grants or through subsidized loans for rebuilding after a disaster. In a mid 1970's survey, Kunreuther et al (1978) asked hazard zone occupants if they expected government aid in the event of a disaster. The results suggested that aid was not expected. However, the availability of government disaster aid is theoretically compelling as an argument in describing an individual's choice to undertake protective action. It is hypothesized that an individual is less likely to take protective action when government disaster aid is expected, this aid reducing the cost of the disaster to the property owner (Cwo in equation [3.4]).

3.4.12   Capitalization of Expenditure (CAP)

The decision to invest in protection can have an effect upon the market value of a property to the extent that the protective action is a desirable characteristic of the property; the salvage value of the protection can be captured by the difference in sale price with and without the project (Vw and Vwo in [3.4]). It is hypothesized that where an individual believes that investments in property improvements

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will be captured by the property value, it is more likely that protective activity will be undertaken; a greater return on investment is perceived.

3.4.13 Risk Attitude (RATT)

In application of the DENB model, it is typically assumed that individuals are risk neutral, that is, individuals will make choices based solely on the mathematical expectation of costs and benefits (Hey, 1979). However, there is evidence to suggest that individuals are not risk neutral and that they may vary in their risk preference depending upon the choice setting. Kahneman and Tversky (1979) suggest that people may be risk seekers when faced with a choice between losses. If a shoreline property owner perceives both the potential property damage and expenditures on protective action as losses then that person may choose not to protect, taking a chance that the damage will not occur. Thus, it is hypothesized that to the extent individuals are risk seeking, they are less likely to undertake protective action.

3.4.14 Age of Property Owner (AGE)

It was hypothesized that older property owners would be less likely to take protective action. Older owners would tend to have less time to personally enjoy the direct benefits of expenditures to protect their shoreline (reducing the difference between Cwo and Cw in [3.4]).

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3.4.15 Education of Property Owner (EDUC)

With respect to education, it was expected that higher educated property owners would be more likely to take protective action. It was expected that these people would be more aware of shoreline hazards. However, by the same token, any increased awareness of damage might lead these individuals to purchase property that is already protected. This variable was included in the analysis to determine if education played a role in the decision to protect or not.

3.4.16 Past Hazard Experience (EXP)

It is expected that an increased experience with flooding and erosion will effect the choice to protect. With past experience the effects of a hazard will tend to be more vivid and an owner will be less likely to feel that "it won't happen to me" (increasing both Cwo and α in equation [3.4]). As such, it is hypothesized that where an owner has experienced flooding or erosion in the past that owner will be more likely to take protective action.

3.4.17 Coalition Membership (COA)

Shoreline property damage incurred in the mid 1980's prompted some property owners to form organizations (or coalitions) to pressure governments to take action to reduce the chance of such damage in the

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future. However, it is difficult to determine, a priori, whether members would be more or less likely to take protective action. Coalition membership may make property owners more aware of the hazard, increasing the chance they will take action (increasing α in [3.4]; Kunreuther et al, 1978). Additionally, to the extent the members see government action as a last resort, their individual actions having failed, there will be a positive relationship between membership and action. However, to the extent that any members perceive the responsibility of shore protection as lying with governments, they may be less likely to take action themselves. This variable will be maintained in the analysis as a control for the effects of the views of the coalitions.

3.4.18 Income

Although the expense of shore protection need not be met entirely through current income it is hypothesized that the income of an owner will be positively related to the level of protective action taken. Lower income persons may have uncertain incomes, little savings and difficulty obtaining credit required to finance protective actions; higher income persons may be able to obtain capital at lower interest rates. Thunberg (1988) observed that individuals with higher incomes were willing to make higher annual payments for flood protection.

Chapter 4

Sample Procedure, Survey

Development, and Data Coding

To meet the objectives of this research, a mail survey was developed to be administered to shoreline property owners. The purpose was to elicit information about protection choice behavior from individuals facing flooding and/or erosion of their property. The survey included some hypothetical questions forming the basis of a field experiment. Specifically, these questions were designed to elicit time preference and probability truncation behavior. Typically this type of question is presented to respondents in a controlled laboratory setting (Loewenstein and Thaler, 1989; Slovic et al, 1977; Schoemaker and Kunreuther, 1979). In this study the questions were framed in an erosion/flooding context with which the respondents would be familiar. Although, relative to a laboratory setting, some experimental control was forsaken, these

questions more closely approximate the actual decision problems faced by shoreline property owners.

This chapter outlines the development of that survey, the choice of sample area, the response to the survey and the coding of the variables to allow empirical testing of hypotheses.

4.1 Sampling Procedure and Sample Region

Property owners along the shores of the Great Lakes were chosen as the source of data for testing the hypotheses set out in the previous chapter. This group was chosen for two main reasons. First, wide fluctuations in lake levels, along with some severe storm events, in the mid 1980's have focused government and property owner attention on flooding and erosion hazards on the Lakes. Thus, it was expected that the population of shoreline property owners would be receptive to research into the issue of flood and erosion hazard protection. Second, a list of shoreline property owners' names and addresses was readily available from the U.S. Army Corps of Engineers. In 1989 and 1990 the Planning Division of the Chicago District of the Corps of Engineers conducted a census of the owners of property on the shore of the Great Lakes. Approximately 66,000 owners were identified. Subsequently, the Corps conducted a telephone survey of a sample of approximately 5,600 of those individuals. Some of the information from that survey was used to choose geographical regions from which the sample for this study was

drawn.

The Corps of Engineers maintains a geographical distinction, called reaches, between segments of the shoreline. The entire U.S. shoreline of the Lakes is divided into 50 reaches of differing length, each reach being defined in terms of a particular level of erosion activity. A subset of the 50 reaches was chosen as the sample region.

Several criteria were applied in choosing the study sample . First, only those reaches on Lakes Michigan, Erie and Ontario were included in the subset. This was done to reduce some of the demographic and socio-economic variation within the sample. Furthermore, a number of the excluded reaches consisted of island groups for which there was no readily available information regarding erosion. Additionally, based on the information gleaned from the Corps' telephone survey, all reaches where multiple unit dwellings existed on 5 percent or more of the properties were excluded from the sample. The intent was to focus on single family property owners. Also based on the Corps' telephone survey, all reaches were removed from the subset where more than 60 percent or less than 40 percent of the properties had undergone some action to protect against flooding or erosion. The types of action specifically considered were: i) raise, move and/or reinforce residence, ii) build or repair groin/jetty and iii) build or repair seawall, breakwater or dike. This criteria ensured that there would be considerable sample variation between those individuals who did and who

did not take protective action against flooding and erosion even though both groups may be or have been at risk.

Ten reaches, satisfying the screening process described above, were chosen as the sample region. Over 15,000 landowners held property in these reaches. This number was reduced to a more logistically and financially practical sample by i) alphabetically ordering the list (by the first name of the owner) and ii) choosing every fourteenth name from that list. After removing all names with incomplete addresses, a final sample of 1,053 property owners remained. The sample size was restricted by the budget available to conduct the mail survey.

The reaches chosen as a basis for the sample were numbers 8, 11, 17-21, 33 and 39-40. Reach 8 is about 40 miles in length with its boundaries defined as the Menominee River confluence and the Bark River confluence on Lake Michigan. More informally, this reach lies between Menominee, Michigan and Escanaba, Michigan. Reach 11 is about 130 miles long and lies between White Fish Point and the Red River confluence on Lake Michigan. This reach includes much of the shoreline of the peninsula on which Sturgeon Bay, Wisconsin is located. As a group, reaches 17 through 21 stretch 410 miles along east side of Lake Michigan bounded by Fisherman Island and Grand Marais Lake. This region lies approximately between Petoskey, Michigan and Holland, Michigan. Reach 33 is 105 miles in length and is bounded by the Twenty Mile Creek confluence and the Euclid Creek confluence on Lake Erie, lying approximately between Erie,

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Pennsylvania and Ashtabula, Ohio. Reaches 39 and 40 total 85 miles in length and lie between the Stony Creek confluence and Lyons Point on Lake Ontario. This corresponds approximately to the region between Watertown, New York and Rochester, New York.

4.2 Survey Procedure

The sample of property owners was surveyed by mail. The Total Design Method advocated by Dillman (1978) was used as a source of reference in designing and implementing the survey. The survey procedure involved three mailings. The first mailing introduced the property owners to the purpose of the survey and urged them to respond to the enclosed questionnaire. The second mailing consisted of a postcard urging those who had not yet responded to do so. The third mailing was sent only to those property owners who had not returned a completed survey; it urged them to do so and included another copy of the survey instrument. The mailings took place on July 9, July 23 and August 6, 1991. A copy of the letters and postcard are presented in Appendix B. The survey instrument is reproduced in Appendix C.

Prior to mailing, the survey was pretested. The purpose of pretesting was to determine whether i) the questions were understood and uniformly interpreted by respondents, ii) the responses could be interpreted without ambiguity, iii) respondents would be motivated to complete the survey, and iv) the questions displayed researcher bias in their

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construction (Dillman, 1978). Pretest surveys were mailed to 17 Great Lakes shoreline property owners. Many of the comments provided by the pretest group were incorporated into the survey instrument.

4.3 Survey Instrument

The survey instrument was divided into four main sections, of which only three were to be answered by any individual (Appendix C). The first and last sections were colored blue and all respondents were asked to respond to the questions in those sections. The second section was color coded green and was to be answered by only those individuals who had taken action to protect their shoreline. The third section was colored yellow and was to be answered only by those who had not taken protective action.

The main purpose of the first section of the survey was to make the respondent aware of how the term "protective action" was defined and to direct the respondent to the green or yellow section depending on whether they had undertaken any such action. Although the green and yellow sections contained many similar questions which could lend itself to combining the two sections into one, the distinction was maintained for two main reasons. First, for those property owners who had taken some action, there were questions about the type of action, when it was taken and the cost at the time. These questions were not applicable to those not taking action. Second, many of the questions in these

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sections referred to the point in time when protective action was taken. For those who had taken action some point in the past was the appropriate reference point, while for those not taking action the present was the appropriate reference point. By using two different sections the questions could be worded to more accurately reflect a particular individual's situation, thus, making it easier for the respondent to understand and reply to the questions.

The fourth section, also colored blue, was to be answered by all respondents. This section contained two types of questions. Socio-economic questions were placed here. It was hoped that the respondents would be more comfortable with the income and education questions after they had seen the earlier questions in the survey. This section also included some questions based upon a hypothetical situation; they make up the field experiment. Respondents were asked to consider a particular piece of property which was described to them. They were then asked to answer questions regarding their preferences for protective measures given different levels of risk and time frames. As these were difficult questions, they too were placed in the last section in the hope respondents would be more comfortable with them after seeing the first part of the survey.

4.3.1 Variations in the Survey Instrument

Four of the survey questions, B1, B2, B8 and B9 (Appendix C) asked the

respondents to state their preferences for hypothetical plans, projects, policies and properties, respectively. In each question the respondent was offered the choice of one of two options with a third option being indifference between the other two options. A possibility exists that the physical position in which a response option appeared, relative to the other possible responses for that question, might affect the response. To statistically test for this possibility six versions of the survey instrument were developed, one for each permutation of the three preference options. The surveys were identical in all respects except for the ordering of response options in the four questions, B1, B2, B8 and B9. The permutation specific to each version of the survey is presented in Table 4.1. Thus, while version I presented the three options in the order A, B, Indifference, version VI reversed that order. Within any given survey all four questions maintained the same option ordering.

The versions of the survey were divided approximately equally among the respondents. In the first mailing versions I through V were allocated to 175 respondents each, with 178 respondents receiving version VI. Where a third mailing was required the respondent was provided with the same version as was initially allocated. Appendix C reproduces version I.

Table 4.1. Order in Which Response Options Were Presented for Questions B1, B2, B8 and B9 in the Six Versions of the Survey.

Options	Versions of the Survey					
	I	II	III	IV	V	VI
Option A*	1	1	2	2	3	3
Option B*	2	3	1	3	1	2
Indifference	3	2	3	1	2	1

*Options A and B refer to Plans, Projects, Policies, and Properties A and B, in questions B1, B2, B8 and B9, respectively (see Appendix C).

4.4 Response to the Survey

Of the 1,053 surveys mailed out initially, 125 were removed from the list for one of the following reasons: i) the addressee had moved leaving no forwarding address, ii) the addressee was deceased, iii) the addressee had sold their shoreline property, or iv) the addressee had never owned shoreline property. Completed questionnaires were accepted from the spouse of any deceased addressee where the spouse still owned the shoreline property. August 20, 1991 was chosen as the cutoff date for accepting responses. This allowed a total period of six weeks from the initial mailing and two weeks from the final mailing. The initial mailing yielded a response rate of approximately 26 percent. The reminder card raised the response rate to approximately 44 percent. As of August 20, 1991 the response rate was 52.4 percent (486 responses from a possible 928). The number of people responding to Versions I through VI, were 86, 80, 79, 85, 76, and 80, respectively.

One potential problem with a mail survey is self-selection bias. That is, those individuals who choose to respond may not be representative of the survey sample. To the extent this bias exists for the relevant variables, it is difficult to draw inferences from the population about the sample. The potential for such a bias exists with this survey data.

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4.5 Measuring and Coding Variables

The data collected from the survey of shoreline property owners must be
coded in a manner which allows for the empirical testing of the
hypotheses set out in the previous chapter. The following sections
describe that process. The variables are organized into three groups:
hypothetical, demographic and situational.

4.5.1 Hypothetical Variables

As indicated in section 4.3 the final, blue colored, portion of the
survey instrument contained some hypothetical questions which required
the respondent to consider a particular hazard situation. In the
literature, questions such as those designed to elicit time preference
rates and the existence of probability truncation are typically
presented to respondents in a controlled laboratory setting. In this
study these questions were taken to the field; other variables in the
analysis were used as controls. Care was taken to make the questions
realistic in order to reduce any response bias which might arise due to
the hypothetical nature of the questions.

4.5.1.1 Risk Attitude (RATT)

An index of risk preference (RATT) was constructed from three questions
taken together, B5, B6 and B7. These questions were worded as follows:

(B5) Suppose there was a 5% chance each year of a storm causing between $3,000 and $5,000 damage to the property described earlier.

Would you buy an insurance policy for $200 per year if it covered damages only in the $3,000 to $5,000 range? (circle one number only)

      1   YES ---> GO TO QUESTION B6
      2   NO ---> GO TO QUESTION B7
      3   I AM INDIFFERENT ---> GO TO QUESTION B8
      4   I AM NOT SURE ---> GO TO QUESTION B8

(B6) Would you buy the insurance policy if it cost $275 per year?

          1   YES ---> GO TO QUESTION B8
          2   NO ---> GO TO QUESTION B8

(B7) Would you buy the insurance policy if it cost $125 per year?

          1   YES
          2   NO

Question B5 was constructed such that the expected storm damage would lie between $150 and $250. Respondents were given this range as opposed to a point estimate of expected damage to make the question more realistic as insurance policies cover a range of possible damages. The price of the insurance policy was set at $200, the midpoint of the expected storm damage range. A negative response to B5 would suggest the respondent is risk seeking, an affirmative response suggesting risk averse behavior. The prices assigned to the insurance policies in B6 and B7 ($125 and $275) were set above and below the range of expected storm damages ($150 to $250). Thus an individual preferring one of these policies could be considered to have a relatively strong preference for or against risk. The respondent's risk attitude (RATT)

was coded as follows:

i) response to B5 = Yes and response to B6 = Yes then RATT = 5,

ii) response to B5 = Yes and response to B6 = No then RATT = 4,

iii) response to B5 = Indifferent then RATT = 3,

iv) response to B5 = No and response to B7 = Yes then RATT = 2,

v) response to B5 = No and response to B7 = No then RATT = 1,

vi) response to B5 = Not Sure then RATT = -7, and

vii) no response to B5 then RATT = -9.

