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Valuing Risk in Experimental Markets: Self-Protection, Self-Insurance, and Collective Action

by

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DISCLAIMER

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Executive Summary

Chapter 1

Economists have begun to use laboratory experiments to provide a more rigorous foundation for the valuation of nonmarket assets. Experiments provide a tightly controlled environment in which explicit structural incentives control for real world noise, thereby isolating potentially damaging biases of mechanisms design to reveal preferences prior to field implementation. By isolating biases and implementing mechanisms with proven demand revealing capacities, lab experiments can increase the accuracy and the validity of the controversial field valuation technique of contingent valuation.

One aspect of nonmarket valuation with the greatest need for experimental examination is risk. Given incomplete Arrow-Debreu contingent claims contracts, risk is unavoidable in the naturally occurring environment. Consequently, obtaining an accurate ex ante economic value for risk reductions is essential for efficient allocation of public resources by policymakers. The purpose of this project is to examine the economic value formation process in experimental markets of private and collective self-protection and self-insurance. Three different experiments are designed which examine individual choice under risk and uncertainty. The goal of the project is to determine if and how the value of risk differs under various reduction mechanisms.

Chapter 2

Four experimental asset markets with one risk reduction mechanism are developed to examine the economic value of reduced risk. Self-protection and self-insurance are examined and compared in both private, sealed-bid second-price Vickrey auctions and collective, sealed-bid Smith auctions.

Results indicate that the upper and lower bounds on value were elicited by the private, probability-influencing self-protection and the collective, severity-influencing self-insurance. The four asset markets induce rapid value formation. Usually only one or two additional market trials were necessary before an individual's valuation of reduced risk stabilized. The robustness of these results declined with low probability lotteries. Overall, the results indicate the addition of a second chance bid will improve the accuracy and reduce the hypothetical bias of the contingent valuation of nonmarket assets.

Chapter 3

Four experimental markets with two risk reduction mechanisms are developed and tested. We argue that, when demand is certain, the prospective removal of supply uncertainty does not necessitate a positive option value, given that the level of uncertainty is at least partly dependent on the consumer's choice of actions. We conclude that the value of altering the uncertainty associated with a lottery on a desirable state of nature is reflected in the individual's option payments and in his willingness-to-pay for self-protection. The experimental results provide weak support for this hypothesis. Additional experimental results include a finding of no significant behavioral outcome between self-protection and self-insurance, slower learning and value formation, further evidence of nonlinearity in probabilities, and mixed support for behavioral differences induced by private relative to collective risk reduction mechanisms.

Chanter 4

Two experiments are designed to examine Coasian bargaining over ex ante lotteries and ex post rewards. The experiments provide an independent test of the question: Is there a fundamental difference in individual behavior given probability (lotteries) or severity (reward). In Chapter 2, the results indicate a significant difference in valuation of risk reduction depending on if the mechanism was probability-influencing self-protection or severity-influencing self-insurance. In the Coasian experiments, however, no significant difference was found in the bargaining over lotteries or rewards. Therefore, we conclude that there is not a fundamental behavioral difference in behavior toward probability or severity, rather the difference or lack of it are situation-specific and can't be generalized to a broader phenomena.

Chanter 5

The results of the experiment provide future avenues for exploration by practitioners of the contingent valuation method.

First, the mechanism used to reduce risk is important. Reducing risk by altering the probability or severity of an undesired event through a private or a collective mechanism has been shown to generate significantly different values. Second, the addition of a second chances bid after new. information is provided could add insight into value formation in a field context. Third, the initial hypothetical bid is generally a significant predictor of the final experienced hypothetical bid. The implication being that. an initial bid adjusted for learning could reflect the value of reduced risk in an experienced market. Fourth, the addition of a substitutable pair of risk reduction mechanisms can provide additional realism to the hypothetical markets constructed under contingent valuation experiments. The addition can reveal personal preferences toward the most valued scheme of risk reduction: private or collective.

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CHAPTER 1

Valuing Risk in Experimental Markets

1.1 Introduction

To provide a more rigorous foundation for the construction of complete Arrow-Debreu contingent claim contracts used in the valuation of nonmarket assets, economists have embraced the burgeoning field of experimental economics.[1] Experimental economics provides an institutional framework to examine how an individual formulates an implicit price for a nonmarket asset. Explicit structural incentives control for real world, noise and match individual behavior with theory, thereby isolating potentially damaging biases of demand revealing mechanisms in a rigorous framework of control and repetition. By isolating biases before field implementation, lab experiments can increase the validity and accuracy of controversial demand revealing mechanisms such as the contingent valuation method.[2] Ideally, as Coursey and Schulze (1986) note, the practitioners of nonmarket valuation will "walk away from the laboratory with a 'best set' of [contingent valuation] questionnaires," accurately revealing preferences for a given asset [p. 48].

One aspect of nonmarket valuation which has the greatest need for the formal institutional framework provided by rigorous experimentation is risk. Given the pervasive element of uncertainty in the naturally-occurring environment, obtaining an accurate ex ante valuation of a reduction in risk is essential for efficient allocation of public resources by policymakers.

While the general topic of risk has long been a staple in economics and psychology, valuing reductions in risk is beginning to receive attention in field application [e.g., Smith and Desvousges (1987)] and laboratory experiments [e.g., Knetsch and Sinden (1984), Schulze et al. (1986)].

The purpose of this project is to examine the value of reduced risk in experimental markets. Three different experiments are designed which examine individual choice and behavioral outcomes under risk and uncertainty. The goal of the project is to determine if and how the value of risk differs under various reduction institutions. The institutions are private and collection self-protection and self-insurance. The lessons learned from these controlled laboratory experiments can then be applied to contingent valuation experiments.

Historically, the U.S. Environmental Protection Agency (EPA) has allocated substantial resources to develop the contingent valuation method. The usefulness of this project to the EPA is it examines if the ex ante value or willingness to pay measure obtained through the contingent valuation method systematically biases the economic value of reductions in risk. The contingent valuation method may bias value estimate by focusing solely on collective risk reduction and probability of an event occurring. For example, by ignoring individual private self-protection, and the reduction of the severity of an undesirable event, the ex ante willingness to pay measure might not reflect an individual's preference for risk reduction already revealed in the private self-protection or self-insurance market. By using an experimental setting the project isolates the influence that efficient self-protection and self-insurance, both private and collective, has on ex ante willingness to pay. We can examine if concepts of risk reduction which refer only to collective action and probability result in biased estimates of actual value. If the ex ante willingness to pay measures are determined to be downwardly biased, the EPA can justifiably require that future contingent valuation experiments determine the willingness to pay for collective action and the willingness to pay for self-protection; or allocate more resources to collect information on private expenditures in the self-protection market. If no bias is found, then the contingent valuation method has passed another test on its way to becoming an accepted tool for policy analysis.

1.2 Experimental Economics and Contingent Valuation

Since Bohm's (1972) original experiments on preference revelation, there has been renewed interest in the use of nonhypothetical laboratory experiments to isolate and control potential biases associated with the contingent valuation method [Coursey and Schulze (1986), Gregory and Furby (1987), Coursey (1987)]. As pointed out by Hoffman and Spitzer (1985), laboratory experiments "provide the cleanest possible test of fundamental theories in economics" since experiments can control for real world noise, and match individual preferences with theory by structural incentives. Due to the generation of substantial and inexpensive data, laboratory experiments offer a viable alternative to a field experiment subject to many unrecognizable errors.

The accuracy and validity of contingent valuation will increase with expanded emphasis on laboratory experiments which isolate and control potential biases prior to field experimentation. Due to the experimenter control, potential biases can be faithfully examined in a scientifically based framework of rigorousness and repetition. Contingent valuation will also improve by verification through repeated, application and comparison and extensive pretesting of payment vehicles and other instruments in the lab.

Researchers in experimental economics have developed and examined several institutional demand revealing mechanisms to elicit individual preference for nonmarket goods. For example the oral and sealed bid auctions described in Smith (1982) and the first price and second price auction described in Coursey and Schulze (1986) have been extensively examined in laboratory setting. The application to field experimentation is still in its infancy, however [see Brookshire, et al. (1987), Dickie, et al. (1987), and Brookshire and Coursey (1987)].

Bohm (1984) has set forth two criteria for assessing a mechanism to reveal preferences for nonmarket commodities: (1) the method must be simple, and (2) the results derived must be easily verified. The first criteria is satisfied by contingent valuation since the technique is extremely straight forward. We expected the second criteria will become satisfied with more experimental replication and verification of the contingent valuation techniques. Consequently, as replication and laboratory experiments increase, we expect more refinement and greater acceptance of the contingent valuation method in the valuation of reduced risk.

1.3 Experimental Markets

The project designs three sets of experiments to examine choice under risk and uncertainty. The first set of experiments examines valuation formation given one mechanism to reduce the risk. Four experimental markets are constructed such that the individual can bid for the right to reduce risk either through collective or private self-protection or self-insurance markets. The second set of four experiments examines valuation given two mechanisms to reduce risk. Two markets are constructed such that the individual will have the choice of purchasing either private or collective self-protection. The remaining two markets the individual can purchase either private or collective self-insurance. The order the private and collective markets are presented depends on the experimental market. The final set of experiments examining Coasian bargaining under uncertainty. The experiments provide an independent test of the existence of fundamental differences in individual behavior toward probability and severity.

1.4 Results Summarized

The main results of the project are the following:

(a) The value of reduced risk given one reduction mechanism depends on whether the probability or severity of the risk is reduced and if the mechanism is private or collective action. Generally, the upper and lower bounds of value was generated by the private probability-influencing self-protection and the collective severity-influencing self-insurance, respectively.

(b) Individuals were found to overestimate the impacts of low probability events as evidenced by relatively large risk premium payments. This holds for both markets with one and two risk reduction mechanisms. The result provides further support for violation of the independence axiom of expected utility theory.

(c) Results indicate that after an initial inexperienced hypothetical bid only one or two additional nonhypothetical trials induce stable value formation. Consequently, hypothetical asset valuation might only be a problem if no learning or second-chance bid adjustment is allowed. The robustness of this result decreased, however, in markets with two risk reduction mechanisms. The results suggest that the accuracy and validity of field contingent valuation experiments can be increased with the addition of a second-chance bid. The second-chance bid is a bid obtained after the respondent is provided with new information about the market.

(d) Given the potential of budget constrained field experimentation, it was shown that the inexperienced hypothetical bid was a significant explanatory variable of the final experienced bid for lotteries of 40%, 20%, and 10% probability of a loss in wealth. The results were mixed for a 1% lottery, which is not encouraging since most naturally-occurring environmental risks are lotteries of less than 1%.

(e) The results indicate weak support for the hypothesis that substitutable private risk reduction mechanisms will induce the option payment for collective action to decrease relative to expected consumer surplus. The results indicate that option value or risk premium can be negative for collective risk reduction if efficient self-protection of self-insurance is available.

(f) In experimental markets with two risk reduction mechanisms there was an insignificant difference between bids for self-protection and self-insurance. The substitutable framework did not induce the different behavioral outcomes induced by markets with one risk reduction mechanism.

(g) No significant difference in behavioral outcomes was observed in bargaining experiments over ex ante lotteries (probabilities) and ex post rewards (severities). The results support the findings of the experimental markets with two mechanisms rather than the markets with one mechanism.

(h) Greater uncertainty did not induce difference in behavioral outcome in ex ante and ex post bargaining. The robustness of bargaining was found to be independent of the degree of uncertainty.

(i) Coasian bargaining remains highly Pareto efficient under uncertain payoff streams. The evidence provides further support for the weak behavioral form of the Coase theorem.

(j) Coasian bargaining does not remain mutually advantageous under uncertainty. Bargainers pooled risks even though this implied a disadvantageous bargain for the owner of property right entitlements. Consequently, our evidence does not support the strong behavioral outcome of the Coase theorem.

1.5 Outline of Report

Chapter 2 presents experimental markets with one mechanism to reduce risk. Four markets are examined: private self-protection, private self-insurance, collective self-protection, and collective self-insurance. Chapter 3 expands the experimental markets to include two substitutable mechanisms to reduce risk. The markets include both private and collective self-protection or self-insurance. Chapter 4 considers if a fundamental difference exists between individual behavior over probability and severity by examining Coasian bargain under certainty. Finally, Chapter 5 discusses the implications of the project for the contingent valuation method, and suggests directions for future research for valuing risk in experimental markets.

Endnotes

1. See Smith (1982) and Roth (1987) for a discussion of the application of experimental economics to the general economics literature. See Coursey and Schulze (1986) for a general discussion of the implications of laboratory experiments on the contingent valuation of non-market commodities.

2. See Brookshire and Crocker (1981) or Durden and Shogren (1988) for a discussion of the contingent valuation method. Also see Cummings, et al. (1986) and Mitchell and Carson (1987) for an in-depth discussion of potentially damaging biases in the contingent valuation method. Biases include hypothetical bias, information bias, strategic bias, and payment vehicle bias.

CHAPTER 2

Experimental Markets with One Risk Reduction Mechanism

2.1 Introduction

The purpose of this chapter is to report results in valuing reductions in risk in four experimental asset markets. Each market has one mechanism to reduce risk: either private or collective self-protection or self-insurance. We focus on risk-reducing asset markets by using Ehrlich and Becker's (1972) definitions of self-protection and self-insurance. Defining risk as the ex ante probability times the severity (i.e., amount) of an ex post loss in assets, self-protection and self-insurance are expenditures to reduce the probability and severity of the risk. Both private and collective purchases of self-protection and self-insurance are considered.

The results reported provide tentative answers to the following questions: (i) Do the four asset markets induce distinct valuation responses for a reduction in risk?--Yes, the value of reduced risk depends on whether probability or severity is reduced and if it is a private or collective reduction. Generally, the upper bound of value is generated by the private provision of probability influencing self-protection. The lower bound of value is obtained by the collective provision of severity-influencing self-insurance. (ii) Do valuations conform to the expected utility requirement of linearity in probabilities as reflected by an individual's risk premium?--No, we find further support that individuals overestimate the impacts of low probability events as evidenced by extremely large initial risk premium payments. We find, however, risk premiums decrease significantly with repeated market interactions. (iii) Does the valuation of hypothetical assets differ significantly from the valuation of nonhypothetical assets?--Yes and no.[1] Yes, the initial inexperienced hypothetical bid differed significantly from the first nonhypothetical trial bid. No, the final experienced hypothetical bid did not differ from the first few nonhypothetical trial bids. The results indicate that after the initial hypothetical bid only one or two nonhypothetical trials were needed to induce rapid value formation. Consequently, hypothetical asset valuation may only be a potentially damaging bias if no learning or second-chance bid adjustment is allowed. (iv) Can the initial inexperienced hypothetical bid explain the final experienced hypothetical bid?--Yes and no. Yes, the inexperienced bid is a statistically significant explanatory variable of the experienced bid for lotteries with relatively high probabilities of a loss (40%, 20%, 10%). Unfortunately, the results were mixed for the low probability lottery (1%). This result is not encouraging since most naturally-occurring nonmarket risks are lotteries of one percent or less.