Thus, where an individual responds and is sure of their preference RATT ranges from 1 to 5 where 5 corresponds to a risk averse attitude, 3 corresponds to risk neutral and 1 corresponds to a risk seeking attitude. By responding "no" to both B5 and B7 (risk seeking) an individual shows a preference for taking the storm risk even though the cost of the insurance ($125) is less than the lowest level of expected storm damage ($150).

4.5.1.2   Rate of Time Preference (TPR1 and TPR2)

The survey included two questions designed to elicit the property owners time preference rate (B1 and B2). Both questions were prefaced by a statement outlining a hypothetical shoreline property which was to form the basis of their responses to the questions to follow. The property was described as follows:

> You are the new owner of a waterfront lot. The lot has 100 feet of waterfront and is worth $40,000. The residence is set back 150 feet from the shore. After purchasing the lot you become aware

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that the lot has an erosion problem. An appraiser tells you that the erosion is reducing the market value of your property.

The first question, B1, presented the respondent with the choice of two payment plans. The annual payments used in this question were chosen such that they were realistic in their magnitude and such that the present value of the two payment streams were equal to each other at a time preference rate of ten percent. The question is as follows:

Suppose you decided to construct an erosion control project, and plan to take a loan to pay for the construction. You are offered two different 5 year payment plans with payments due at the beginning of the year:

Year:	1	2	3	4	5
Annual Payment for Plan A:	$1800	$1800	$1800	$1800	$1800
Annual Payment for Plan B:	$900	$1400	$1900	$2400	$2900

Which plan would you prefer? (circle only one number)

```
1    PLAN A WITH PAYMENTS OF $1800 PER YEAR
2    PLAN B WHERE PAYMENTS INCREASE EACH YEAR
3    EITHER PLAN WOULD BE ALRIGHT
4    I AM NOT SURE
```

The time preference rate implied by the response to this question (TPR1) was coded as follows:

i) response = "plan A" then TPR1 = 0,

ii) response = "either plan" then TPR1 = 1,

iii) response = "plan B" then TPR1 = 2,

iv) response = "not sure" then TPR1 = -7, and

v) no response then TPR1 = -9.

Thus, where the respondent chose one plan or expressed indifference, TPR1 ranges from 0 to 2 corresponding to a discount rate lower than, equal to, or higher than ten percent.

The other time preference rate question, B2, was phrased such that the time dimension of choice was explicitly stated. As with question B1, the present value options offered in B2 were equal to each other at a ten percent time preference rate. This allowed for a comparison of the responses to B1 and B2. The wording of the question is as follows:

> Suppose you consult a contractor who describes two erosion control projects which both cost the same amount:
>
> Project A will reduce the yearly loss of property value by $600. The project will be fully effective as soon as it is built.
>
> Project B will reduce the yearly loss of property value by $1000. However, this project will not become effective for 5 years.
>
> Which project would you prefer? (circle one number only)
>
> 1   PROJECT A WHICH REDUCES YEARLY EROSION DAMAGE BY $600 BEGINNING IMMEDIATELY
> 2   PROJECT B WHICH REDUCES YEARLY EROSION DAMAGE BY $1000 BEGINNING IN 5 YEARS
> 3   EITHER PROJECT WOULD BE ALRIGHT
> 4   I AM NOT SURE

The time preference rate implied by the response to B2 (TPR2) was coded as follows:

i) response = "project B" then TPR2 = 0,

ii) response = "either project" then TPR2 = 1,

iii) response = "project A" then TPR2 = 2,

iv) response = "not sure", then TPR2 = -7, and

v) no response then TPR2 = -9.

Thus, where the respondent chose one plan or expressed indifference,
TPR2 ranges from 0 to 2 corresponding to a rate lower than, equal to, or
higher than ten percent.

4.5.1.3 Probability Truncation (PROB1 and PROB2)

The survey contained two questions designed to elicit a respondent's
tendency to truncate low probabilities, questions B8 and B9. These
questions were in the same section of the survey as the time preference
rate questions, thus, were prefaced by the same property description on
which responses were to be based. Question B8 was framed as an
insurance choice question as follows:

> Storms causing slight damage can occur fairly often, while storms
> causing severe damage occur rarely. Suppose you had a choice
> between these two insurance policies each costing $250 per year:

	Annual Chance of Damage	Range of Storm Damage Protection
Policy A	10% chance	$0 to $5,000
Policy B	2% chance	$10,000 to $15,000

> Which policy would you prefer? (circle one number only)
>
> 1   POLICY A WITH A HIGH CHANCE OF A LOW INSURANCE PAYOFF
> 2   POLICY B WITH A LOW CHANCE OF A HIGH INSURANCE PAYOFF
> 3   EITHER POLICY WOULD BE ALRIGHT
> 4   I AM NOT SURE

The hypothetical policies above each offered a range of protection;
taking the midpoints of the ranges the expected payout of each policy is

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the same ($250). There was no guarantee that respondents would focus on the midpoints of the ranges but offering payout ranges is a realistic feature of insurance policies. The payout ranges offered do not overlap; this simplifies the choice of policy. The degree of probability truncation implied by the response to B8 (PROB1) is coded as follows:

     i) response = "policy A" then PROB1 = 2,

     ii) response = "either policy" then PROB1 = 1,

     iii) response = "policy B" then PROB1 = 0,

     iv) response = "not sure" then PROB1 = -7, and

     v) no response then PROB1 = -9.

To the extent that an individual truncates the low probability of storm damage they will be less likely to desire insurance against such damage and will tend to choose Policy A. Thus, as the degree of truncation increases, PROB1 increases (ignoring those not sure and non respondents).

In the second truncation question, B9, the respondent was simply asked which property he or she preferred to live on, one with a low probability of high storm damage, the other with a high probability of low storm damage. In stepping away from the insurance frame, question B9 presented point estimates of storm damage such that the expected value of both options was equal ($250). The question was worded as follows:

Suppose you had a choice between two pieces of shoreline property? The only differences between the pieces of property are the chance and level of storm damage:

	Annual Chance of Damage	Level of Damage for Each Storm
Property A	10% chance	$2,500
Property B	2% chance	$12,500

Which property would you prefer to live on? (circle one number only)

1 PROPERTY A WITH A HIGH CHANCE OF LOW DAMAGE STORMS
2 PROPERTY B WITH A LOW CHANCE OF HIGH DAMAGE STORMS
3 EITHER PROPERTY WOULD BE ALRIGHT
4 I AM NOT SURE

The degree of probability truncation implied by the response to B9 (PROB2) is coded as follows:

i) response = "property A" then PROB2 = 0,

ii) response = "either property" then PROB2 = 1,

iii) response = "property B" then PROB2 = 2,

iv) response = "not sure" then PROB2 = -7, and

v) no response then PROB2 = -9.

To the extent that an individual truncates the low probability of storm damage they will be more likely to choose the property with the low probability of storm damage. Thus, as the degree of truncation increases, PROB2 increases (ignoring those not sure and non respondents).

4.5.1.4 Time Horizon (TH)

A respondents time horizon with respect to shoreline protection was
elicited via question B4:

>   In general, how far into the future do you think it is reasonable
>   for an owner to plan investments to protect shoreline property
>   against flooding and/or erosion?
>
>   1   LESS THAN 5 YEARS
>   2   5 TO 10 YEARS
>   3   OVER 10 YEARS

The respondents time horizon (TH) was coded as follows:

   i) response = 1 then TH = 0,

   ii) response = 2 then TH = 1,

   iii) response = 3 then TH = 2, and

   iv) no response then TH = -9.

As the time horizon lengthens, TH increases from 0 to 2.

4.5.1.5 Capitalization (CAP)

Question B3 was designed to capture the degree to which a property owner

expects that property improvements will be reflected in the market value

of the property. The question was worded as follows:

>   How do you think the market value of a shorefront property is
>   affected by money spent on shore protection?
>
>   1   THE MARKET VALUE RISES BY MORE THAN THE AMOUNT SPENT
>   2   THE MARKET VALUE RISES BY THE SAME AS THE AMOUNT SPENT
>   3   THE MARKET VALUE RISES BY LESS THAN THE AMOUNT SPENT
>   4   THE MARKET VALUE IS UNAFFECTED BY THE AMOUNT SPENT

CAP was coded:

i) response = 1 then CAP = 4,

ii) response = 2 then CAP = 3,

iii) response = 3 then CAP = 2,

iv) response = 4 then CAP = 1, and

v) no response then CAP = -9.

4.5.2 Demographic Variables

Each respondent was asked several questions to determine their demographic characteristics.

4.5.2.1 Age (AGE)

The age of the respondent was taken directly from question B12 (What is your age?). The variable AGE took the value of the response to B12; where there was no response AGE took the value -9.

4.5.2.2 Education (EDUC)

The level of respondent education was determined from question B14 of the survey which was worded as follows:

What is the highest level of education you have completed?

    1   LESS THAN HIGH SCHOOL
    2   HIGH SCHOOL
    3   SOME COLLEGE OR TRADE SCHOOL
    4   COLLEGE DEGREE
    5   GRADUATE STUDIES

The variable (EDUC) was coded as:

    i) response = 1 then EDUC = 1,

    ii) response = 2 then EDUC = 2,

    iii) response = 3 then EDUC = 3,

    iv) response = 4 then EDUC = 4,

    v) response = 5 then EDUC = 5, and

    vi) no response then EDUC = -9.

4.5.2.3 Experience (EXP)

The level of experience with storms was taken to be represented by question B10 (How many years have you owned this property?). The variable EXP took the value of the response to B10; where there was no response EXP took the value -9.

4.5.2.4 Coalition Membership (COA)

Question B13 of the survey instrument directly asked respondents if they were members of any coalitions or organizations of shoreline property owners. For a negative response COA = 0; COA = 1 for the affirmative; COA = -9 for a non response.

4.5.2.5 Family Income (INC90 & INC)

Two different income variables were used in the analysis. An individual's discount rate, probability truncation and time horizon were elicited by way of questions referring to the respondents present frame of mind. As such, the 1990 family income (INC90) was used as an explanatory variable in the analysis of those variables. However, the shore protection model focussed on the time at which protective action was taken. Thus, another income variable (INC) was defined to reflect the income at the time of action.

Present family income (INC90) was derived from question B15 and was coded as follows where the dollar values were taken at the midpoints of the ranges of B15:

    i) response = 1 then INC90 = $12,500,

    ii) response = 2 then INC90 = $37,500,

    iii) response = 3 then INC90 = $62,500,

    iv) response = 4 then INC90 = $87,500,

    v) response = 5 then INC90 = $112,500, and

    vi) no response then INC90 = -9.

The family income of the respondent at the time of taking action was based on the response to questions G10 (action) and B15 (no action). Taken at the means of the response ranges the variable INC was initially coded as:

i) response = 1 then INC = $12,500,

ii) response = 2 then INC = $37,500,

iii) response = 3 then INC = $62,500,

iv) response = 4 then INC = $87,500,

v) response = 5 then INC = $ 112,500, and

vi) no response then INC = -9.

This is the same coding scheme used to define present family income (INC90). However, in defining INC the dollar values as assigned above were subsequently deflated to account for inflation using the overall Consumer Price Index (U.S. Congress, 1991); all values were converted to 1990 dollars. For those property owners taking action in the past, the income was deflated by the index for the year they first reported taking action (from question G2). It was not necessary to deflate the incomes of those not taking action as their income was reported in 1990 dollars.

4.5.3 Situational Variables

A variety of other variables were used in the analyses. They reflect the physical and economic characteristics of the owner and the property.

4.5.3.1 Property Value (PVAL)

The value of the shoreline property was elicited using questions G11 (act) and Y9 (not act) and was coded as PVAL as follows:

i) response = 1 then PVAL = $15,000,

ii) response = 2 then PVAL = $45,000,

iii) response = 3 then PVAL = $75,000,

iv) response = 4 then PVAL = $105,000,

v) response = 5 then PVAL = $135,000,

vi) response = 6 then PVAL = $165,000,

vii) response = 7 then PVAL = $195,000, and

viii) no response then PVAL = -9.

The dollar values assigned to the responses were taken at the mean of

the response ranges. All values were converted to 1990 dollars using

the Consumer Price Index for all shelter (U.S. Congress, 1991). For

those property owners taking action in the past, the property value was

deflated by the index for the year they first reported taking action

(from question G2). It was not necessary to deflate the property values

of those not taking action as those values were reported in 1990

dollars.

4.5.3.2 Cost of Protection (KSP)

As with many of the variables described above the cost of shore

protection (KSP) consists of responses from both those who took action

and those who did not. For those who took action cost figures were

obtained from question G2. The cost of an action was deflated using the

Cost of Construction Index (Engineering News Record, various years).

Where more than one action was taken over time, the costs were converted

to 1990 dollars and summed. For the individuals who did not take any

protective action question Y8 was used to elicit an estimate of what the property owner expects protection would cost. Taking the midpoints of the ranges in Y8 the responses to that question were coded as:

    i) response = 1 then KSP = 0,

    ii) response = 2 then KSP = $1,000,

    iii) response = 3 then KSP = $3,000,

    iv) response = 4 then KSP = $5,000,

    v) response = 5 then KSP = $7,000,

    vi) response = 6 then KSP = $9,000,

    v) response = 7 then KSP = $11,000,

    vi) response = 8 then KSP = -7, and

    vii) no response then KSP = -9.

The variable KSP is made up of values taken at the mid points of response ranges (those persons not taking action) and of dollar values elicited directly (those taking action). This distorts the variable somewhat as the responses of those not taking action, those estimating the cost of action, are capped at a value of $11,000 while the responses of those taking action are not restricted. To remove this distortion any value of KSP which was greater than or equal to $11,000 (1990 dollars) was set to that value. Unfortunately, this reduces the variation in KSP.

4.5.3.3 Commercial Insurance (INS)

The coding of a variable to reflect the holding of commercial flood

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insurance (INS) relies on question G8 for those property owners taking protective action and on question Y3 for those not taking action. Where a respondent replied that they held insurance then INS = 1; INS = 0 if insurance was not held and INS = -9 for no response. Where there was no response INS take the value -9.

4.5.3.4 Government Aid (AID)

The respondents expectation of government aid is gleaned from questions G9 (act) and Y4 (not act). The variable AID = 1 if aid was expected, AID = 0 if it was not expected and AID -9 if no response was given.

4.5.3.5 Protection Adoption (PROT)

The dependant variable (PROT) in the protection adoption model (section 3.4) was defined on question Q4 where respondents were asked if they had taken action to protect their property. If they had not taken any action then PROT = 0, if they had taken action then PROT = 1, and for a non response then PROT = -9. Action is taken to mean at least one of raising, moving or reinforcing a residence, or building, or repairing a groin/jetty, seawall, breakwater or dike.

4.5.3.6 Previous Action (PRPR)

Whether or not a previous owner took protective action (PRPR) is derived

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from the response to question Q4. Where a previous owner took no action

then PRPR = 0. If a previous owner did take action then PRPR = 1. PRPR

= -9 for non respondents.

4.5.3.7 Erosion Level (ERO)

Questions G3 and Y5 of the survey were used to provide a physical

measure of the erosion level. The question was worded (Y5):

What is your best estimate of the average amount of your property
eroded each year since you have owned this property?

        1   I HAVE NO EROSION PROBLEM
        2   LESS THAN 1   FOOT PER YEAR
        3   1 TO 2   FEET PER YEAR
        4   2 TO 3   FEET PER YEAR
        5   OVER 3 FEET PER YEAR
        6   I'M NOT SURE.

ERO was coded as:

i) response = 1 then ERO = 1,

ii) response = 2 then ERO = 2,

iii) response = 3 then ERO = 3,

iv) response = 4 then ERO = 4,

v) response = 5 then ERO = 5,

vi) response = not sure then ERO = -7, and

vii) no response then ERO = -9.

4.5.3.8 Flooding Level (FLO)

A measure of the existence of a flooding problem was obtained from

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questions G4 and Y6 of the survey. Where there was no flooding problem FLO = 0; where there was a problem FLO = 1; for a response of "not sure" FLO = -7 and for a non response FLO = -9.