These results have implications for two important issues in nonmarket valuation: determining a complete measure of ex ante value and the continuing use of contingent valuation. First, consider the ex ante valuation of nonmarket goods. With imperfect contingent claims markets, individuals are not fully insured. Questions of ex ante versus ex post valuation become relevant. Since complete contingency markets rarely if ever exist, ex ante measures are especially appropriate for nonmarket risk [see Helms (1985)]. An ex ante value measure refers to the minimum ex ante payment to maintain an individual's expected utility given a change in the probability or severity of a future state of nature.

Traditional ex ante value theory has focused on a static framework for examining individual valuation. Our evidence suggests that the static framework does not capture the individual's value formation process which requires additional trial periods of new information. A dynamic approach such as Graham-Tomasi (1985) or the learning approach presented herein are more appropriate for examining the importance of feedback and learning in determining complete measures of ex ante value.

Second, our results suggest the accuracy of the field contingent valuation of nonmarket assets can be increased with the addition of a second-chance bid. A second-chance bid is defined as the bid obtained after the respondent is presented with new market information and allowed to adjust his initial inexperienced bid. Such information could include the mean bid of other respondents, the Vickrey second-price bid, and the payout in terms of monthly or annual expenditures.[2] By replicating experimental market learning in field application, the second-chance bid could capture the rapid learning observed in our experimental asset markets.

The second-chance bid has two potential methodological advantages over traditional bidding schemes. First, the second-chance bid is inexpensive in terms of a respondent's subjective costs of participating in a field contingent valuation experiment. Often respondents are engaged in other activities when asked to participate in a field contingent valuation experiment. Our results indicate that only one or two additional trial periods are necessary before a respondent's valuation of reduced risk stabilizes. The second-chance bid can allow the experimenter to quickly obtain a more accurate valuation.[3] Second, our results indicate that the bias associated with hypothetical valuation is greatly reduced with the addition of one or two trial periods. The second-chance bid would allow for learning, thereby allowing the contingent valuation experiment to more accurately replicate an actual market. Consequently, the nonmarket asset becomes more realistic to the respondent.

Chapter 2 proceeds as follows: Section 2.2 describes the four experimental asset markets. Section 2.3 briefly describes two aspects of experimental procedure: monetary incentives and learning. Section 2.4 presents the conceptual framework, the experimental results, and discusses the implications of the results on ex ante economic valuation and the contingent valuation methodology. Finally, Section 2.5 presents the conclusions.

2.2 Experimental Asset Markets

Four experimental asset markets under private and collective reductions risk were examined. Following Schulze et al.'s (1986) framework, the economic conditions of the markets are listed below.[6]

(a) Each experiment consisted of a fixed group of subjects ($n = 6$) given an initial identical bundle of assets, \$M.

(b) Each asset market consisted of four binary lottery periods (P, -\$L; 1 - P, +\$G), where P ($0 \leq P \leq 1$) is the probability of a monetary loss \$L, and 1 - P is the probability of a monetary gain \$G. Each lottery period was consistent across asset markets to ensure comparability of results.

(c) Each binary lottery, period consisted of twelve bidding auctions: one inexperienced hypothetical auction, ten non-hypothetical auctions, and one experience hypothetical auction. Each subject, therefore, reported eight hypothetical bids and forty non-hypothetical bids for reduction in risk.

(d) The four asset markets were defined in terms of private and collective reductions in risk. Markets SP and SI are the private provision of self-protection and self-insurance to reduce a risk to zero. Self-protection reduces the probability of a loss to zero; self-insurance reduces the severity of the loss to zero. Markets CSP and CSI are the collective provision of self-protection and self-insurance.

(e) The private risk reduction markets (SP and SI) were organized as a Vickrey sealed-bid second-price auction [Vickrey (1961)]. Each subject competes for the purchase of protection on insurance. The winner is the subject with the highest bid who pays the second highest bid for a 100% reduction in risk. Both the winner and second bid were posted as public information for each **auction.**[6] All subjects were present for all bids.

(f) The collective risk reduction markets (CSP and CSI) were organized as a modified version of the sealed-bid Smith Auction process [Smith (1980)]. The Smith Auction process works as follows. Each subject provides a bid to reduce risk to zero. If the sum of the bids equals or exceeds the costs of providing a 100% reduction in risk, then an adjusted (or average) bid is posted as the reigning price of protection or insurance. Acceptance by the collective of the price occurs only if all members agree. If at least one subject disagrees, then everyone is subject to a controlled draw of the **lottery.**[7] If the sum of bids does not exceed costs, then a controlled draw of the lottery occurs. Communication among subjects is forbidden. The experimenter sets the costs $C of 100% risk reduction equal to the sum of expected consumer surplus given the lottery period. Costs were not posted. For the four experimental asset markets the Smith Auction process is modified in three ways: (i) given a 100% risk reduction, subjects were not asked to provide bids for the quantity of collective good, (ii) no rebate rule was used, and (iii) there was no stopping rule after unanimous agreement, all 12 auctions were completed.

(g) A controlled draw from an urn containing P red chips and (1 - P) white chips determine the results of the binary lottery. A red chip is a $L loss, a white chip is a $G gain to assets. The drawn chip was replaced after each draw.

(h) Initial assets $M were reinitialized at the start of each bidding auction, thereby avoiding capital gains and losses across bidding auctions.

(i) No other market insurance was available. No transaction costs other than the price of self-protection or self-insurance were present. Appendix A contains the instructions for a private and collective asset market.

The four asset markets were examined using subjects who were undergraduate students at Appalachian State University.[8] All subjects were considered inexperienced in that they had not previously participated in a laboratory experimental market.

In accordance with induced value theory [Smith (1982), Plott (1982)], the experimental parameters were consistent across asset markets and lottery periods: initial asset endowment M = $10; monetary loss in assets L = $4; monetary gain in assets G = $1; and the four lottery periods (in order of presentation to respondents) were P = .2, .1, .01, or .4. The respective collective costs for each lottery period equaled the sum of expected consumer surplus C = $6, $3, $.3, or $12.[9] As in Schulze et al. (1986), the range of lottery periods examines if and how behavior in low probability lotteries differs from behavior in high probability lotteries.

2.3 Experimental Procedures: Incentives and Learning

Given the importance of methodological design in determining individual preferences [Smith (1982)], consider two points of experimental procedure. The first involves the use of monetary incentives. Many economists believe that without real-money incentives subjects behave strategically not revealing true preferences, or will not bother to take the experiment seriously. Consequently, they fear purely hypothetical experiments in the field or laboratory to inaccurately reveal preferences. Evidence suggests that when payment depends on the quality of the decision, subjects pay more attention [Thaler (1987)]. Essentially, dollar incentives force individuals to behave rationally by replicating a real-life competitive market. We examine how non-market values are affected in market situations by utilizing both hypothetical and nonhypothetical scenarios.

The second point involves learning or value realization. Experiments are designed as either one-shot decisions or repeated trial decisions. Thaler (1987) questions whether subjects actually do better in repeated trials. One-shot experiments, Thaler argues, attempt to discover the intuitions that subjects bring into the laboratory and report as their initial response. This initial response may well be the one a subject would make in a real life situation. There are many, however, who question whether a one-shot response is meaningful [Coppinger et al. (1980), Coursey and Schulze (1986), Coursey et al. (1987)]. They argue that one should distinguish between individual choice behavior and individual behavior in markets [Coursey (1987)]. market influences individual learning of value due to the learning-feedback-environment-of a repetitive framework. Contributions to reduce risk are rarely in-terms of a one-shot lifetime subscription. Therefore, to determine to what extent repetition affects value formation and implicit prices for reduced risk, we explore the dynamics of repeated market trials compared to static one-shot responses.

2.4 Experimental Results

2.4.1 Conceptual Framework

Individuals perceive they can exercise substantial control over their lives, including the ability to do something about many of the risks which they face. If, because of moral hazard and incomplete contingent claims contracts, individuals are not fully insured, the ex ante willingness to pay measures for a reduction in risk become relevant to value estimation. Since complete contingent claims markets-rarely, if ever, exist for environmental risks, these ex ante measures are especially appropriate for these goods. The ex ante measures we are concerned with are the maximum willingness to pay for self-protection or self-insurance [Ehrlich and Becker (1972)].

Self-protection decreases risk by reducing the probability of an undesired event occurring. For example, suppose an individual has a probability P of drinking unpotable water. It is possible for the individual to influence the probability by purchasing, say a private water filter, such that $P = P(s_t)$ where s_t is the monetary equivalent of self-protection at time period t (t = 1,...T). An increase in self-protection decreases the probability of drinking unpotable water, $P_s < 0$.[10] Subscript denotes the relevant partial derivative.

Self-insurance decreases risk by reducing the severity of an undesired event. For example, an individual has a loss $L from drinking unpotable water. The individual can reduce severity of the loss by adopting assorted measures to increase personal resistance, e.g., exercising or preventive medication, such that $L = L(Z_t)$, where Z_t is the monetary equivalent of self-insurance at time period t. An increase in self-insurance reduces the severity of drinking unpotable water, $L_z < 0$.

To illustrate self-protection and self-insurance, consider an individual who is uncertain about which of two mutually exclusive and jointly exhaustive states of nature will occur. The individual, whose preferences and income are independent of the states, makes a choice in a von Neuman-Morgenstern framework where his expected utility is an increasing and differentiable function of his certain asset endowment M. In the absence of self-protection or self-insurance, expected utility, EU, is

$$EU = PU(M - L) + (1 - P)U(M + G), \qquad (2.1)$$

where E is an expectations operator, and P ($0 \leq P \leq 1$) is the individual's initial degree of belief a loss of L will occur, $(1 - P)$ is his belief that a gain of G will occur, and $U(M - L) < U(M + G)$.

When opportunities are available to purchase self-protection or self-insurance or both, (2.1) can be rewritten as

$$\overline{EU_t} = P(s_t|K_{t-1})U_t(M - L(Z_t) - s_t - Z_t) + [1 - P(s_t|K_{t-1})]U_t(M + G - s_t - Z_t) \quad (t = 1,...,T), \tag{2.2}$$

where K_{t-1} is the message or information from trial t-1 used to update a prior likelihood. If only self-protection is available, the maximum s_t^m an individual would pay to reduce the probability of a \$L loss to zero is

$$U_t(M + G - s_t^m) = PU(M - L) + (1 - P)U(M + G), \tag{2.3}$$

or solving for s_t^m

$$s_t^m = M + G - U_t^{-1}[EU] \tag{2.4}$$

The last term on the right-hand side of (2.4) is called the certainty equivalent for the wealth prospect M + G.
If only self-insurance is available, the maximum Z_t^m an individual would pay to reduce the severity of a P probability to zero, is

$$P(K_{t-1})U_t(M - Z_t^m) + (1 - P(K_{t-1}) (M + G - Z_t^m) = PU(M - L) + (1 - P)U(M + G) \quad (t = 1,...,T) \tag{2.5}$$

In general, for risk averse or risk neutral individuals $s^m_t > Z^m_t$ since self-protection guarantees a certain gain of G, while self-insurance does not.[11]

2.4.2 Analysis of Means

Table 2.1 summarizes the results for risk reductions for all four asset markets and lottery periods.[12] The first two columns describe the four experimental asset markets and the four lottery periods of a potential loss in assets. The table reports two measures of central tendency for each bid (inexperienced hypothetical bid, average nonhypothetical bid over ten trials, and experienced hypothetical bid), the estimated mean and median bids in dollars; and one measure of dispersion, the estimated variance.

2.4.2.1 Learning

Coppinger et al. (1980), Coursey et al. (1987) and others have noted that a number of trial iterations are required before the respondent realizes that revealing "true" values is the dominant strategy in a Vickrey or Smith auction. Therefore, perhaps the most striking result is how rapidly respondents adjust their initial inexperienced hypothetical bid (UEHB). Learning and adjustment to a dominant strategy occur during the first few nonhypothetical trials. The immediate feedback environment of the experiments induce rapid bid adjustment. Figure 2.1 illustrates for each lottery period and all asset markets the UEHB bid was significantly larger than the mean first

TABLE 2.1

Summary Statistic of Experimental Markets
with One Risk Reduction Mechanism

Asset Market'	Probability of A Loss	Inexperienced Hypothetical Bid(UEHB)			Average Nonhypothetical Bid(ANB)			Experienced Hypothetical Bid(EHB)		
		Mean	Median	Variance	Mean	Median	Variance	Mean	Median	Variance
1. Self-Protection (Private)	20%	3.35	3.00	5.40	2.93	3.36	1.49	3.45	3.50	3.80
	10%	2.87	3.00	5.42	1.09	2.98	1.42	1.13	1.38	4.19
	1%	2.73	1.50	11.72	0.78	0.38	0.94	0.81	0.35	2.08
	40%	4.62	4.00	7.45	3.93	3.70	2.66	4.37	4.00	4.57
2. Self-Insurance (Private)	20%	3.93	4.00	5.26	2.56	2.16	2.69	2.44	2.25	2.59
	10%	2.93	2.28	6.23	1.09	0.79	1.10	1.13	0.86	0.92
	1%	1.85	0.50	10.35	0.09	0.07	0.02	0.07	0.03	2.01
	40%	4.91	5.00	5.32	3.35	3.31	1.81	3.33	3.58	1.87
3. Self-Protection (Collective)	20%	2.77	3.00	3.04	1.27	1.02	0.89	1.00	0.90	0.32
	10%	2.74	2.00	6.57	0.80	0.54	0.60	0.75	0.48	0.89
	1%	2.79	1.00	12.37	0.84	0.06	3.30	0.78	0.06	3.97
	40%	3.04	3.00	2.39	2.13	2.02	1.46	2.09	2.00	1.34
4. Self-Insurance (Collective)	20%	1.81	2.00	0.91	1.26	0.88	2.23	1.11	1.00	1.21
	10%	1.25	1.00	1.03	0.70	0.50	0.77	0.43	0.38	0.20
	1%	0.97	0.50	2.82	0.77	0.06	7.09	0.78	0.02	0.03
	40%	2.55	2.50	2.22	1.95	1.41	3.19	1.73	1.21	2.14