4.5.3.9 Occupancy Status (OCC)

The occupancy status of a shoreline property residence was determined by questions G6 (act) and Y1 (not act). The variable OCC is coded:

   i) response = "no residence" then OCC = 1,

   ii) response = "unoccupied" then OCC = 2,

   iii) response = "occupied part year" then OCC = 3,

   iv) response = "occupied all year" then OCC = 4, and

   v) no response then OCC = -9.

4.5.3.10 Tenancy Status (TEN)

The tenancy status of the residence (TEN) was determined by questions G7 (act) and Y2 (not act) and coded as:

   i) response = "no residence" then TEN = 1,

   ii) response = "unoccupied" then TEN = 2,

   iii) response = "rented to others" then TEN = 3,

   iv) response = "personally occupied" then TEN = 4, and

   v) no response then TEN = -9.

4.5.3.11 Residence (RESID)

The existence of a residence on the property was captured by question Q1 on the survey. Where there was no residence, RESID = 0; where a residence existed RESID = 1; RESID = -9 for non respondents.

4.6 Conclusion

The variables outlined above were chosen to empirically test hypotheses derived from a theoretical model. The degree to which these variables actually represent theoretical concepts may not be obvious until after the empirical analysis is carried out. Additionally, the results from the experimental questions will help to indicate the appropriateness of the experimental design.

Chapter 5

Empirical Results

This chapter presents the empirical results of the tests of the
hypotheses set out in previous chapters. The first section describes
the estimation methods used in the analyses. The next major section is
devoted to a discussion of the responses to the experimental questions
regarding time preference rates and probability truncation; presentation
order bias, non-respondent characteristics and framing effects are
discussed. Subsequent sections are devoted to presenting the results of
the estimation of the four main models: time preference rate,
probability truncation, time horizon, and protection adoption behavior.

The survey response rate of over 52 percent suggests that the sample of
respondents took an interest in the subject matter. These individuals
owned property on the shores of Lakes Michigan, Erie and Ontario.

Approximately 26 percent of respondents expected government aid in the event of flood and/or erosion damage. On average these individuals are over 60 years old and have owned their property almost 20 years. They are also a highly educated group with an average education of 3.9 on a scale where 4.0 corresponds to the completion of a college degree. Even though a considerable number of these individuals reported an annual family income of less than $25,000, the mean income was 3.22 which corresponds approximately to a figure of $68,000. On average the respondents appeared interested in the survey, were well educated and had considerable experience as shore front residents. Of the entire sample approximately 39 percent took some action to protect their property from flooding and/or erosion; 61 percent did not. Recall that action is taken to mean at least one of: raising, moving or reinforcing a residence, or building or repairing a groin/jetty, seawall, breakwater or dike.

5.1 Estimation Methods

The empirical analyses relied on the econometric methods of Ordinary Least Squares (OLS), Probit and Ordered Probit as required. All results were obtained using the LIMDEP software package (Greene, 1990). OLS is widely used to characterize relationships between variables and is described in all basic econometric texts (e.g. Koutsoyiannis, 1977). Probit analysis has been used when the dependent variable of the relationship to be estimated is dichotomous, for example a binary

variable taking only the value of 0 or 1. Such is the case in estimating the adoption protection model where 1 indicates that action was taken and 0 indicates that it was not. Ordered Probit analysis has been applied when the dependent variable is discrete and represents more than two ordered options (polytomous). For example, the time preference rate variables take the values of either 0, 1 or 2 and the order is significant as this scale represents low through high time preference rates. It is because these dependent variables are limited to a narrow range and are discrete that OLS is not appropriate; OLS yields results which will display heteroscedastic error variance and the errors will not be normally distributed (Aldrich and Nelson, 1984; Gujarati, 1988; Maddala, 1983). Thus, OLS estimates will be unbiased but inefficient.

The Probit and Ordered Probit models, using Maximum Likelihood estimation techniques, estimate the probability that an observation (e.g. property owner) will fall within a particular group (e.g. took action or didn't). The basis of Probit models is the normal cumulative density function. This function restricts the estimates of probabilities to lie between zero and one. Logit models, relying on an exponential cumulative density function, are a ready alternative to Probit models. The Logit and Ordered Logit methods were also employed in the following analyses but offered no noticeable improvement in estimating the models; no Logit estimates are reported.

One of the standard measures of goodness of fit in OLS analyses is the

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R-squared value. However, in Probit models (and Logit) the R-squared is
inapplicable (Aldrich and Nelson,1984). A Chi-squared test is used to
test for overall significance of the estimated relationship. T-tests
can also be used to check the significance of each estimated
coefficient. Estimated t-values are not reported below; instead the
prob-values are reported. Prob-values indicate the significance level
of the calculated test statistic, a prob-value of 0.01 indicates a
confidence level of 99 percent (1 - 0.01). The t-value can be readily
calculated from the presented results as the estimated coefficient
divided by its standard error.

An additional test of goodness of fit is the degree to which the
estimated model correctly categorizes each observation (e.g. as a 0 or a
1 in the Probit model); this too, is reported for the Probit and Ordered
Probit models below. For the Probit model, if the estimated probability
for a particular observation is above 0.50, then that observation is
classified as taking the value of 1; if below 0.50 then it is classified
as 0. For the Ordered Probit model, each observation is categorized as
belonging to the group for which the highest probability was estimated.
For example, if the model estimates the probabilities associated with
belonging to the groups 0, 1 and 2, as 0.3, 0.6 and 0.1, respectively,
then the observation in question will be placed in group 1.

5.2   Responses to Experimental Questions

This section focusses on the responses to the time preference rate and probability truncation questions.   The possibility of presentation order bias is examined in addition to non-respondent characteristics and framing effects.

5.2.1   Presentation Order Bias

In asking the respondents questions of a hypothetical nature it was recognized that the order in which the response options were presented may influence the response.   To test for this occurrence, the sample was subdivided into six different groups, each receiving questions in which the responses were ordered differently.   This ordering was done only for questions regarding the time preference rate and probability truncation (B1, B2, B8 and B9).   For each of these four hypothetical questions the following relationship was estimated using OLS:

$$R_i = f(D_j) \text{ for all } j = (I, II, III, IV, V),$$

where:

R_i = is the response to question i by each individual, where i refers to
     questions B1, B2, B8 and B9 of the survey,

D_j = a binary variable set to 1 if the respondent received a survey of
     format j, and set to 0 otherwise.

This method is equivalent to an ANOVA and provides a test as to whether

the subsample means (mean response to a given question for each version of the survey) are statistically different from each other (Koutsoyiannis, 1977). The test results for the time preference rate variables (TPR1 and TPR2) and the probability truncation variables (PROB1 and PROB2) are presented in Tables 5.1 through 5.4, respectively. Those observations where the property owner did not respond or responded "not sure" were removed from the sample for these analyses.

In all four cases, the adjusted R-squareds and the F-values are quite low. At best, the F-value for the test of TPR2 (Table 5.2) becomes significant at the 77 percent (1 - 0.2338) level. The other tests show less significance. Given these results, it was concluded that there was no significant presentation order bias in the responses; the version of the survey completed by each respondent was ignored in the remainder of the analyses.

5.2.2 Non-Respondents

Two variables were defined for the time preference rate (TPR1 and TPR2) and for probability truncation (PROB1 and PROB2). Tables 5.5 and 5.6 present cross tabulations of the responses to each of the question pairs. In each table the response to TPR2 (PROB2) is presented on the horizontal axis; the response to TPR1 (PROB1) is on the vertical axis. Thus, for example, Table 5.5 shows that 27 respondents indicated a low time preference rate for both of the rate questions. One of the

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Table 5.1. Test for Presentation Order Bias: Dependent Variable: Time Preference Rate (TPR1).

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.4407	0.0923	0.0000
D1	-0.0526	0.1266	0.6779
D2	0.0223	0.1335	0.8675
D3	-0.0043	0.1329	0.9741
D4	-0.1573	0.1300	0.2269
D5	-0.0945	0.1348	0.4838

* * * * *

Number of Observations = 347

Adjusted R-Squared = -0.0068

Overall F-value = 0.5328, Prob-value for F = 0.7514

Table 5.2. Test for Presentation Order Bias: Dependent Variable: Time
Preference Rate (TPR2).

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	1.4630	0.0938	0.0000
D1	0.2489	0.1298	0.0561
D2	0.3287	0.1368	0.0168
D3	0.1493	0.1360	0.2733
D4	0.2320	0.1298	0.0750
D5	0.1841	0.1346	0.1724
	* * * * *		

Number of Observations = 320

Adjusted R-Squared = 0.0058

Overall F-value = 1.3737, Prob-value for F = 0.2338

Table 5.3. Test for Presentation Order Bias: Dependent Variable:

Probability Truncation (PROB1).

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.9535	0.1404	0.0000
D1	-0.3868	0.1839	0.0363
D2	-0.2785	0.2022	0.1694
D3	-0.1266	0.1897	0.5052
D4	-0.1618	0.1933	0.4031
D5	-0.1888	0.1905	0.3226

*   *   *   *   *

Number of Observations = 294

Adjusted R-Squared = 0.0007

Overall F-value = 1.0428, Prob-value for F = 0.3926

Table 5.4. Test for Presentation Order Bias: Dependent Variable:

   Probability Truncation (PROB2).

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	1.3704	0.1183	0.0000
D1	-0.0847	0.1611	0.5997
D2	0.0806	0.1697	0.6350
D3	0.0534	0.1637	0.7446
D4	0.1118	0.1657	0.5005
D5	0.0395	0.1624	0.8081

         *   *   *   *   *

Number of Observations = 344

Adjusted R-Squared = -0.0092

Overall F-value = 0.3759, Prob-value for F = 0.8651

Table 5.5.   Cross Tabulation of Time Preference Rate Variables: (TPR1

and TPR2).

			TPR2			
	Low	Medium	High	Not Sure	No Response	Total
TPR1=Low	27	10	171	38	10	256
TPR1=Med.	4	8	27	7	0	46
TPR1=High	6	6	22	6	5	45
Not Sure	3	4	26	51	11	95
No Response	0	3	3	3	35	44
Total	40	31	249	105	61	486

Table 5.6. Cross Tabulation of Probability Truncation Variables: PROB1
and PROB2.

| | PROB2 | | | | | |
	Low	Medium	High	Not Sure	No Response	Total
PROB1=Low	32	9	106	20	2	169
PROB1=Med.	3	5	18	2	0	28
PROB1=High	32	5	47	12	1	97
Not Sure	19	10	45	44	3	121
No Response	1	3	9	2	56	71
Total	87	32	225	80	62	486

features of Tables 5.5 and 5.6 is that a large number of property owners did not respond to both questions of a question pair. Only about 58 percent responded with a high, medium or low to both TPR1 and TPR2 (281/486). Only about 53 percent responded in like fashion to PROB1 and PROB2 (257/486).

A test was conducted to determine whether an individual's response was a function of their age, education and whether they belonged to a coalition of property owners. It was expected that older individuals and less educated individuals might find the questions more difficult and be less likely to respond. It was expected that individuals with membership in a coalition might be more interested in providing a response than non-members. A dependent variable was created taking the value of one if a property owner responded with a high, medium or low to a question (alternately variables TPR1, TPR2, PROB1 and PROB2) and set to zero otherwise. Using Probit analysis, this dependent variable was estimated as a function of age (AGE), education (EDUC) and coalition membership (COA) as coded in the previous chapter. The results appear in Tables 5.7 through 5.10. Note that in all cases the Chi-squared values are highly significant suggesting a strong relationship between the dependent and independent variables. For the analyses of TPR1, PROB1 and PROB2, both AGE and EDUC are highly significant and of expected sign (based on t-test prob-values). In the analysis of TPR2 only AGE appears significant. The variable COA appears of little significance in all cases. Even though age and education appear as

Table 5.7. Probit Analysis of Response to Time Preference Rate
        Question: TPR1.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.5678	0.4451	0.2020
AGE	-0.0138	0.0056	0.0131
EDUC	0.2376	0.0585	0.0001
COA	0.0995	0.1682	0.5543

*   *   *   *   *

Chi-Squared = 30.183,   Prob-value for Chi-Squared = 0.1573E-07

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	11	106	117
Actual	1	7	320	327
Total		18	426	444

Table 5.8. Probit Analysis of Response to Time Preference Rate
        Question: TPR2.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	1.1723	0.4346	0.0070
AGE	-0.0149	0.0054	0.0059
EDUC	0.0514	0.0562	0.3603
COA	0.0614	0.1583	0.6983

*   *   *   *   *

Chi-Squared = 10.400,   Prob-value for Chi-Squared = 0.0155

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	1	140	141
Actual	1	3	300	303
Total		4	440	444

Table 5.9. Probit Analysis of Response to Truncation Question: PROB1.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.8020	0.4252	0.0593
AGE	-0.0138	0.0053	0.0092
EDUC	0.1052	0.0556	0.0587
COA	0.1142	0.1572	0.4676

*   *   *   *   *

Chi-Squared = 13.894, Prob-value for Chi-Squared = 0.0031

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	15	140	155
Actual	1	10	279	289
Total		25	419	444

Table 5.10. Probit Analysis of Response to Truncation Question: PROB2.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	1.2896	0.4610	0.0052
AGE	-0.0162	0.0057	0.0047
EDUC	0.1164	0.0592	0.0494
COA	-0.1360	0.1626	0.4029

$$*\quad*\quad*\quad*\quad*$$

Chi-Squared = 16.413, Prob-value for Chi-Squared = 0.0009

$$*\quad*\quad*\quad*\quad*$$

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	2	105	107
Actual	1	1	336	337
Total		3	441	444

strong explanatory variables, the estimates provided by all four of the
analyses are not good predictors. They tend to overpredict the number
of individuals who respond to the questions and underpredict those that
do not. For example (Table 5.7), of the 327 property owners who
responded to TPR1 (also excluding those "not sure"), the model correctly
classified (predicted) owners in 320 cases. However, of the 117
individuals who did not answer TPR1 or responded "not sure", only 11
were correctly categorized.

5.2.3 Framing Effects

Tables 5.5 and 5.6 offer some insight into the issue of the framing of
questions. With respect to time preference rates, TPR1 and TPR2 (Table
5.5), of those individuals responding with a high, medium or low, only
about 20 percent were consistent in their responses, that is, they gave
the same response to each question (sum of diagonal / total responses =
57/281). Furthermore, the simple correlation coefficient of TPR1 and
TPR2 is -0.108 indicating a low (and negative) correlation between the
responses. Turning to the probability truncation variables, PROB1 and
PROB2 (Table 5.6), a similar pattern of inconsistency arises. The
simple correlation coefficient of PROB1 and PROB2 is -0.163. Of 257
people responding with a high, medium or low, about 33 percent responded
consistently (sum of diagonal / total responses = 84/257). Both simple
correlations were calculated after removing from the sample those
individuals who did not respond and those who responded "not sure".

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The cross tabulation in Table 5.5 displays an interesting result. A large number of the respondents who answered both of the time preference rate questions displayed a higher rate when responding to the second question (TPR2). Of the 281 responding, 208 people reported a higher rate for the second question (171 + 10 + 27). Some indication of the reason for this large shift was gleaned from notes written in the margins of some surveys. In responding to TPR1 some individuals simply summed the two rows of costs and chose the lower cost plan. This summation implies a time preference rate of zero. In responding to TPR2 some people indicated that it was not reasonable to put off shore protection activity for any length of time: i) "always should stop any erosion IMMEDIATELY!!," ii) "erosion control projects are usually not undertaken until there is an immediate need" and iii) "erosion control is not an issue that can be delayed for five years." In the context of TPR2, these comments suggest a high time preference rate. Thus, the fact that TPR2 explicitly presented a time tradeoff, while the tradeoff in TPR1 was implied, may have led to this phenomenon. As TPR2 relies on an explicit statement of time tradeoff, it may more realistically reflect the property owner's decision problem.

An attempt was made to explain the shift in responses as a function of several socioeconomic and physical variables. A dependant variable was created which was set to one for all those individuals displaying the shift and set to zero otherwise. The shift was estimated as a function of age (AGE), education (EDUC), present income (INC90), coalition

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membership (COA), and the levels of flooding (FLO) and erosion (ERO). The results are presented in Table 5.11. Although the Chi-squared test suggests a significant relationship, the model is not good at categorizing individuals who did not shift their responses to a higher time preference rate (only 1 of 52 correct). However, the model correctly categorized all but one of those who did shift their response to a higher rate (129 of 130 correct). AGE and ERO appeared as significant explanatory variables. The significance of ERO offers some insight into the framing issue discussed in the previous paragraph. TPR2 was derived from a question making explicit reference to erosion and a time tradeoff; TPR1 was more abstract with no explicit mention of an erosion threat. As such, it is not surprising that as the erosion rate increased individuals tended to express more urgency (higher time preference rate) when presented with the question in the erosion frame (TPR2). The significance of AGE may also reflect an urgency associated with the framing of TPR2; older people may tend to prefer taking protective action sooner giving them more time to directly enjoy the benefits of the action.

The cross tabulation of responses to the truncation questions B8 and B9 (yielding PROB1 and PROB2) presents a phenomenon similar to that shown by the different framing of the time preference rate questions and discussed above (Table 5.6). That is, of the 257 people who responded to both of the truncation questions, 133 indicated a higher level of truncation when responding to the second truncation question (B9) than

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Table 5.11. Probit Analysis of Responses With Change in the Framing of Time Preference Rate Variables TPR1 and TPR2.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	-0.5036	0.7395	0.4958
AGE	0.0198	0.0091	0.0302
EDUC	-0.0528	0.1075	0.6236
INC90	-0.2374E-05	0.3057E-05	0.4373
ERO	0.1696	0.0859	0.0483
FLO	0.0693	0.3349	0.8360
COA	-0.2040	0.2562	0.4259

* * * * *

Chi-Squared = 12.786, Prob-value for Chi-Squared = 0.0466

* * * * *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	1	51	52
Actual	1	1	129	130
Total		2	180	182

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they indicated for the first question (B8; 9 + 106 + 18). As with the
time preference rate questions, an attempt was made to explain the shift
in responses as a function of several socioeconomic and physical
variables. A dependant variable was created which was set to one for
all those individuals displaying the shift from lower to higher
truncation and set to zero otherwise. This shift was estimated as a
function of age (AGE), education (EDUC), present income (INC90),
coalition membership (COA), and the levels of flooding (FLO) and erosion
(ERO). The results are presented in Table 5.12. The Chi-squared test
suggests the relationship between dependent and independent variables is
quite weak (prob-value = .3628). Furthermore, the model correctly
categorized only 105 respondents out of 177. The variable INC90 appears
significant although this is not readily explainable.

Question B8 (PROB1) is set in an insurance context and focusses on an
insurance payoff while question B9 (PROB2) is free of insurance
connotations and focusses directly on property damage. Thus, the
questions differ, both in their level of abstraction, and in the
outcomes of the options (gain in B8 versus damage in B9). Question B8,
with its payout context, may have appeared as a form of a lottery; thus,
respondents choosing the option of a low chance / high payout (low
truncation) may have focussed on the high payout (Slovic and
Lichtenstein, 1983). This may account for the significance of income
(INC90) in Table 5.12 to the extent that low income people tend to play

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Table 5.12. Probit Analysis of Responses With Change in the Framing of
Probability Truncation Variables PROB1 and PROB2.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	-0.5975	0.6958	0.3905
AGE	0.0069	0.0082	0.4057
EDUC	-0.0567	0.0991	0.5671
INC90	0.6127E-05	0.3034E-05	0.0434
ERO	0.0121	0.0772	0.8673
FLO	-0.2712	0.2793	0.3316
COA	0.2174	0.2648	0.4118

*   *   *   *   *

Chi-Squared = 6.566, Prob-value for Chi-Squared = 0.3628

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	45	40	85
Actual	1	32	60	92
Total		77	100	177

lotteries more than persons with a higher income.

Another explanation for the shift in truncation preferences may lie in a different aspect of the framing of the questions. The large group of people (106) responding to B8 with a 0 (low truncation) and to B9 with a 2 (high truncation) may simply have preferred a situation with a low storm probability (despite the high insurance payout offered in B8). The reason they differed from question to question may not be so much the framing as the assumption behind the coding of the variables, PROB1 and PROB2. In question B9 (PROB2), the preference for property of low chance damage was coded as low truncation. In B8 (PROB1), the low chance situation was coded as high truncation. Question B8 was coded this way under the assumption that if a person was to spend money on an insurance policy, they would not spend it on a policy with a low chance of payout if they, indeed, truncated that low probability. However, the respondents may not have perceived the "forced" spending of $250 implied by the framing of B8. Thus, the 106 individuals who appear to have switched preferences from B8 to B9, may not have done so, but rather may be consistent in their choice of a low chance storm situation. The implication here is that B9 (PROB2) may more accurately reflect the truncation phenomenon. Question B9 approaches the truncation question in a less complicated manner; it is not clouded by the abstract notion of insurance and the respondent does not need to consider the added feature of being "forced" to spend $250 on top of the decision regarding policies. It is also interesting to note that 294 people responded to

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B8 with a high, medium or low, while 344 people responded in like
fashion to B9. Margin notes made by some respondents indicated a
dissatisfaction with the insurance frame. Some respondents disliked
insurance in general, while others stated that insurance could not
replace property lost to erosion. Some comments were: i) "I consider
shore protection insurance a 'rip-off' and would consider any
governmental support of an insurance program irresponsible," ii) "I
don't believe in insurance," iii) "Buying insurance doesn't stop
erosion, so why bother," iv) "No insurance!!!," v) "Insurance does not
fix the problem," vi) "Insurance is not the answer," vii "Are you
selling insurance? Don't bother me again," viii) How do you calculate
damage in dollars," and ix) "When land (dunes) are gone - it is for a
lifetime."

The analysis presented in this section suggests that TPR2 and PROB2 may
be more appropriate than the TPR1 and PROB1 as explanatory variables in
the protection adoption model. TPR2 was derived from a question which
presented the respondent with an explicit intertemporal choice; PROB2
was derived from a question which presented options uncluttered by an
individual's views on insurance.

5.2.4 Risk Attitude

A set of three questions on the survey was designed to elicit a person's
attitude toward risk. The variable RATT was coded such that it ranged

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from 1 to 5 where the value of 1 indicated strong risk seeking behavior, and 5 indicated strong risk aversion; a value of 3 indicated risk neutrality. The question was framed in terms of insurance policies which could be purchased to protect against storm damage. The average risk attitude score was 2.39 on the five point scale indicating people tended to be risk seeking (standard deviation of 1.53). Of the 371 people who responded to the set of questions, 246 indicated a score of 1 or 2. A minority of the respondents (125 of the 371) were risk neutral or risk averse. This result supports the findings of some laboratory studies which found that people tended to be risk seeking when faced with losses (Kunreuther et al, 1978; Schoemaker and Kunreuther, 1979).

5.3   Time Preference Rate Models

One of the objectives of this study was to determine if time preference rates varied over individuals. The responses to the time preference rate questions are presented in Table 5.13. There is a considerable dispersion among responses for both of the questions although the majority of people responded with a 'low' to TPR1 and with a 'high' to TPR2.

It was hypothesized that an individual's response to the time preference rate questions could be characterized by several physical and socio-economic factors:

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Table 5.13. Number of Responses to TPR1 and TPR2.

Response	TPR1	TPR2
0	256	40
1	46	31
2	45	249
-7	95	105
-9	44	61
Total	486	486

TPR = g(INC90, AGE, EXP, RATT, FLO, ERO, COA)

where

TPR   = the personal rate of time preference applying to shore

          protection decisions,

INC90   = the income of the landowner,

AGE   = the age of the landowner,

EXP   = the owners experience with flooding and/or erosion,

RATT   = risk attitude of the landowner,

ERO   = level of erosion activity,

FLO   = level of flooding activity, and

COA   = membership in a coalition.

INC90 is a measure of present income and is used in the following

analyses because time preference rates were elicited using hypothetical

questions set in the present. Separate analyses were conducted for TPR1

and TPR2.

The results of the analysis of TPR1 (obtained from B1) are displayed in

Table 5.14. The Chi-squared test suggests that there is little

relationship between TPR1 and the independent variables. The model

displays no predictive power, placing all respondents in the low time

preference rate group (group 0). Based on the prob-values on the

individual variables, only income (INC90) appears to show some

significance (prob-value = 0.0790). This may reflect the frame of the

question. The margin notes of some respondents indicate that they

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Table 5.14. Ordered Probit Analysis of Time Preference Rate Model With
    TPR1 as the Independent Variable.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	-0.0528	0.7486	0.9437
AGE	-0.0130	0.0104	0.2089
COA	0.1915	0.2647	0.4693
INC90	0.5404E-05	0.3076E-05	0.0790
EXP	0.0054	0.0081	0.5043
RATT	0.0109	0.0620	0.8601
ERO	-0.1083	0.0798	0.1745
FLO	0.1821	0.3095	0.5563
EDUC	-0.0365	0.1011	0.7181

*   *   *   *   *

Chi-Squared = 8.284,   Prob-value for Chi-Squared = 0.4063

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted			Total
		0	1	2	
Actual	0	138	0	0	138
Actual	1	26	0	0	26
Actual	2	27	0	0	27
Total		191	0	0	191

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simply summed the annual costs of the options presented in B1 and chose the option of lower nominal cost, ignoring any notion of some time preference rate. An individual choosing the higher nominal cost option (interpreted by this analysis as indicating a high time preference rate) might have done so because of a higher income.

Changes in the time preference rate as elicited from question B2 (TPR2) were estimated as a function of the same independent variables as used in the analysis of TPR1. The results are presented in Table 5.15. In terms of its predictive ability and the Chi-squared test, this model does little to explain the variation in TPR2. Based on the individual variable prob-values, only erosion (ERO) appears related to TPR2. Question B2 elicits the time preference rate by presenting an explicit time tradeoff situation. Individuals who do not prefer to wait to stop erosion were considered to have a high rate. As such it is quite reasonable that as the erosion rate increases individuals will be more likely to want to take action sooner.

From the above analysis it appears that the time preference rate varies over individuals and furthermore, that this rate is difficult to explain in terms of socioeconomic and damage potential variables. As such, the time preference rate may enter the adoption protection model as independent of these variables.

Table 5.15. Ordered Probit Analysis of Time Preference Rate Model With
TPR2 as the Independent Variable.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.7755	0.7566	0.3054
AGE	0.0113	0.0099	0.2538
COA	-0.1089	0.3003	0.7168
INC90	0.3595E-06	0.3282E-05	0.9128
EXP	-0.0051	0.0096	0.5948
RATT	-0.0921	0.0811	0.2560
ERO	0.2033	0.1168	0.0818
FLO	-0.0936	0.4074	0.8183
EDUC	-0.1238	0.1168	0.2892

*   *   *   *   *

Chi-Squared = 10.275,   Prob-value for Chi-Squared = 0.2462

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted			Total
		0	1	2	
Actual	0	27	0	0	27
Actual	1	15	0	0	15
Actual	2	133	0	0	133
Total		175	0	0	175

5.4 Probability Truncation Models

The responses to the probability truncation questions are presented in Table 5.16. There is a wide dispersion in responses.

It was hypothesized that the degree to which a property owner truncates the low probability of a hazard will be influenced by several factors:

PROB = h(EXP, EDUC, RATT, INC90, ERO, FLO, COA,)

where

PROB = the degree to which a landowner truncates the probability of the occurrence of an hypothesized hazard event,

EXP   = the owners experience with flooding and/or erosion, and

EDUC = the education of the landowner.

RATT = risk attitude of the landowner,

INC90 = the income of the landowner,

ERO   = level of erosion activity,

FLO   = level of flooding activity, and

COA   = membership in a coalition.

Separate analyses were conducted for PROB1 and PROB2.

Table 5.17 reports the results of the analysis for PROB1. The Chi-squared test indicates that a relationship between PROB1 and the independent variables exists with a confidence level of 92 percent. The

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Table 5.16. Number of Responses to PROB1 and PROB2.

Response	PROB1	PROB2
0	169	87
1	28	32
2	97	225
-7	121	80
-9	71	62
Total	486	486

Table 5.17. Ordered Probit Analysis of the Probability Truncation Model
With PROB1 as the Independent Variable.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.7998	0.4672	0.0869
FLO	0.1774	0.2779	0.5233
ERO	-0.0884	0.0725	0.2222
COA	-0.5569	0.2794	0.0462
EDUC	-0.1350	0.0969	0.1635
EXP	-0.0023	0.0068	0.7301
INC90	-0.4007E-05	0.3040E-05	0.1874
RATT	0.0179	0.0633	0.7771

*   *   *   *   *

Chi-Squared = 12.623,   Prob-value for Chi-Squared = 0.0818

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted			Total
		0	1	2	
Actual	0	88	0	10	98
Actual	1	12	0	4	16
Actual	2	44	0	12	56
Total		144	0	26	170

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model is not a good predictor but does have some ability to categorize individuals with a low and a high level of truncation (PROB1 = 0, 2). Any significance in the model appears to arise from the variable COA. Perhaps coalition members are more concerned with smaller but frequent storms and thus, would tend to prefer insurance against these storms (Policy A in question B8).

The results of the analysis for PROB2 are presented in Table 5.18. The Chi-squared test and the model predictions suggest that PROB2 has little relationship to the dependent variables. Only income (INC90) appears to show some significance (prob-value = 0.0147). This suggests that the higher the income the more likely a property owner is to truncate low probability (choose Property B in question B9). The high income group may be more able to endure costly storms and thus be more concerned with choosing a property with a low hazard.

As indicated by Table 5.16 there is a wide dispersion in the responses to both probability truncation questions. Additionally, it is difficult to explain this variation in terms of socioeconomic variables and hazard level variables. Thus, the probability truncation variable may enter the adoption model independent of the socioeconomic and hazard level variables. Note that risk attitude (RATT) does not appear to play a role in the responses to either of the truncation questions.

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Table 5.18. Ordered Probit Analysis of the Probability Truncation Model With PROB2 as the Independent Variable.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.5718	0.4810	0.2345
FLO	-0.2068	0.2649	0.4349
ERO	0.0063	0.0753	0.9330
COA	-0.1719	0.2474	0.4871
EDUC	-0.1050	0.0967	0.2774
EXP	-0.0007	0.0070	0.9171
INC90	0.7687E-05	0.3152E-05	0.0147
RATT	-0.0038	0.0611	0.9507

* * * * *

Chi-Squared = 8.476, Prob-value for Chi-Squared = 0.2925

* * * * *

Frequencies of Predicted and Actual Outcomes

		Predicted			Total
		0	1	2	
Actual	0	0	0	51	51
Actual	1	0	0	14	14
Actual	2	2	0	126	128
Total		2	0	191	193

5.5 Time Horizon Model

The time horizon question allowed a choice of one of three responses. The number of individuals responding was dispersed almost evenly among the three options: 139 responded "less than 5 years", 133 responded "5 to 10 years", and 145 responded "over 10 years" (69 did not respond).

It was hypothesized that an individual's time (planning) horizon would be affected by several variables:

TH = f (AGE, EDUC, INC90, ERO, FLO, COA)

where:

TH   = time horizon,

AGE   = age of the property owner,

EDUC = education of the property owner,

INC90 = income of the property owner,

ERO   = level of erosion activity,

FLO   = level of flooding activity, and

COA   = membership in a coalition.

Because the time horizon (TH) question was framed in terms of planning for shoreline property protection, it was expected that the level of flooding (FLO) and erosion (ERO) experienced by the property owner might affect their response. Where they perceive a greater hazard they may see a need for immediate planning. It was also expected that age (AGE),

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income (INC90), and education (EDUC) might be positively related to time horizon. The need for and ability to make long range plans may be reflected in the time horizon. Additionally it was expected that coalition (COA) members might display a shorter time horizon as they are more visibly concerned with immediate shoreline hazards.