[a]n=30 for each asset market

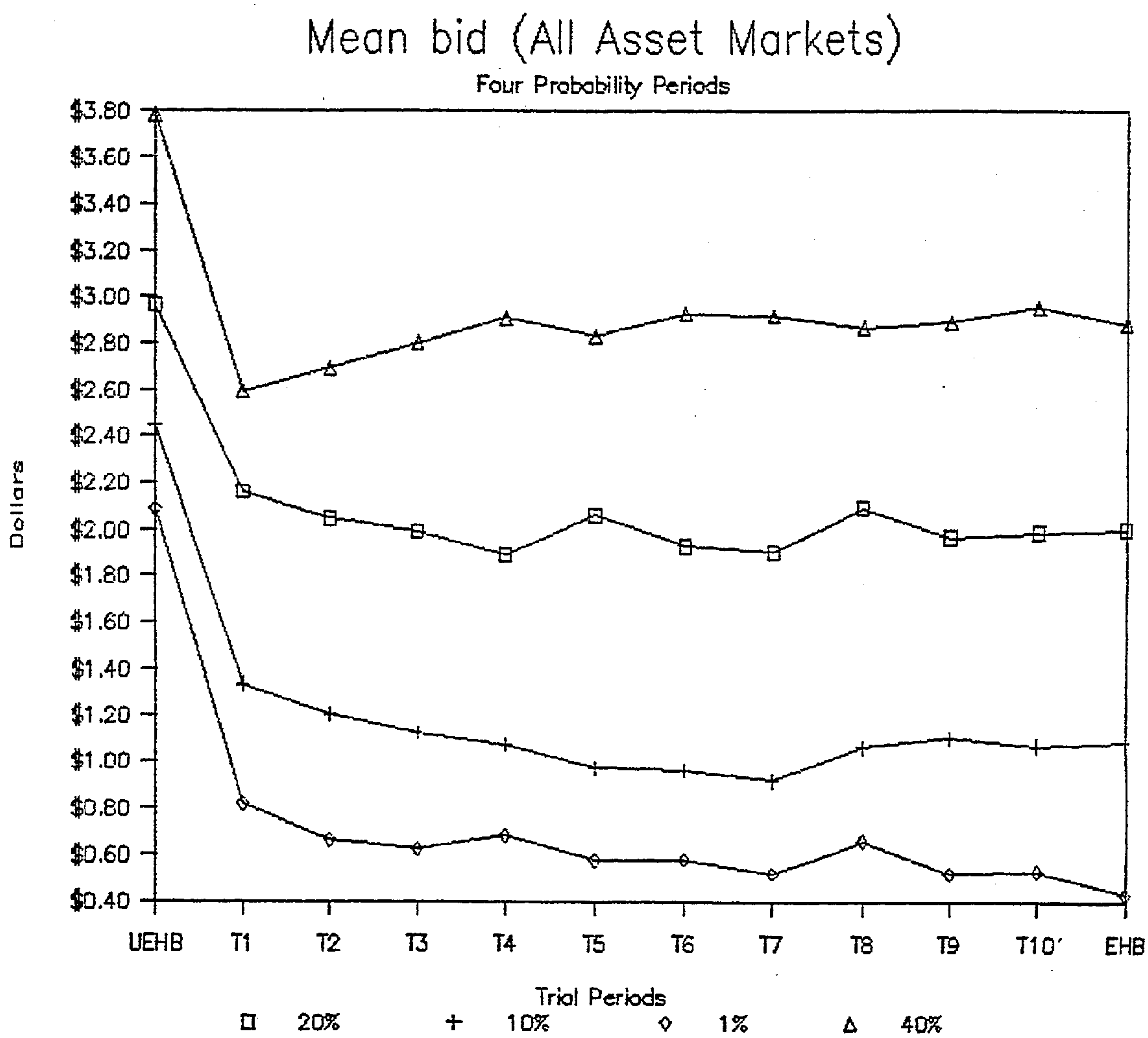
NOTE: We do not accept the null hypothesis that the population mean is zero at the .01 level using a one-tailed test for all UEHB, ANB, and EHB bids across asset markets and lottery periods.

nonhypothetical trial bid (T1). Using a one-tailed Wilcoxon matched-sample sign test conducted at the 99% confidence level, we did not accept the hypothesis that the respective UEHB bids and the T1 bids are derived from the identical parental distribution [20% Z = -4.928; 10% Z = -6.969: 1% Z = -6.626; 40% Z = -6.0051. See Siegel (1956) for a discussion of the Wilcoxon test.

Figure 2.1 shows after the first three trial bids (T1 - T3) the remaining trial bids relative to the experienced hypothetical bid (EHB) revealed relatively minor adjustments in value. For the 20% and 10% probability of a loss, using a one-tailed Wilcoxon rank sum test at the 99% confidence level we accepted the hypothesis that the first trial bid (T1) was statistically equivalent to the experienced hypothetical bid (EHB) [20% z = 1.455; 10% z = -1.279]. For the 1% probability the second trial bid (T2) was insignificant from EHB (Z = -1.293); for the 40% probability the third trial bid (T3) was insignificant from EHB (Z = 1.375).

Also note that the trials induce the dispersion of bids to collapse as the variance decreases with repeated bids. For example, Figure 2.2 and 2.3 show the variance of bids to reduce a 20% and 1% chance of a loss declines significantly. Therefore, bids are focusing in on a common unit, reducing the spread of the bid distribution.

Rapid learning is encouraging for the continuing use of demand revealing mechanisms such as contingent valuation since



Mean bid (All Asset Markets)
Four Probability Periods
$3.80
$3.60
$3.40
$3.20
$3.00
$2.80
$2.60
$2.40
$2.20
$2.00
$1.80
$1.60
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
Dollars
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10'
EHB
Trial Periods
20%
10%
1%
40%