The results of this analysis are presented in Table 5.19. The Chi-squared test indicates that the relationship between TH and the independent variables is quite weak (prob-value = 0.59). The prob-values for the t-test also indicate that each individual variable does little to explain TH. The weakness of these relationships is also indicated by the poor predictive capacity of the model.

Responses to the time horizon question varied considerably and are difficult to explain in terms of socioeconomic characteristics of the respondent. As such, TH may enter the protection adoption model independently of these other variables.

5.6 Protection Adoption Models

The protection adoption model is rooted in the expected net benefits model, that is, the arguments were derived from that model. As discussed in Chapter 3 the decision to take action is a function of several variables; the empirical model is as follows:

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Table 5.19. Ordered Probit Analysis of Time Horizon Model.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	0.3238	0.5105	0.5259
AGE	0.0052	0.0059	0.3829
INC90	-0.1192E-05	0.2245E-05	0.5955
COA	-0.1882	0.1981	0.3421
ERO	-0.0505	0.0517	0.3293
FLO	-0.1646	0.1932	0.3942
EDUC	0.0325	0.0699	0.6416

* * * * *

Chi-Squared = 4.658, Prob-value for Chi-Squared = 0.5883

* * * * *

Frequencies of Predicted and Actual Outcomes

		Predicted			Total
		0	1	2	
Actual	0	30	3	50	83
Actual	1	21	10	58	89
Actual	2	16	10	68	94
Total		67	23	176	266

Protect/Not Protect = g(TPR, PROB, TH, PRPR, PVAL, KSP, ERO,

FLO, INS, OCC, TEN, RESID, AID, CAP,

RATT, AGE, EDUC, EXP, COA, INC)   [5.1]

where

TPR   = landowner's personal time preference rate,

PROB = probability of experiencing damage,

TH   = the landowner's personal time (planning) horizon,

PRPR = shoreline protection taken by a previous owner,

PVAL = the market value of the property,

KSP   = the perceived capital cost of shore protection,

ERO   = severity of erosion,

FLO   = existence of a flooding problem,

INS   = commercial insurance to protect against flooding,

OCC   = the frequency of occupancy of the dwelling,

TEN   = the tenancy status of the property,

RESID = existence of a residence on the property.

AID   = expectation of government aid for protection,

CAP   = the degree that protection expenditure is expected to be

        capitalized into the market price of the property,

RATT = the property owner's risk attitude,

AGE   = age of the property owner,

EDUC = education of the property owner,

EXP   = past experience with flooding and erosion of property,

COA   = membership in a coalition, and

INC   = income.

Two different measures of the time preference rate (TPR1 and TPR2) and the level of probability truncation (PROB1 and PROB2) were available as explanatory variables in this model. However, the analyses presented above (sections 5.3 and 5.4) suggest that TPR2 and PROB2 would be the most appropriate. TPR2 was derived from a question (B2) which explicitly presented both the erosion issue and the time trade off issue. TPR1 was derived from a question (B1) where the time trade off issue was implied only by the choice loan repayment plan. As such, TPR2 may more appropriately reflect the intertemporal nature of a decision to take protective action. With respect to probability truncation, PROB2 was elicited via a choice between two properties differing only in the probability and severity of hazard (question B9). PROB1 was derived from a question (B8) posed as a choice between insurance policies. The insurance frame may have clouded the elicitation of probability truncation in that many individuals expressed a dislike of insurance policies. Some respondents saw insurance as inapplicable to their situation: available insurance does not cover loss of soil nor is there a way to replace soil even if insurance did cover soil loss. A few individuals were upset with the question as they saw it as some scheme to sell insurance. Thus, PROB2 may more accurately reflect probability truncation.

In some preliminary estimation of the adoption models, property value (PVAL) was used as a measure of economic damage potential. Initial results indicated that PVAL was strongly and negatively related to the

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likelihood of taking protective action. This result is counter to the hypothesized direction of the relationship. However, with further reflection this result is not a surprising. The property value reported by some owners would have reflected the fact that their property was not susceptible to erosion or flooding hazard. Thus, a high property value may not reflect a high damage potential but rather may reflect no damage potential. So as to capture the effect of damage potential in economic terms, two new variables were created to include in the adoption protection model; one the product of erosion level and property value (ERO*PVAL); the other was the product of flooding hazard and property value (FLO*PVAL).

Initial estimates of the adoption model are presented in Table 5.20. The Chi-squared test indicates there is a strong relationship between PROT (taking protective action or not) and the independent variables. The model correctly classifies 118 out of 148 observations.

The initial model contained a large number of explanatory variables. Final estimates were obtained after a process of removing some of the variables which were of low statistical significance (Table 5.21). The variables that were deleted were removed one or two at a time in an iterative process. This was done in order to view the stability of the coefficients of the remaining variables. Existence of instability may reflect multicollinearity. The results were relatively robust, that is, the coefficients were stable given changes in the model specification.

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Table 5.20. Initial Probit Analysis of Protection Adoption Model
        Including TPR2 and PROB2.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	-4.6131	1.5269	0.0025
INS	-0.0551	0.4041	0.8915
ERO	0.6025	0.1988	0.0024
FLO	0.7926	1.1139	0.4767
ERO*PVAL	$-0.7472E-06$	$0.1031E-05$	0.4684
FLO*PVAL	$-0.2226E-05$	$0.6799E-05$	0.7434
PRPR	0.3611	0.4839	0.4556
RATT	-0.1043	0.0945	0.2698
INC	$0.7858E-05$	$0.4080E-05$	0.0541
CAP	0.1917	0.1329	0.1491
EXP	0.0129	0.0122	0.2897
AID	-0.0193	0.1414	0.8913
OCC	0.1845	0.2365	0.4355
TPR2	0.3881	0.2193	0.0768
PROB2	-0.2946	0.1587	0.0634
TH	-0.0755	0.1718	0.6602
COA	0.4759	0.3335	0.1537
AGE	-0.0095	0.0138	0.4911

*   *   *   *   *

Table 5.20.   Continued.

Independent Variable	Coefficient	Standard Error	Prob-value
EDUC	0.0484	0.1332	0.7163
RESID	1.6203	0.8134	0.0464

*   *   *   *   *

Chi-Squared = 63.004,   Prob-value for Chi-Squared = 0.1357E-06

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	92	10	102
Actual	1	20	26	46
Total		112	36	148

Table 5.21. Final Probit Analysis of Protection Adoption Model
        Including TPR2 and PROB2.

Independent Variable	Coefficient	Standard Error	Prob-value
Intercept	-3.2075	0.8568	0.0002
ERO	0.4733	0.1030	0.0000
FLO	0.4117	0.3988	0.3019
RATT	-0.1332	0.0897	0.1375
INC	0.7150E-05	0.3420E-05	0.0366
AID	-0.5156	0.3105	0.0969
TPR2	0.3628	0.2024	0.0730
PROB2	-0.2531	0.1489	0.0892
COA	0.4263	0.3085	0.1670
RESID	1.1373	0.6913	0.1000

*   *   *   *   *

Chi-Squared = 60.494, Prob-value for Chi-Squared = 0.3089E-11

*   *   *   *   *

Frequencies of Predicted and Actual Outcomes

		Predicted		Total
		0	1	
Actual	0	95	10	105
Actual	1	21	26	47
Total		116	36	152

Additionally, simple correlation coefficients among the independent variables did not point out any potential sources of multicollinearity. Unfortunately, no formal procedures exist for diagnosing multicollinearity in Probit or Logit models. The variables that were removed were those that were highly statistically insignificant. Although some relatively insignificant variables remain in the final model, these variables have theoretical appeal.

The Chi-squared test indicates a statistically significant relationship. The model correctly categorizes 121 of 152 observations (79.6%), although there is a tendency to predict that a property owner did take action when in fact they did not (21 cases out of 31 mispredicted). Both TPR2 and PROB2 display a strong statistical significance (Table 5.21). The sign on PROB2 is negative as expected, that is, as a property owner ignores the chance of a storm (truncates the probability) that owner is less likely to take protective action. The sign on TPR2 is positive which is opposite of what was initially hypothesized. However, the initial hypothesis assumed that the costs of shore protection would fall in the present while benefits would accrue over a longer time; thus, a high time preference rate would reduce benefits more than costs and would tend to reduce the likelihood that protective measures would be undertaken. The framing of question B2 (the basis of TPR2) presented a situation where some individuals saw the erosion of property as something that must be stopped immediately, that is, the benefits were immediate and presumably costs could be put off until

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later. Thus, a high time preference rate would tend to be positively related to the likelihood that action was taken. For the purpose of comparing the explanatory power of TPR1 with TPR2, and PROB1 with PROB2, the model was estimated including TPR1 and PROB1. Neither of these variables were statistically significant, although, for the other variables in the model, there was little change significance or in the magnitude of the coefficients.

The coefficients on the variables ERO, FLO, RATT, INC, AID, COA, and RESID were of expected sign except for RATT. As the level of flooding and erosion increase (FLO and ERO), a person is more likely to take protective action; properties with a residence (RESID) are more likely to be protected; where government aid is expected (AID) properties are less likely to be protected; coalition members are more likely to have taken action, and those with higher incomes are more likely to act.

RATT, with a negative sign, appears as an anomaly. It was expected that those individuals who were more risk averse would tend to adopt protective measures. However, risk averse individuals may have initially purchased properties that were not subject to flooding or erosion hazards; as such, they would be less likely to take protective action. The findings of section 5.2.3 (Framing Effects) may offer another explain for this observed relationship. Because of the expressed aversion to insurance on the part of some respondents, the variable RATT may be reflecting an attitude toward insurance rather than

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risk attitude. To the extent that insurance and physical protection measures are substitutes, it can be expected that those persons preferring insurance may be less likely to adopt physical protection measures, hence, the negative sign on RATT. The variable INS did not pick up this relationship as it only asked if an owner had special flood insurance. Of 472 people responding to this question, only 36 held such insurance. Furthermore, the construction of the questions from which RATT was coded provided a measure of greater variability than INS.

The cost of shore protection (KSP) did not appear significant in explaining the probability that a property owner would take action. This may be due to the construction of the variable KSP. KSP was constructed from responses of those who had actually built shore protection and from responses of those who had not; the latter estimated what they thought it would cost. For the latter group the upper end of the response range was coded at $11,000; the former group faced no such restriction. Thus, in coding KSP, any response over $11,000 by those who did take action was truncated to $11,000 (see coding of KSP). This greatly reduced the variation in KSP. The variation in KSP was further reduced as most of the respondents who did not take action indicated they thought the cost would lie in the upper end of the response range.

In themselves the reported coefficients do not indicate how important each of the variables is to the adoption protection decision. An indication of this importance is presented in Table 5.22. These figures

Table 5.22 Change in the Probability That a Property Owner Will Take
Protective Action Given a Unit Increase in the Explanatory
Variables*

Independent Variable	Change in Probability
ERO	0.149
FLO	0.130
RATT	-0.042
INC	0.23E-5
AID	-0.162
TPR2	0.114
PROB2	-0.080
COA	0.134
RESID	0.358

* estimated based on the means of all variables.

show the change in the probability that an individual will take
protective action, given a one unit change in the independent variable
in question. For example, as erosion (ERO) increases by one (ERO was
coded as taking a value of 1 to 5), the probability that an owner will
take action increases by 14.9 percent. Note that the time preference
rate and the degree of probability truncation will have a considerable
impact upon the likelihood a property owner takes action (as do most of
these variables).

5.7   Conclusions

Responses to the questions eliciting the time preference rate (TPR2),
probability truncation (PROB2) and time horizon (TH) varied considerably
from person to person. However, the models characterizing these three
variables as functions of socio-economic and damage level variables were
not supported by the data.

With respect to the protection adoption model, TPR2 (time preference
rate) and PROB2 (probability truncation) were significant in explaining
an individual's choice. Other variables, more traditionally appearing
in economic analyses, also proved to be significant. TPR2 and PROB2
also proved to have greater explanatory power than the alternative
measures, TPR1 and PROB1. This result was expected as TPR2 and PROB2
were derived from questions that focussed more clearly on the phenomena
in question.

Some respondents indicated that eroded soil could not be replaced. As such, insurance policies were unattractive. Additionally, this encouraged some individuals to choose shore protection projects that would take effect immediately, implying a high time preference rate. Thus, it appears that some respondents do not think of soil losses in monetary terms. One property owner stated "What an appraiser thinks my property is worth does not concern me as much as how the damage affects my feelings of the property....The amount of footage lost is more important than someone else's idea of value lost." Another owner stated "We are more concerned about the security of the residence from the water than we are of the value of the property."

Chapter 6

Summary and Implications

In recent years shoreline residential property owners along the Great Lakes have petitioned government agencies to take action to mitigate the effects of flooding and erosion on the Lakes. This direct public pressure, particularly at a time of government spending restraint, has focussed attention on the rationale and techniques used by public planners in: i) assessing the benefits of various measures which might be taken and ii) encouraging behavioral changes on the part of the public to take actions to reduce natural hazards.

The various forms of benefit-cost analyses used by public planners to assess various mitigative actions are rooted in the economic models of rational choice. These models can serve in both a normative capacity (how we should make decisions) or a descriptive capacity (how we do make

decisions). Although the economic models of expected and discounted utility theory are elegant in their simplicity and are normatively appealing, they have come under criticism as descriptive models at both theoretical and applied levels in geography, psychology and economics. To the extent that some of that criticism is valid, benefit assessment models will not appropriately describe human behavior and, hence, will be inaccurate both in accounting for project benefits and predicting behavior.

This study has focussed on several elements of the net benefits assessment model. The hypotheses developed in Chapter 2 were not derived from the theoretical economic model, but rather from criticism of that model, criticism based upon observation. Specifically, those elements addressed here are the time preference rate, time horizon, and the understanding of probability of individual decision makers. Much of the criticism of the economic model reflects concern with the manner in which these elements are treated in economic analyses. Typically, the time preference rate is fixed at one rate (market or otherwise), the time horizon is set equal to the project life and probability is treated as the analyst understands it. This study found that, for a particular decision, time preference rates varied among property owners and that this variation was significant in explaining the likelihood that these individuals would take action to protect their shoreline. Additionally, this study found that some individuals appear to disregard the possibility that low probability events will occur; this too was

significant in explaining the likelihood that owners would take protective action.

6.1 Implications for the Economic Theory of Rational Choice

One result of this study was the finding that the framing of a question affected the response. Two time preference rate questions were formulated such that they were equivalent, by the axioms of discounted utility theory. Additionally, two probability truncation questions were formulated such that they were approximately equivalent given the axioms of expected utility theory. For each question pair, a large number of people provided different answers in response to a change in the question frame. Similar results abound in the literature (Tversky and Kahneman, 1987).

Although, question framing appears to affect responses, this might not indicate a violation of any particular axiom of either Expected Utility or Discounted Utility Theories. Indeed, the normative appeal of the model remains intact. However, the framing effects do threaten the overall descriptive capacity of these models. Where two questions are theoretically equivalent, different responses indicate that there is some element of choice that has not been accounted for in the theory. An alternative interpretation is that such respondents are irrational, a particularly unpalatable notion to a modeler of human behavior, especially considering the robustness of similar results.

In the time preference rate question which was framed as a loan repayment schedule, individuals tended to choose a low rate (less than ten percent); for the question framed as a choice between protection now or later, people tended to choose a high rate (over ten percent). This suggests individuals apply different time preference rates to different choice situations which supports similar findings by Ruderman, Levine and McMahon (1987). Although, this finding in itself does not threaten utility theory as applied to an individual, it does suggest that an individual does not employ some single rate determined by a market in making all intertemporal comparisons. Furthermore, from this research, it is not clear what factors determine the time preference rate for a particular individual. Models estimated for this study which described the rate as a function of socio-economic variables and damage potential variables were singularly weak at explaining an individual's time preference rate.

Thus, the findings of this study do not threaten the normative capacity of the rational economic model of individual behavior. However, the findings do suggest that the theoretical model is difficult to apply with consistency (framing issue). Furthermore, variations among people in time preference rates suggest these rates have not equilibrated as the economic model of market behavior would suggest.

6.2 Implications for Fieldwork

The main advantage of designing the time preference rate and probability truncation questions for field use is that the actual decision maker can be confronted with a relatively realistic choice setting: protection of the shoreline. Much of the previous research designed to elicit time preference rates and probability truncation was conducted in controlled laboratory settings. Subjects, community volunteers or often university students, would be offered simple and abstract options from which to choose. As such, the analyst could maintain relative control over the experiment. Experiments can be replicated easily and can be explained carefully to ensure uniform understanding. However, the findings of such experiments may not be readily transferable to all situations outside of the lab. Indeed, as mentioned previously, this study shows that a slight variation in the framing of a question can provide quite different results. In this study, the controlled laboratory environment was approached by way of a multivariate analysis. That is, a considerable information was collected regarding each individual and their environment; this information formed an experimental control.

The time preference rate and probability truncation questions were difficult to answer relative to the rest of the survey. They were hypothetical in nature and involved extended reading on the part of the respondent. However, a large number of property owners did respond to these questions indicating this type of question can be used

successfully in the field. The success of these questions may be due, in part, to an interest in the issue and in demographics. The respondents were more educated and had higher incomes than average; analysis showed these variables to be a positive function of respondent age and education. The severe storms of recent years may have promoted an increased concern over hazard issues.

In summary, this study suggests that experimental exercises can be removed from the laboratory with success, the advantage being that the questions can be designed for the decision maker in question. However, considerable care must be taken in developing the questions to reduce the trade-off between a loss of experimental control and targeting the subject. In a mail survey format, there is no opportunity to correct misunderstandings or to provide additional explanations.

6.3   Implications for Policy

Aside from the framing issue, the findings of this study have little implication for the theoretical economic model of individual decision making. This is, no doubt, due to the abstractness of the model. However, it is in the application of the economic model that these findings will yield some implications.

Many different measures have been proposed to mitigate the flooding and erosion hazards on the Great Lakes. These measures have been broadly

categorized as follows:

i) direct government spending on structures to modify lake levels and

      channel flows,

ii) direct government spending to reduce or eliminate flooding or

      erosion hazards. This group would exclude modification of coastal

      processes as in i); it would include such actions as shore

      protection (sea walls, breakwaters) and harbor dredging,

iii) direct government restriction of land and water use. This category

      includes zoning to restrict building construction in hazard areas,

iv) indirect government restriction of land and water use. Included are

      various taxes and/or subsidies to influence activities affecting

      damage potential, and

v) emergency planning by governments. Timely forecasting of levels and

      severe weather conditions are measures which fall into this group.

In viewing the array of available measures, the policy analyst will be

concerned, for all measures, with benefit assessment and, for some

measures, with the tools which may be available to encourage property

owners to take protective action. The implications of this research for

these two concerns will be presented in turn.

6.1 Benefits Assessment

In assessing the benefits of hazard reduction a public planner may rely

upon the concept of willingness to pay (WTP) as a reflection of those

benefits (Herfindahl and Kneese, 1974). That is, the benefits of a proposed hazard reduction measure are equal to what each individual, rational and fully informed, would be willing to pay for the hazard reduction (summed over all individuals). The WTP reflects the utility associated with the hazard reduction measure in question. In practice, as utility is difficult to measure, planners have come to rely on the damages avoided model (DA), that is, the property damages which can be avoided by undertaking a particular measure are taken to represent WTP for that measure.

Care must be taken in using damages avoided as a measure of WTP for shore protection. That is, several assumptions must be made for DA to be an appropriate proxy. Some of these assumptions are:

i) all shoreline property owners are risk neutral. To the extent that a property owner is risk averse (seeking) the use of the DA model will underestimate (overestimate) that person's WTP for shore protection. From this study, it appears that the majority of property owners are risk seeking when making decisions about flooding and/or erosion hazards they may face (section 5.2.4). Similar findings appear in the literature (Schoemaker and Kunreuther, 1979; Kunreuther et al, 1978). This suggests that application of the damages avoided model in assessing shore protection on the Great Lakes will tend to overestimate the WTP for protection by property owners.

ii) the marginal utility of a dollar of income is equivalent over all dollars and all property owners. This assumption implies that a

given increment of hazard reduction will be valued the same by all

individuals and no matter what their income level. This makes it

possible to aggregate benefits over a number of individuals by a simple

summation process. Although not an original objective, this study found

evidence that individuals faced with erosion of their property placed a

higher marginal utility on the soil subject to loss than on the dollar

value assigned to that soil. This evidence appeared in margin notes

associated with the time preference rate question which was framed in

terms of shore protection to be built now or later. These notes

indicated that action must be taken immediately because soil was not

replaceable at any price. To the extent this phenomenon persists, the

use of DA techniques will underestimate the property owner's WTP for

shore protection.

iii) it is assumed that the public planner and all the shoreline

property owners in question have the same information about the

probability and severity of hazard events and that they all apply the

same time preference rate to intertemporal choice decisions regarding

hazard reduction. This assumption, if met along with assumption ii)

ensures that the public planner is accurately accounting for the

discounted and expected utility of each individual for shore protection.

To the extent that these assumptions do not hold, the level and

direction of inaccuracy of DA as a measure of WTP is not readily

obvious. This study found that individuals varied considerably in the

time preference rates they applied to their decisions and in the degree

to which they truncated low probabilities. The time preference rate

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issue may offer more of a problem than the truncation issue. By ignoring truncation in a damages avoided analysis the direction of any estimation error lies in one direction: the analyst will overestimate the expected damage relative to the property owner. However, for any particular time preference rate chosen by an analyst and applied to all individuals, it is not clear whether that rate will over or underestimate the individual's rate.

In accounting for variations in time preference rates and probability truncation, the model developed here is more descriptive than the typical benefit-cost model that holds these factors constant. However, despite the potential biases discussed above, the applied benefit cost model remains a useful tool. Basic elements of the model were important in explaining the likelihood that individuals would adopt shore protection. To improve the descriptive capacity of the model, the analyst will need to direct attention toward the time preference rates specific to the individuals in question, and to their understanding of the probability of hazard events.

With respect to the time preference rate, it will no doubt be prohibitively difficult to attempt to elicit such rates from the public on an individual basis. However, such elicitation may be done for a sample of the population of study; an average rate may then be applied. The main point is that, a particular market rate may not reflect the average time preference rate, reducing the accuracy of benefits

assessment should the market rate be used.

With respect to probability truncation, it may be possible to develop a measure useful in assessing benefits. No doubt obtaining such a measure would be difficult. Here, information programs may be useful; the more a person understands the probability of potential hazards, the more accurate the benefits assessment model. The need for a measure of probability truncation disappears.

6.3.2 Behavioral Implications

The preceding pages have provided some indication that the DA technique may provide an inaccurate measure of WTP for the hazard reduction measures described above. Although the DA technique is a method of accounting for the benefits individuals place on hazard reduction, it is also a behavioral model. This is reflected in arguments of the model (Chapter 2) and in the assumptions, just stated, which outline its usefulness as a measure of willingness to pay. Thus, for example, any variation between the public planner and property owners in their time preference rates, suggests the planner's model will not be able to account for some behavior.

One measure which might be considered to influence the behavior of property owners is that of hazard insurance, whether offered by the private or public sectors. To the extent an individual is insured

against a hazard, that person will be less likely to desire public protection from any hazards. This study suggests that property owners tend to be risk seeking and tend to truncate the low likelihood of hazard damage. Both of these forces will tend to reduce the demand for hazard insurance. Indeed, many people may choose not to buy insurance even at highly subsidized prices. This was the finding of Kunreuther et al (1978) in a study of people living in earthquake and flood zones. This is not to say that hazard insurance is not an option open to policy makers. Perhaps two basic types of policies may be developed which are attractive to two different types of property owners: policies with a low ceiling designed to cover the high probability, low damage events, and policies with a high deductible to cover only the low probability, high damage events.

It may be difficult to develop any insurance policies for erosion damage. Several of the hypothetical questions in the survey were framed as choices of insurance policies. These questions drew comments which reflected a distaste of insurance as an option for protecting property. The point of these comments was that existing insurance policies would not cover erosion losses such as soil and trees. This is related to the observed responses to the time preference rate survey question which was framed as an explicit tradeoff between less protection now and a greater degree of protection at a later period. Comments suggested that, where property is eroding, action must be taken immediately; there is no substitute for the loss of soil. Perhaps the argument favoring

government regulation of Lake levels is pursued to the extent it is because insurance is seen as a poor substitute for physical measures. As shoreline erosion is a continuing process, which over long periods can thwart the best of human efforts to stop it, it is unlikely that viable insurance policies can be developed for losses of beaches and other land.

One method of indirectly influencing people to take protective action, is to provide financing for them to undertake such action. However, the findings of this study suggest this measure would meet with limited success. Those individuals who are experiencing flooding and erosion tend to display a high time preference rate, above ten percent. For some, this rate may be well above the market finance rate. Thus, a finance rate below the time preference rate may not encourage borrowing to undertake protective action, although no doubt, there maybe be some very low finance rate which might encourage such borrowing. This suggests that finance rate is not preventing individuals from protecting their property. It is more likely that, for those experiencing flooding and erosion, the total cost of protection may be the prohibiting factor (thus the cry for the USACE to take action).

It appears that insurance programs and financing programs will meet with little success in encouraging self protective behavior. Aside from direct government expenditure on mitigative measures, the remaining major types of measures are government restriction of land and water

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use, and information programs. Zoning restrictions can be highly successful at reducing property damage but may be politically difficult to institute.

With respect to information programs, this study provides evidence that some individuals expect government aid in mitigating flood and erosion losses (26 percent in this sample) and that this expectation reduces the chance that protective action will be taken. This suggests that any information programs make clear the role the government will take concerning such issues. The extent and type of any aid must be made clear.

The empirical results of this study suggest that there is a tendency for individuals to truncate the likelihood of low probability hazard events; that is, they ignore low probability events. Furthermore, this tendency reduces the likelihood that individuals will take action to protect themselves. As such, in designing information programs, it may be more appropriate to express hazard probabilities in periods of longer than an annual recurrence. Using a ten or twenty five year period as the basis of presenting probability information may provide property owners with a better understanding of the risks they will face during their ownership of the property. For example, consider an event for which there is a 2 percent chance of occurrence in any one year. This can be restated as an 18.3 percent chance of occurring at least once in a ten year period, or as a 39.7 percent chance of occurring at least once in a twenty five

year period.

6.3.3 Awareness of Hazards

One of the questions concerning the geographers of the 1960's was why
would people continue to live in areas of established risk. Although
not directly investigating the residential location choice of property
owners, this study offers some suggestion that individuals purposefully
choose to live along the Great Lakes with some awareness of potential
hazards. The study sample contained well educated people with quite
respectable incomes and who had lived along the shore for almost 20
years on average. These people were likely to be aware of flooding and
erosion hazards. Although some of these people may have been surprised
by the hazard potential, they have chosen to remain on the Lakes. Such
actions suggest they prefer to live with the hazards in order to gain
the benefits of shoreline living. That is, they could have moved away
but chose not to. Note that this may be quite a different phenomenon
than a flood hazard in a riverine setting. It may be quite difficult to
recognize an urban floodplain in a low water period as such floodplains
can extend for considerable distances beyond the river bank; in a lake
front setting the water hazard directly abuts each owners property.

The survey results provide an additional suggestion that the sample of
property owners is aware of the hazard situation on the Lakes. Of the
entire sample almost 39 percent took some sort of protective action. It

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is obvious that this group is aware of the shoreline hazards. Of the remaining 61 percent, all were either aware of their flooding and/or erosion problem or felt they had no problem. Although some were not able to provide an estimate of their erosion or flooding rate they were able to indicate whether or not they had a problem.

6.4   Limitations and Future Research

Some of the limitations of this study are associated with the variables chosen to measure theoretical concepts. There were two main groups of property owners, those having taken action in the past to protect their property and those who have not taken action. As such, in attempting to explain the likelihood that an owner would take such action, some of the explanatory variables (expectation of government aid, erosion level, etc.) reflected the point in time when the action was taken; where no action was taken the present was the reference point. As some people took protective action many years ago it may have been difficult for them to accurately recall their situation at that time. However, of greater concern, is the fact that some of the variables in this model were defined only in terms of the present; the time preference rate, risk attitude and other variables represent the present frame of mind of the respondent. With no measure of these concepts available at the point in time an action was taken, it was hoped that the present measures would suffice. Although it is not clear how the study results might have been affected, decreasing the time span over which variables

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are measured would help reduce variable misspecification.

Some of the variables in the adoption model did not account for any predisposition some owners might possess towards purchasing a particular piece of property. This is particularly noticeable for the variables measuring risk attitude (RATT) and property value (PVAL). In the case of RATT, individuals with a strong risk aversion appear to have purchased property which was not very susceptible to flooding and/or erosion. Hence, opposite to what was hypothesized, the greater the risk aversion the less likely an individual is to take action; no action is required. With respect to PVAL, property values may already reflect flooding and/or erosion potential; that is, properties not subject to hazard (either naturally or due to protection by previous owners) may claim a higher market value. Thus, PVAL may not reflect damage potential (positively related to taking of protective action), but rather, may indicate that protective action was not required. These results, for both PVAL and RATT, suggest that modeling protection behavior should include arguments to account for the original purchase decision.

The variable RATT displayed another problem. The questions used to elicit risk attitude were framed as a decision to purchase insurance protection against storm damage. Some respondents indicated a strong aversion to insurance as they felt that it would not cover some losses. As such, their responses to the risk attitude questions may have

indicated an aversion to insurance rather than risk seeking behavior.
This highlights the need to carefully consider the frame used to elicit
attitudes.

The variable used to measure the cost of shore protection (KSP) in the
adoption model presents another limitation of the study. This variable
was constructed of two types of information: actual construction
expenditures of those who took some form of action and, for those not
taking action, their expected costs. However, those people who did not
take action may be less informed about actual costs. An additional
problem arose with the coding of this variable. The range of response
categories made available to the respondent was too low at the upper
end. This reduced the variation in responses resulting in the variable
having no explanatory power in the adoption model.

This study considered three models to explain observed variations in the
time preference rate, probability truncation and personal planning
horizon. In all three cases demographic variables and damage level
variables failed to explain any variation. There is room here for
future research efforts. With some knowledge of what factors influence
time preference rates, for example, a public planner may be able to
choose a discount rate (or several rates) which more closely reflect the
rate or rates used by the decision makers in question.

To the extent that the public planner is concerned with directly

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eliciting time preference rates (or degree of truncation), careful

attention should be directed toward the framing of the elicitation

question. Although there are an infinite number of frames which could

be applied, the particular decision making issue under study should

dictate a close approximation to the appropriate frame. Observing that

individuals may apply different rates in different situations begs the

question of how this may come about. To what extent do markets actually

equilibrate time preference rates (or any prices)?

Present government policy regarding expenditures on the mitigation of

flooding and erosion hazards points to another area requiring study. In

surveying the policies of the federal government Shabman et al (1989)

found that a main theme of policy was to encourage informed and

responsible decision making on the part of hazard zone occupants. To be

informed is to understand the consequences and likelihood associated

with a hazard; to be responsible requires that the benefits and costs of

a decision are borne only by the decision maker. To the extent that

individuals are informed and responsible there is less of a basis for

government expenditure to mitigate the effects of hazards. Thus it is

useful for the policy maker to know the extent to which individuals are

informed and how to inform those that are not. Although this study

suggests that shoreline property owners have a general understanding of

the hazards they face, it did not look directly at the initial decision

to take up residence along the shore. An improved understanding of the

factors affecting this decision will reflect the degree to which

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property owners are actually informed and will suggest ways their
information can be improved.