Figure 2.1

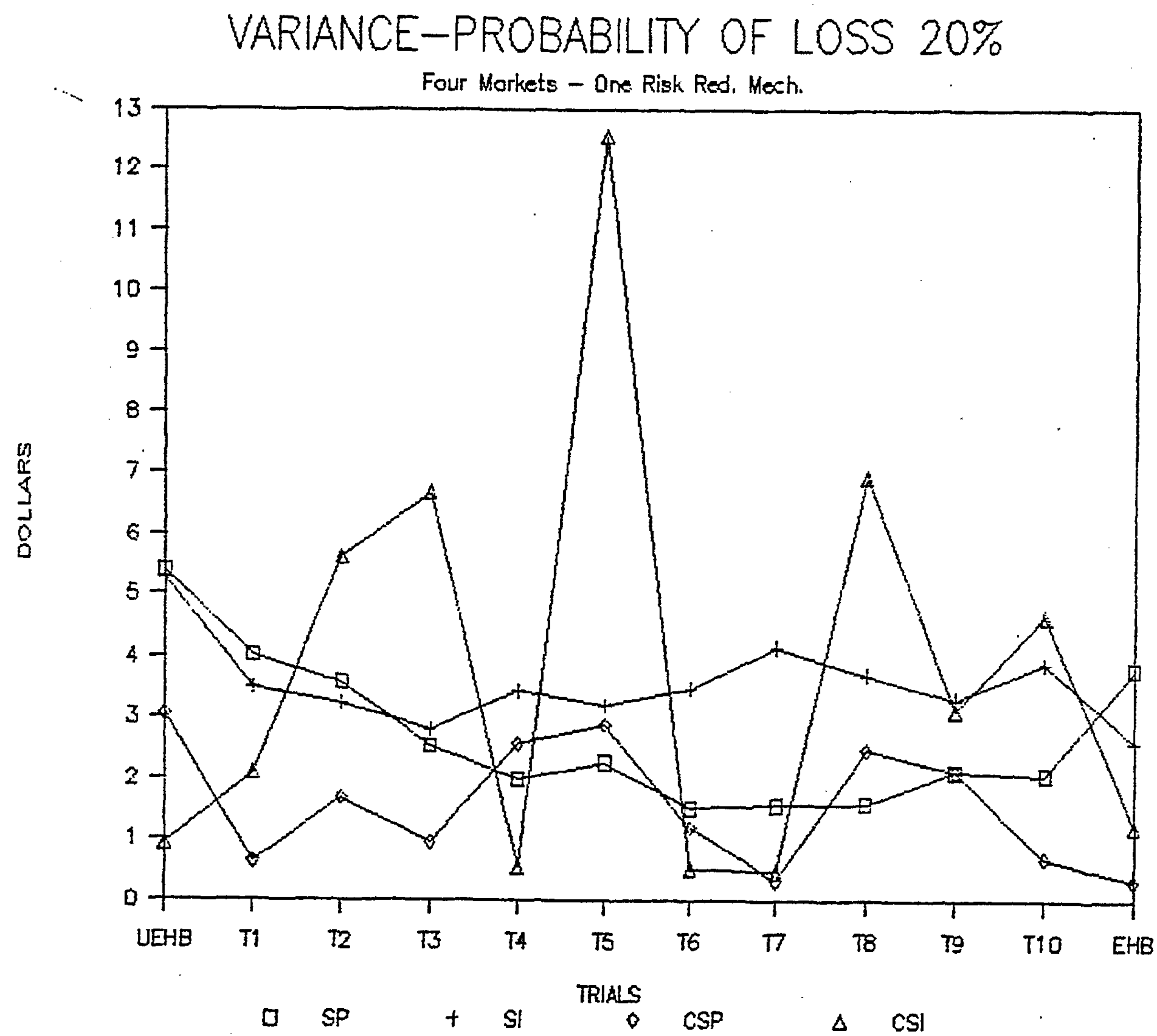

VARIANCE–PROBABILITY OF LOSS 20%
Four Markets – One Risk Red. Mech.
DOLLARS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SP
SI
CSP
CSI

Figure 2.2

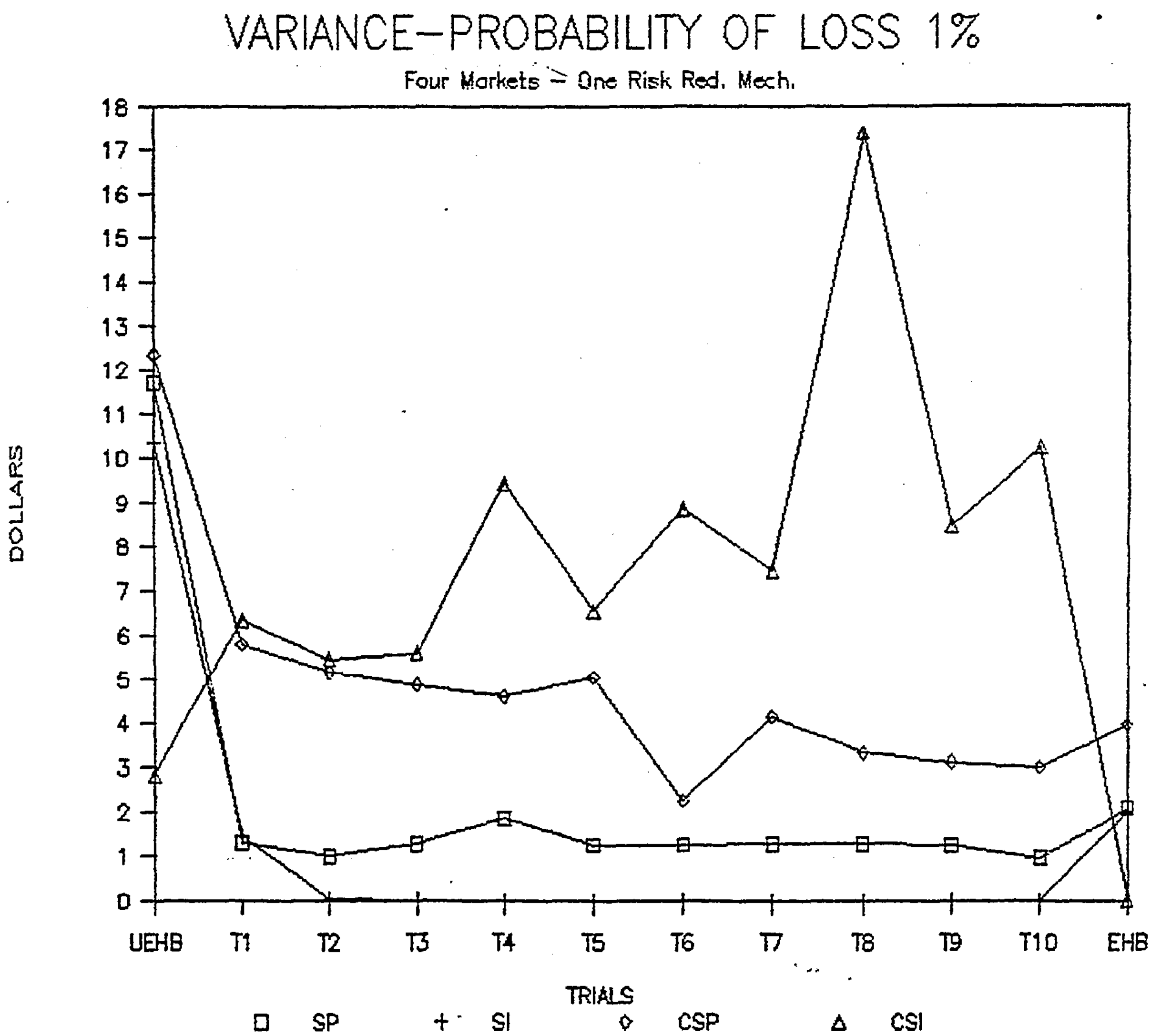

VARIANCE-PROBABILITY OF LOSS 1%
Four Markets = One Risk Red. Mech.
DOLLARS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SP
SI
CSP
CSI

Figure 2.3

simple adjustments can be made to the current one-shot field experiments. Without greatly increasing the respondent's subjective costs of participating in the field experiment, the addition of one extra bidding trial, a second chance bid, will allow for learning, thereby more accurately reflecting an actual market response. The opportunity for bid adjustment is important for valuing reduced risk since respondents initial beliefs are generally quite different from equilibrium behavior. For example, a field contingent valuation experiment by Dickie et al. (1987) found that after explaining the implications of the respondent's initial bid in terms of monthly monetary outlay, initial bids to reduce headaches and coughing declined from $178 and $355 to $3.24 and $1.60.[13] One additional second chance bid was all that was necessary to induce a more accurate market response. Allowing the respondent a second chance to adjust their bid after additional information of implications or what other respondents bid, differentiates between what respondents are willing to pay and what they are willing and able to pay.

However, if binding constraints force a field contingent valuation experiment to use only a one-shot inexperienced hypothetical bid mechanism, can we predict the experienced market bid from the initial inexperienced bid? To test if the inexperienced hypothetical bid (UEHB) is a statistically significant predictor of the experienced bid (EHB) we estimate a separate ordinary least squares model for each asset market for the four lottery periods. Table 2.2 summarizes the results of

TABLE 2.2

Summary Results for Ordinary Least Squares
Model of Experienced Hypothetical Bid
for Experimental Market with One Risk Reduction Mechanism

Probability of Loss	Asset Market[a]	Constant[b]	Inexperienced Hypothetical Bid	R^2
1. 20%	SP	1.836	0.481	.33
		(3.486)**	(3.706)**	
	SI	0.681	0.447	.41
		(1.472)	(4.380)**	
	CSP	-0.781	0.078	.06
		(3.996)**	(1.301)	
	CSI	-0.289	0.775	.45
		(-0.878)	(4.784)**	
2. 10%	SP	0.728	0.451	.26
		(1.390)	(3.156)**	
	SI	0.800	0.114	.09
		(3.011)**	(1.641)	
	CSP	0.247	0.184	.25
		(1.105)	(3.066)**	
	CSI	0.104	0.267	.36
		(0.977)	(4.001)**	
3. 1%	SP	0.653	0.056	.02
		(1.907)	(0.711)	
	SI	0.076	-0.003	.01
		(3.077)**	(-0.496)	
	CSP	-0.085	0.308	.30
		(-0.213)	(3.428)**	
	CSI	0.039	0.034	.10
		(1.053)	(1.744)*	
4. 40%	SP	3.011	0,293	.14
		(4.105)**	(2.139)**	
	SI	4.316	0.168	.09
		(4.316)**	(1.569)**	
	CSP	1.519	0.187	.06
		(3.260)**	(1.363)	
	CSI	0.207	0.595	.37
		(0.478)	(4.031)**	

a - The asset market definitions are: SP = private self-protection, SI = private self-insurance, CSP = collective self-protection, and CSI = collective self-insurance.
b - Number in parentheses are the ratios of the estimated coefficients to their standard errors.
* - Significant at the .05 level using a one-tailed test for 'the null hypothesis that the population mean is zero.
**- Significant at the .01 level using a one-tailed test.