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Appendix A

Expected and Discounted Utility

Theories: History and Axioms

This appendix presents a brief history of the development of expected and discounted utility theories. This is followed by a presentation of the axioms of the theories. These axioms provide a formal statement of the rational economic model of choice under uncertainty and over time.

A.1 History of Expected and Discounted Utility Theories

The original formulation of Expected Utility Theory (EUT) has been attributed to a publication by Daniel Bernoulli in 1738 although Bernoulli acknowledged that the work of Gabriel Cramer anticipated some of Bernoulli's efforts (Friedman and Savage, 1948). Bernoulli offered the famous St. Petersburg Paradox as a counter example to the prevailing view that rational individuals ought to act so as to maximize the mathematical expectation of gains and losses (Borch, 1968). The St. Petersburg Paradox can be illustrated by the following game. Suppose a fair coin is tossed only as many times as necessary to obtain a "head". At this point the player receives a prize of 2^n dollars where n is the number of tosses performed. The mathematical expectation of gain obtainable by playing this game is infinite. That is:

$$\sum_{n=1}^{\infty} 2^n \cdot (\frac{1}{2})^n = \infty$$

where $(1/2)^n$ is the probability of obtaining the first "head" on the nth toss. Thus, if a player acted to maximize expected gain, the player would pay an infinite amount to play the game. However, people are

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observed to be willing to pay only a modest sum to play the game.
Bernoulli explained this paradox by proposing that people seek to
maximize expected utility as opposed to expected monetary gain.
Bernoulli proposed that marginal utility decreases with increases in
wealth and, as such, expected utility is finite.

Although Bernoulli's explanation fit well with the ordinal utility
theory of value developed in the 1870's it remained, primarily, a
simple, descriptive model (Arrow, 1951; Schoemaker, 1982). It was not
until 1931, through the work of Ramsey, that EU theory was rigorously
formalized as an axiomatic theory of rational choice although Ramsey's
work was virtually unknown until acknowledged by Savage in 1954
(Fishburn, 1977). However, it was the axiomatic utility theory of John
von Neumann and Oskar Morgenstern presented in 1947 that provoked
widespread attention. Von Neumann and Morgenstern proved that a basic
set of normatively appealing axioms implies the existence of a utility
function such that greater expected utility corresponds to higher
preferences (Schoemaker, 1982). Since 1931, there has been much
discussion of the theory leading to numerous formulations of the axioms
(Fishburn, 1981; Schoemaker, 1982). The next section presents one
formulation.

It was not until 1960 with the work of Koopmans that Discounted Utility
Theory (DUT) was rigorously formalized as a set of axioms. However, the
tendency of individuals to prefer, in varying degrees, present or future

consumption has been the subject of considerable discussion over time.
Loewenstein (forthcoming) traces the history of explanations of time
preference as found in the work of early economists; the following
discussion relies on Loewenstein. The axiomatic formalization
essentially removed, for economists, the psychological explanations of
time preference that were prevalent, although declining, to that point
in time. Rae, Senior and Jevons developed motivational explanations of
time preference. That is, they felt people were motivated by such
personal attributes as prudence, the pleasure of anticipation, the pain
of abstinence, the shortness of life, and the desire to bequeath to
others. Later, Böhm-Bawerk and Fisher presented cognitive reasons for
time preference. That is, people have difficulty imagining future likes
and dislikes, thus under-valuing them relative to present likes and
dislikes.

Paradoxically, it was the work of Fisher and Böhm-Bawerk that led, in
economics, to the decline of psychological explanations for time
preference. Fisher cast some of Böhm-Bawerk's work in terms of the now
familiar indifference curve analysis, allowing the intertemporal choice
problem to be treated no differently than atemporal choice problems.
This enhanced the mathematical formulation of intertemporal choice
problems and led the discussion away from the psychological explanations
put forth by the earlier economists and by Fisher himself (Hirshleifer,
1965). In 1937, Samuelson presented DUT in the form we recognize today
where total utility is the sum of all time period utilities, each

weighted by a discount factor. Subsequently, in 1960 Koopmans provided the axiomatic underpinning for DUT although other sets of axioms have been developed since then (Benzion, Rapoport and Yagil, 1989). The axioms are presented in section A.3.

A.2 The Axioms of Expected Utility Theory

The following presentation of the axioms, popular among economists, is taken from Luce and Raiffa (1957) who employ objective probabilities in their formulation. The axioms are defined with reference to two basic components, prizes and lotteries. A prize (or outcome) is the possible result of an action. Associated with a prize is the probability that an action will yield that prize. A lottery consists of a set of mutually exclusive prizes and their associated probabilities such that the probabilities sum to one. As a special case a compound lottery is a lottery which contains at least one other lottery as a prize. The axioms of Luce and Raiffa are presented below in non-technical terms.

The problem of risky choice has been characterized as a choice between a pair of lotteries each of which is composed of a finite set of risky prizes (often referred to as outcomes or alternatives). The set of outcomes or prizes may be denoted A_i where each outcome occurs with a known probability p_i ($i = 1, \ldots I$), $p_i \geq 0$ for all i, and

$$\sum_{i=1}^{I} p_i = 1.$$

Thus, a lottery may be denoted by:

L = [(p$_1$, A$_1$), (p$_2$, A$_2$), ... (p$_I$, A$_I$)] or more simply by:

L = [(p$_i$, A$_i$), i = 1, ...I]

where only one outcome will occur and the probability that it is A$_i$ is

p$_i$. Presentation of the axioms can be simplified using the notation ~

to indicate "is indifferent to" and ≥ to indicate "is preferred or

indifferent to."

Axiom 1: Ordering of Outcomes

Any two prizes are comparable in that an individual prefers one prize to

another or is indifferent between them. That is, either:

A$_i$ ≥ A$_j$ or A$_j$ ≥ A$_i$.

Furthermore, any relationship, preference or indifference, between the

prizes is transitive. That is, if A$_i$ ≥ A$_j$ and if A$_j$ ≥ A$_k$, then A$_i$ ≥ A$_k$.

Axiom 2: Reduction of Compound Lotteries

Any compound lottery can be decomposed into simple lotteries using

probability calculus. A compound lottery is a lottery containing at

least one simple lottery as an outcome. Compound lottery C is comprised

of a series of j simple lotteries:

L$_j$ = [(p$_{ij}$, A$_i$), i = 1, ...I] for j = 1, ...J. That is:

C = [(q$_j$, L$_j$), j = 1, ...J]. Thus C ~ B where

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$$B = [(q_i, A_i), i = 1, \ldots I] \text{ and}$$

$$p_i = \sum_{j=1}^{J} p_{ij}q_j.$$

Axiom 3: Continuity

Given the ranking of outcomes $A_1 \succeq A_2 \succeq \ldots \succeq A_I$ there is a lottery consisting only of the least and the most preferred outcomes:

$$L = [(u_i, A_1), (1 - u_i, A_I)] \text{ for all } i = 1, \ldots I \text{ and } 0 \leq u_i \leq 1,$$

such that $L \sim A_i$. That is, as u_i is shifted from 0 to 1 the preference ordering between L and A_i reverses; there is some level of probability u_i which renders an individual indifferent between a certain outcome A_i and a lottery L.

Axiom 4: Substitutability

If an individual is indifferent between any two prizes then the individual is indifferent between any two lotteries obtained by substituting one of these prizes for the other. That is, if $A_i \sim a_i$ (a_i is another outcome) then $L_1 \sim L_2$ where:

$$L_1 = [(p_1, A_1), \ldots (p_i, A_i), \ldots (p_I, A_I)] \text{ and}$$

$$L_2 = [(p_1, A_1), \ldots (p_i, a_i), \ldots (p_I, A_I)].$$

In slightly different formulations this axiom is also known as "the sure thing principle" or the assumption of "the independence of irrelevant alternatives" (Luce and Raiffa, 1957).

Axiom 5: Transitivity of Lotteries

Any relationship, preference or indifference, between lotteries is transitive. That is, if lotteries $L_i \succeq L_j$ and $L_j \succeq L_k$, then $L_i \succeq L_k$.

Axiom 6: Monotonicity

For any two lotteries, each consisting of the most and the least preferred prizes of any set of prizes, the preferred lottery is that lottery with the highest probability associated with the most preferred prize. That is, if $A_1 \succeq A_I$ then:

$$L_1 = [(p, A_1), (1 - p, A_I)] \succeq L_2 = [(u, A_1), (1 - u, A_I)],$$

if and only if $p \geq u$. Axioms 1 through 5 allow the choice problem to be reduced to a comparison of lotteries containing only the worst and best outcomes. The final decision can then be based on Axiom 6.

These axioms insure that for any two lotteries, $L_1 \succeq L_2$ if and only if $U(L_1) \geq U(L_2)$. Thus, a utility function can be derived from these axioms such that the expected utility of a lottery is the summation of the utilities associated with each of the prizes in the lottery, weighted by their respective probabilities. That is the expected utility of lottery $L = [(p_i, A_i), i = 1, \ldots I]$ is

$$U(L) = \sum_{i=1}^{I} p_i U(A_i)$$

This utility function is unique up to a positive linear transformation. Hey (1979) provides a derivation of this utility function.

A.3   The Axioms of Discounted Utility Theory

The following presentation of the axioms of DUT is taken from Bell
(1972) and Koopmans, Diamond and Williamson (1964); the latter paper
corrects and expands the original work of Koopmans. The axioms are
defined in terms of non-negative commodity bundles, x, to be consumed in
period t. A consumption vector is defined for n consumption goods as
$x_t = (x_{t1}, \ldots, x_{tn})$ for the successive time periods $t = (1, 2, \ldots)$.
An infinite sequence of consumption vectors is defined, $_1x = (x_1, x_2,$
$\ldots) = (x_1, {}_2x) = ({}_1x_{t-1}, {}_tx)$, $t = (2, 3, \ldots)$.

Axiom 1: Existence and Continuity
There exists a utility function, $U({}_1x)$, which is defined on time
streams, is continuous, and no two iso-preference curves become
arbitrarily close.

Axiom 2: Sensitivity
There exist consumption vectors, x_1, x_1' and $_2x$, such that:

$$U(x_1, {}_2x) > U(x_1', {}_2x).$$

This ensures that the utility function changes when some consumption
vector is changed in some time period.

Axiom 3: Limited Noncomplimentarity
For all x_1, x_1', $_2x$, and $_2x'$:

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$U(x_1, {}_2x) \geq U(x_1', {}_2x)$ implies $U(x_1, {}_2x') \geq U(x_1', {}_2x')$ and

$U(x_1, {}_2x) \geq U(x_1, {}_2x')$ implies $U(x_{1\cdot}, {}_2x) \geq U(x_1', {}_2x')$.

This axiom isolates the effect of timing on decisions. It requires that the bundle of commodities to be consumed in any period has no effect on the preference between bundles at an earlier or later time period.

Axiom 4: Stationarity

For some x_1 and all ${}_2x, {}_2x'$:

$U(x_1, {}_2x) \geq U(x_1, {}_2x')$ if and only if $U({}_2x) \geq U({}_2x')$.

This requires that preferences are independent of the passage of time. That is, for example, the preference for consumption between years 1995 and 1996 is not different than the preference between 2005 and 2006 as both cases involve a one year time span.

Taking the four axioms together Koopmans, Diamond and Williamson (1964) prove the familiar formulation:

$$U({}_1x) = \sum_{t=1}^{\infty} \delta^{t-1} u(x_t)$$

where δ is the discount factor, $0 < \delta < 1$.

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Appendix B

Letters to Property Owners

July 10, 1991

Jane Doe
Shoreline
Great Lakes   123456

As a shoreline property owner you are aware of flooding and erosion
problems on the Great Lakes. As part of a research project at Virginia
Tech we are investigating property owners' views on the protection of
property against these hazards. The enclosed survey offers you the
opportunity to tell us what is important to you in making decisions to
protect or not protect your property from flooding and erosion. This
information will help governments make decisions regarding the
protection of shoreline property from natural hazards.

Please fill out the survey whether or not you have a problem with
flooding or erosion. It is important that you personally answer the
questions and think carefully about the answers. The survey will take
15 minutes to complete. You are asked to answer questions on the blue
pages and in only one of the other colored sections. We assure you of
complete confidentiality. The identification number on the survey is
for our bookkeeping needs.

The results of this research will also be made available to the
International Joint Commission which is currently studying the effects
of fluctuating water levels in the Great Lakes and the St. Lawrence
River. You also may obtain a copy of the results by checking the
appropriate box on the cover of the survey.

We appreciate your time and assistance. If you have any questions about
this study please call Kevin O'Grady at (713) 231-3757 or write to the
address above.

Sincerely,

Leonard Shabman   Kevin O'Grady

Professor   Project Assistant

July 24, 1991

Two weeks ago a questionnaire was mailed to you that asked about your experiences with flooding and erosion of your shoreline property. If you have already completed the questionnaire and returned it, please accept our thanks. If not, it would be appreciated if you would return it to us today.

Your response is important to us whether or not you have a problem with flooding or erosion. This information will be used to help governments better understand the hazard protection needs of shoreline property owners.

If you did not receive a questionnaire or it has been misplaced, you will receive another one in about two weeks.

Thanks again for your help.

Sincerely,

Kevin O'Grady
Project Assistant

August 7, 1991

Jane Doe
Shoreline
Great Lakes   123456

Four weeks ago, we mailed you a survey questionnaire about flooding and
erosion hazards on the Great Lakes. At this time we have not received
your completed questionnaire.

We are writing you again because your response is important to us. We
are investigating shoreline property owners' views on the protection of
property against these hazards. <u>We are interested in your views whether
or not you presently have a flooding or erosion problem</u>.

The information you provide will help governments make decisions
regarding the protection of shoreline property from natural hazards.
The results of this research will be made available to the federal
government and to other interested parties including the International
Joint Commission. You also may obtain a copy of the results by checking
the appropriate box on the cover of the survey.

It is important that you personally answer the questions and think
carefully about the answers. The survey will take 15 minutes to
complete. You are asked to answer questions on the blue pages and in
only one of the other colored sections. We assure you of complete
confidentiality. The identification number on the survey is for our
bookkeeping needs.

In case your survey has been misplaced, another copy is enclosed. If
you have already completed the survey and returned it, please accept our
thanks. If not, it would be appreciated if you would return it to us
today. Again, thank you for your time and assistance. If you have any
questions about the survey or this study please call Kevin O'Grady at
(713) 231-3757 or write to the address above.

Sincerely,

Leonard Shabman   Kevin O'Grady

Professor   Project Assistant

Appendix C

Survey Instrument

A Survey of Great Lakes Property Owners:
Experience with Flooding and Erosion
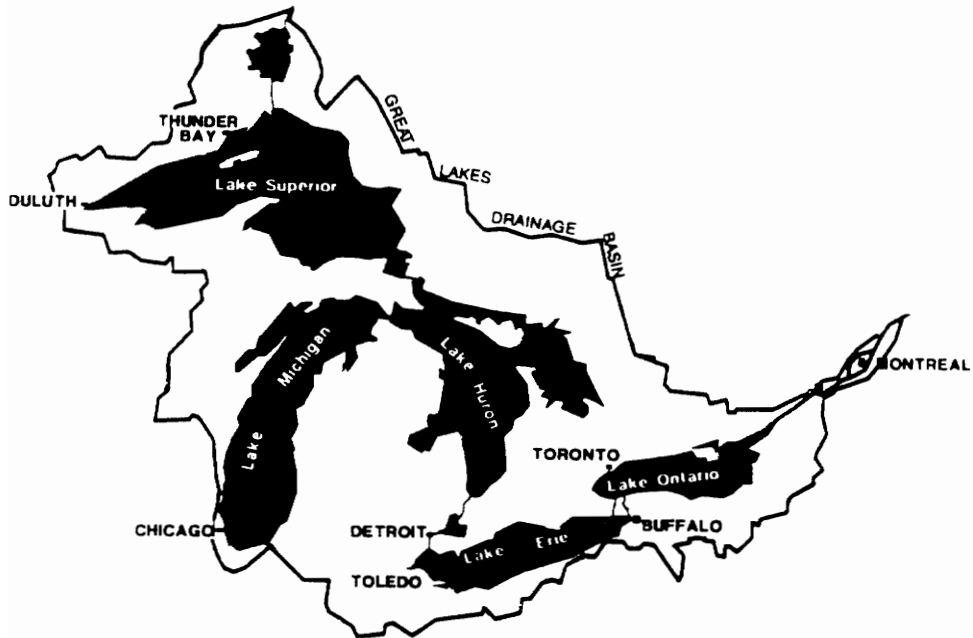
☐ If you would like a copy of the survey results please check this box

Return to:
Department of Agricultural Economics
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0401
Phone: (703)231-3757

Note: The various sections of the original survey questionnaire were color coded. The cover and the following page, with questions Q1 through Q4, were blue. The next four pages, with questions G1 through G12, were colored green. The following section was yellow (questions Y1 through Y9). The remaining pages were blue (questions B1 through B15).

The survey was page numbered 1 through 13 with the cover being unnumbered.

This survey is made up of three sections colored blue, yellow and green. Everyone is asked to answer the questions in the blue section. However, you need only answer questions on the green pages OR the yellow pages, NOT BOTH. At the bottom of this page you will be directed to the appropriate color.

Some questions will have blanks for you to fill in. Other questions will have numbers next to the possible answers. Circle the number that applies to you. For some questions you will be asked to circle more than one number. You are welcome to make comments in the margins throughout the survey.

Q1.   Is there a residence on this property? *(circle one number)*

              1   SINGLE FAMILY RESIDENCE
              2   MULTIPLE FAMILY RESIDENCE
              3   NO RESIDENCE ----> GO TO QUESTION Q3

Q2.   Approximately, how far is the waterline from your residence at the present time?

              FEET? _____

Q3.   What is the approximate length of your shoreline in feet?

              FEET? _____

Q4.   These are some actions that people may take to protect their property from flooding and erosion:
              raise, move, reinforce residence
              build or repair groin/jetty
              build or repair seawall, breakwater or dike.

       Have you or a previous owner taken any of the above actions? *(circle only one response below and proceed to answer the questions in the colored section indicated)*

1 *NONE* OF THESE ACTIONS HAVE BEEN TAKEN ---> GO TO YELLOW, PAGE 6

2 *BOTH* MYSELF *AND* A PREVIOUS OWNER TOOK ACTION ---> GO TO GREEN, PAGE 2

3 *ONLY* I TOOK ACTION ---> GO TO GREEN, PAGE 2

4 *ONLY* A PREVIOUS OWNER TOOK ACTION ---> GO TO YELLOW, PAGE 6

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COMPLETE THIS SECTION IF YOU TOOK ACTION TO PROTECT YOUR SHORELINE. For
the following questions erosion means *the washing away of property due
to storms or high water levels*. Flooding occurs *where water enters or
covers buildings or building sites due to storms or high water levels*.

G1.   Which of the following actions have you taken to protect your
       property from flooding or erosion? *(circle all appropriate
       numbers)*

                    1   RAISE, MOVE, REINFORCE RESIDENCE
                    2   BUILT GROIN/JETTY
                    3   BUILT SEAWALL, BREAKWATER, DIKE
                    4   REPAIRED SHORE PROTECTION STRUCTURES

G2.   What was the year and cost of those protective actions that you
       took?

YEAR	ACTION (use list from G1)	COST

G3.   What is your best estimate of the average amount of your property
       eroded each year *before* you first took protective action?

                    1   I HAD NO EROSION PROBLEM
                    2   LESS THAN 1 FOOT PER YEAR
                    3   1 TO 2 FEET PER YEAR
                    4   2 TO 3 FEET PER YEAR
                    5   OVER 3 FEET PER YEAR
                    6   I'M NOT SURE

G4. What is your best estimate of the number of times this property had suffered flood damage *before* you first took protective action?

      1   I HAD NO FLOODING PROBLEM
      2   NUMBER OF TIMES FLOODING OCCURRED? _____
      3   I'M NOT SURE

G5. How would you rate the flooding and/or erosion hazard at your property *before* you first took protective action? *(circle one number on scale below)*

NO PROBLEM   VERY SEVERE

   1   2   3   4   5

G6. *Before* you took any action, when was your residence occupied?

      1   ALL YEAR ROUND
      2   ONLY PART OF THE YEAR
      3   RESIDENCE WAS UNOCCUPIED
      4   THERE WAS NO RESIDENCE ON THE PROPERTY

G7. For most of the year *before you took any action* did you occupy the residence yourself or rent it to others?

      1   PERSONALLY OCCUPIED RESIDENCE
      2   RENTED TO OTHERS
      3   RESIDENCE WAS UNOCCUPIED
      4   THERE WAS NO RESIDENCE ON THE PROPERTY

G8.   Did you have special flood insurance for your property in addition
       to regular homeowners insurance *before* you took any protective
       action?

                    1   YES
                    2   NO

G9.   *Before* you took any action to protect your property, did you
       expect that there would be government assistance in case of future
       flooding or erosion damage? (e.g. grants, low interest loans, lake
       level regulation)

                    1   YES
                    2   NO

G10.   Estimate your total annual family income (before taxes) *when you
       first* took protective action?

                    1   LESS THAN $25,000
                    2    $25,001   TO $50,000
                    3    $50,001   TO $75,000
                    4    $75,001   TO $100,000
                    5   MORE THAN $100,000

G11. Estimate the market value of your shoreline property *at the time you first* took protective action?

        1   LESS THAN $30,000
        2   $30,001 TO $60,000
        3   $60,001 TO $90,000
        4   $90,001 TO $120,000
        5   $120,001 TO $150,000
        6   $150,001 TO $180,000
        7   MORE THAN $180,000

G12. Estimate the market value of your shoreline property *at the present time*?

        1   LESS THAN $30,000
        2   $30,001 TO $60,000
        3   $60,001 TO $90,000
        4   $90,001 TO $120,000
        5   $120,001 TO $150,000
        6   $150,001 TO $180,000
        7   MORE THAN $180,000

COMPLETE THIS SECTION IF YOU DID NOT TAKE ACTION TO PROTECT YOUR
SHORELINE. For the following questions erosion means *the washing away
of property due to storms or high water levels*. Flooding occurs *where
water enters or covers buildings or building sites due to storms or high
water levels*.

Y1.   When is your residence occupied?

                1   ALL YEAR ROUND
                2   ONLY PART OF THE YEAR
                3   RESIDENCE IS UNOCCUPIED
                4   THERE IS NO RESIDENCE ON THE PROPERTY

Y2.   For *most of the time during 1990* did you occupy your residence
       yourself or rent it to others?

                1   PERSONALLY OCCUPIED RESIDENCE
                2   RENTED TO OTHERS
                3   RESIDENCE IS UNOCCUPIED
                4   THERE IS NO RESIDENCE ON THE PROPERTY

Y3.   Do you have special flood insurance for your property in addition
       to regular homeowners insurance?

                1   YES
                2   NO

Y4.   Do you expect there will be government assistance in case of
       future flooding and erosion (e.g. grants, low interest loans, lake
       level regulation)?

                1   YES
                2   NO

Y5.   What is your best estimate of the average amount of your property
       eroded each year since you have owned this property?

                1   I HAVE NO EROSION PROBLEM
                2   LESS THAN 1 FOOT PER YEAR
                3   1 TO 2 FEET PER YEAR
                4   2 TO 3 FEET PER YEAR
                5   OVER 3 FEET PER YEAR
                6   I'M NOT SURE

Y6.   What is your best estimate of the number of times this property
       has suffered flood damage since you have owned this property?

                1   I HAVE NO FLOODING PROBLEM
                2   NUMBER OF TIMES FLOODING OCCURRED? _____
                3   I'M NOT SURE

Y7.   How would you rate the flooding and/or erosion hazard at your
       property? *(circle one number on scale below)*

       NO PROBLEM   VERY SEVERE

           1   2   3   4   5

Y8.   What do you think it would cost to stop your flooding and/or
       erosion problem?

                1   ZERO, I HAVE NO PROBLEM
                2   LESS THAN $2,000
                3    $2,001   TO $4,000
                4    $4,001   TO $6,000
                5    $6,001   TO $8,000
                6    $8,001   TO $10,000
                7   OVER $10,000
                8   I'M NOT SURE

Y9.   Estimate the present market value of your shoreline property?

                1   LESS THAN $30,000
                2    $30,001   TO $60,000
                3    $60,001   TO $90,000
                4    $90,001   TO $120,000
                5    $120,001   TO $150,000
                6    $150,001   TO $180,000
                7   MORE THAN $180,000

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This section includes several questions about a situation which *could* be faced by a shoreline property owner. While it is not your situation, respond as if the choices were ones *you had to make*.

There are no correct answers to the questions asked. But, your responses will help governments understand how shoreline property owners, such as yourself, view the hazards of flooding and erosion. Therefore, we ask that you carefully consider the situation and each question before responding.

The situation is:

> You are the new owner of a waterfront lot. The lot has 100 feet of waterfront and is worth $40,000. The residence is set back 150 feet from the shore.

> After purchasing the lot you become aware that the lot has an erosion problem.

> An appraiser tells you that the erosion is reducing the market value of your property.

B1.   Suppose you decided to construct an erosion control project, and plan to take a loan to pay for the construction. You are offered two different 5 year payment plans with payments due at the beginning of the year:

Year:	1	2	3	4	5
Annual Payment for Plan A:	$1800	$1800	$1800	$1800	$1800
Annual Payment for Plan B:	$900	$1400	$1900	$2400	$2900

Which plan would you prefer?   *(circle only one number)*

1   PLAN A WITH PAYMENTS OF $1800 PER YEAR

2   PLAN B WHERE PAYMENTS INCREASE EACH YEAR

3   EITHER PLAN WOULD BE ALRIGHT

4   I AM NOT SURE

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B2. Suppose you consult a contractor who describes two erosion control projects which both cost the same amount:

Project A will reduce the yearly loss of property value by **$600**. The project will be fully effective as soon as it is built.

Project B will reduce the yearly loss of property value by **$1000**. However, this project will not become effective for **5** years.

Which project would you prefer? *(circle one number only)*

1   PROJECT A WHICH REDUCES YEARLY EROSION DAMAGE BY $600 BEGINNING IMMEDIATELY

2   PROJECT B WHICH REDUCES YEARLY EROSION DAMAGE BY $1000 BEGINNING IN 5 YEARS

3   EITHER PROJECT WOULD BE ALRIGHT

4   I AM NOT SURE

B3. How do you think the market value of a shorefront property is affected by money spent on shore protection?

1   THE MARKET VALUE RISES BY *MORE* THAN THE AMOUNT SPENT
2   THE MARKET VALUE RISES BY THE *SAME* AS THE AMOUNT SPENT
3   THE MARKET VALUE RISES BY *LESS* THAN THE AMOUNT SPENT
4   THE MARKET VALUE IS *UNAFFECTED* BY THE AMOUNT SPENT

B4. In general, how far into the future do you think it is reasonable for an owner to plan investments to protect shoreline property against flooding and/or erosion?

1   LESS THAN 5 YEARS
2   5 TO 10 YEARS
3   OVER 10 YEARS

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Storms that create some shoreline problems do not occur every year.
Therefore, the following questions require you to consider uncertainty
in your responses.

B5.   Suppose there was a **5%** chance each year of a storm causing between
       $3,000 and $5,000 damage to the property described earlier.

       Would you buy an insurance policy for $200 per year if it covered
       damages *only* in the $3,000 to $5,000 range? *(circle one number
       only)*

              1   YES ---> GO TO QUESTION B6

              2   NO ---> GO TO QUESTION B7

              3   I AM INDIFFERENT ---> GO TO QUESTION B8

              4   I AM NOT SURE ---> GO TO QUESTION B8

B6.   Would you buy the insurance policy if it cost **$275** per year?

                     1   YES ---> GO TO QUESTION B8
                     2   NO ---> GO TO QUESTION B8

B7.   Would you buy the insurance policy if it cost **$125** per year?

                     1   YES
                     2   NO

B8. Storms causing slight damage can occur fairly often, while storms causing severe damage occur rarely. Suppose you had a choice between these two insurance policies each costing $250 per year:

	Annual Chance of Damage	Range of Storm Damage Protection
Policy A	10% chance	$0 to $5,000
Policy B	2% chance	$10,000 to $15,000

Which policy would you prefer? *(circle one number only)*

1   POLICY A WITH A HIGH CHANCE OF A LOW INSURANCE PAYOFF

2   POLICY B WITH A LOW CHANCE OF A HIGH INSURANCE PAYOFF

3   EITHER POLICY WOULD BE ALRIGHT

4   I AM NOT SURE

B9. Suppose you had a choice between two pieces of shoreline property? The only differences between the pieces of property are the chance and level of storm damage:

	Annual Chance of Damage	Level of Damage for _Each_ Storm
Property A	10% chance	$2,500
Property B	2% chance	$12,500

Which property would you prefer to live on? *(circle one number only)*

1   PROPERTY A WITH A HIGH CHANCE OF LOW DAMAGE STORMS

2   PROPERTY B WITH A LOW CHANCE OF HIGH DAMAGE STORMS

3   EITHER PROPERTY WOULD BE ALRIGHT

4   I AM NOT SURE

To help us better analyze your responses we need to know more about you. *All responses will be kept strictly confidential*.

B10. How many years have you owned this property?

            YEARS? _____

B11. In the past have you owned any other property which may have been subject to flooding or erosion?

            1   YES
            2   NO

B12. What is your age?

            YEARS? _____

B13. Are you a member of any coalitions or organizations of shoreline property owners?

            1   NO
            2   YES; WHICH ONES? _____

                                 _____

B14. What is the highest level of education you have completed?

            1   LESS THAN HIGH SCHOOL
            2   HIGH SCHOOL
            3   SOME COLLEGE OR TRADE SCHOOL
            4   COLLEGE DEGREE
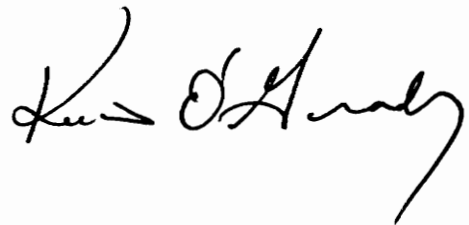   5   GRADUATE STUDIES

B15. Which of the following categories best describes your total family income (before taxes) in 1990?

            1   LESS THAN $25,000
            2    $25,001 TO $50,000
            3    $50,001 TO $75,000
            4    $75,001 TO $100,000
            5   MORE THAN $100,000

We sincerely appreciate the effort you have taken to fill out this survey. Please return the survey in the self addressed post-paid envelope to:

        Department of Agricultural Economics
        Virginia Polytechnic Institute & State University
        Blacksburg, VA   24061

For additional information about this survey please call Kevin O'Grady at (703) 231-3757.

_____ Check here if you would like to receive a copy of the survey
         results.

PLEASE INDICATE ANY ADDITIONAL COMMENTS YOU MAY HAVE:

_____

_____

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Vita

Kevin Lawrence O'Grady was born on August 22, 1955 and raised near Allan, Saskatchewan, Canada. After graduating from high school in 1973 Kevin attended the College of Arts and Sciences at the University of Saskatchewan, Saskatoon. After an extended leave Kevin graduated in 1982 with the degree of Bachelor of Science in Agriculture (BSA) and two years later received a Master of Science degree in Agricultural Economics from the University of Saskatchewan. For the next three years Kevin was engaged in water resource economics research in Lethbridge, Alberta and in Saskatoon. Kevin entered the United States in August, 1987 to begin a Ph.D. program at Virginia Tech.

Kevin married Marilyn Rose Gatin on December 30, 1982.