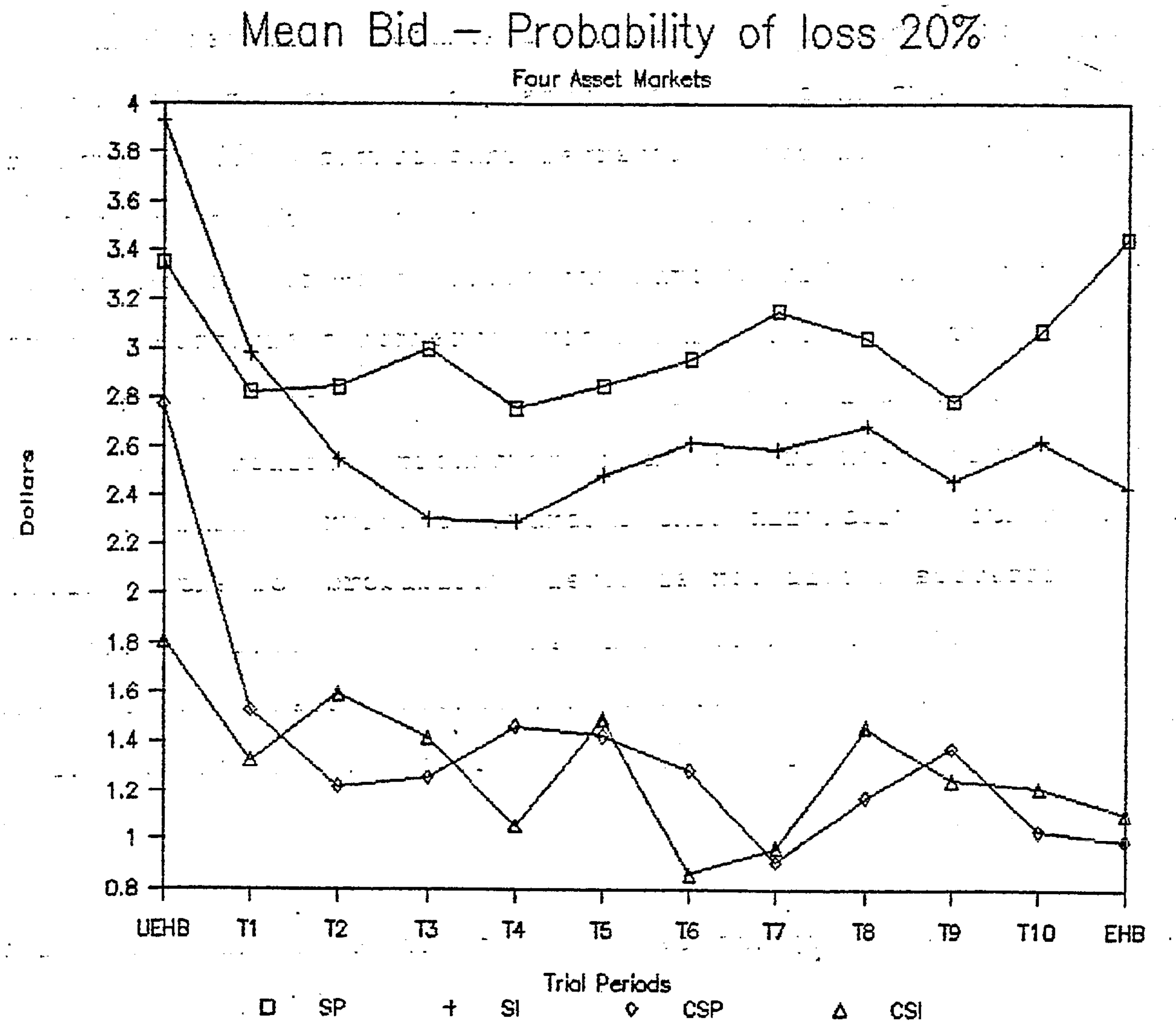
the models. For the 20%, 10% and 40% lottery periods at least three of the four asset markets yielded statistically significant regression coefficients (99% confidence level).

For the 1% probability period, however, the inexperienced bid (UEHB) had mixed results at explaining the experienced bid (EHB). Only two of the four asset markets (collective self-protection) had a significant regression coefficient; one at the 99% confidence level, and one at 95%. This result is not encouraging for one-shot field experiments since the majority of naturally-occurring nonmarket risks fall well below the 1% level [see Smith and Desvousges (1987)]. The inexperienced bid may or may not be a reliable predictor of the experienced market bid for low level risk. Trying to overcome this difficulty with repeated trials at the low probability level is not always successful. Four trial periods (T4) were required before three of the four asset markets yielded significant coefficients at the 99% confidence level. The collective self-insurance market, however, never yielded significant coefficients for the experienced bid (EHB) for the respective ten trial periods (T1 - T10). Whether this result is due to the group of respondents or the auction market is unclear.[14] Regardless, if repeated trials (three or more) are required to elicit market values, it may increase the field respondent's subjective costs of participating to a prohibitive level [also see Coursey and Schulze (1986)]. Consequently, the effectiveness of field contingent valuation is reduced.

2.4.2.2 Private vs. Collective Risk Reductions

Respondents in the asset markets were exposed to either private or collective reductions in risk. The private, competitive asset markets of self-protection or self-insurance were designed to capture individual reductions in risk, the collective markets capture group risk reductions. Figures 2.4 through 2.7 illustrate the mean bids for the four asset markets, over the trial periods. Except for the 1% probability period [Figure 2.53], the experienced market value bid (EHB) for private risk reductions exceeded the value bid for collective reductions. Using a Wilcoxon rank-sum test at 95% confidence level we did not. accept the hypothesis that the mean experienced hypothetical bid (EHB) for the respective private risk reduction through self-protection or self-insurance were derived from the same parental distribution as the collective reductions.[15]

The results have implications on the payment mechanism used in field contingent valuation experiments. Traditionally, the payment mechanism is a collective scheme in which an agency exogenously reduces a risk if the sum of individual payments (i.e., higher taxes, group fund) exceeds the costs of reduction e.g., Weinstein et al. (1980), Smith and Desvousges (1987)]. A large number of risks are endogenous, however, and can be reduced privately through self-protection or self-insurance mechanisms. By concentrating on collective risk reduction mechanisms and not private mechanisms, our results indicate that traditional use of contingent valuation may in fact only be a lower bound on the



Mean Bid — Probability of loss 20%
Four Asset Markets
Dollars
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
Trial Periods
SP
SI
CSP
CSI

Figure 2.4

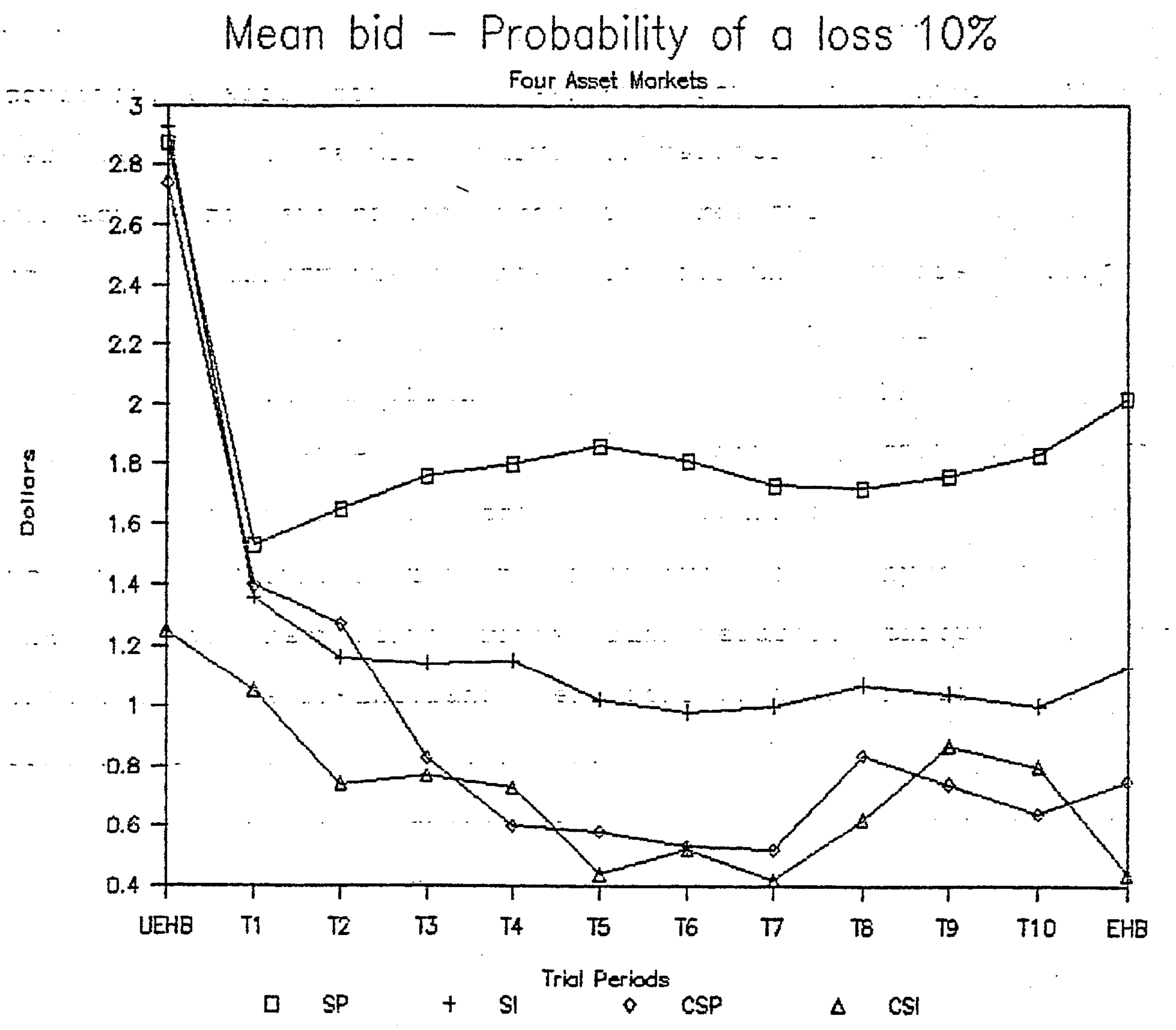

Mean bid - Probability of a loss 10%
Four Asset Markets
Dollars
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
Trial Periods
SP
SI
CSP
CSI

Figure 2.5

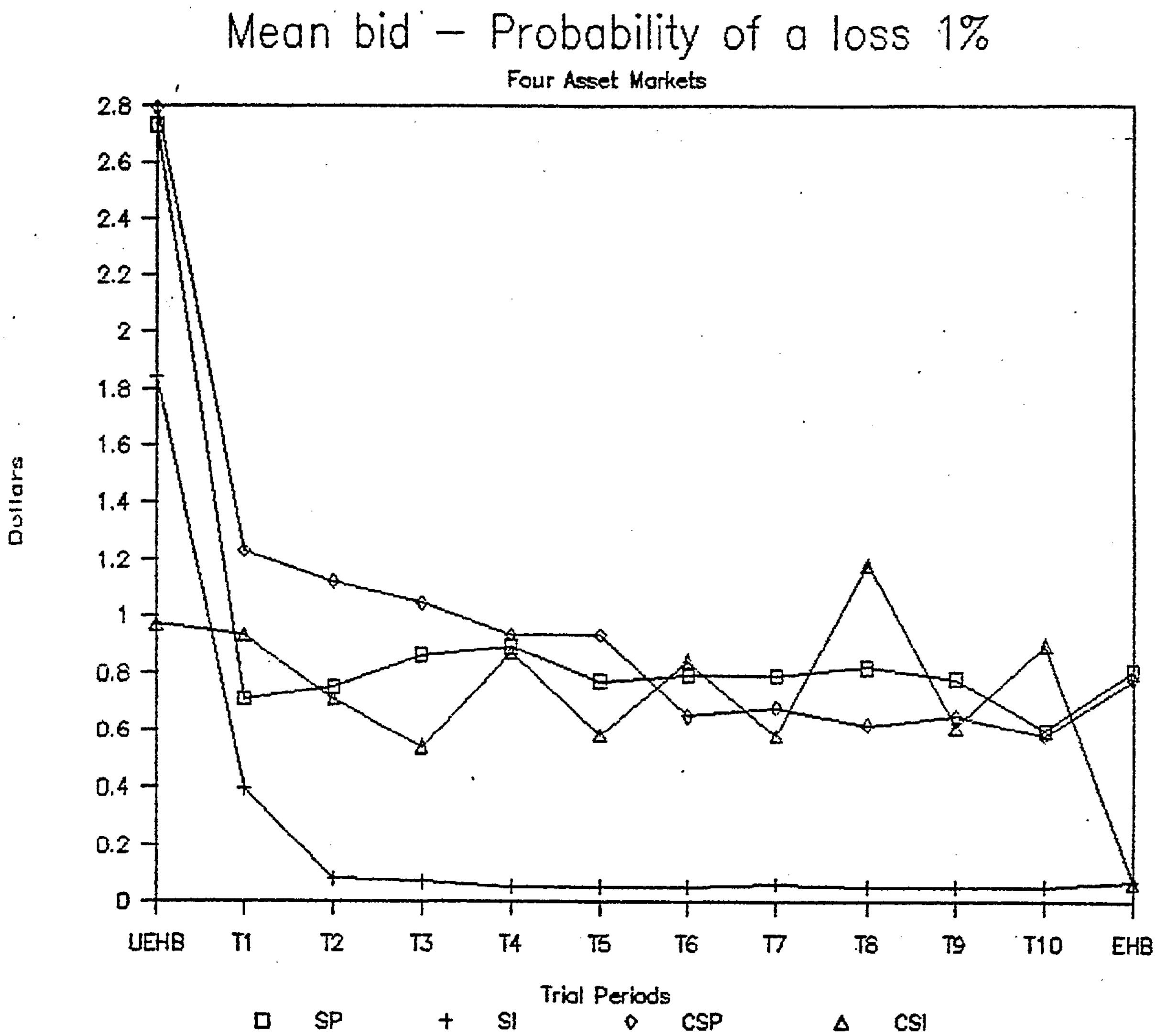

Mean bid – Probability of a loss 1%
Four Asset Markets
Dollars
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
Trial Periods
SP
SI
CSP
CSI

Figure 2.6

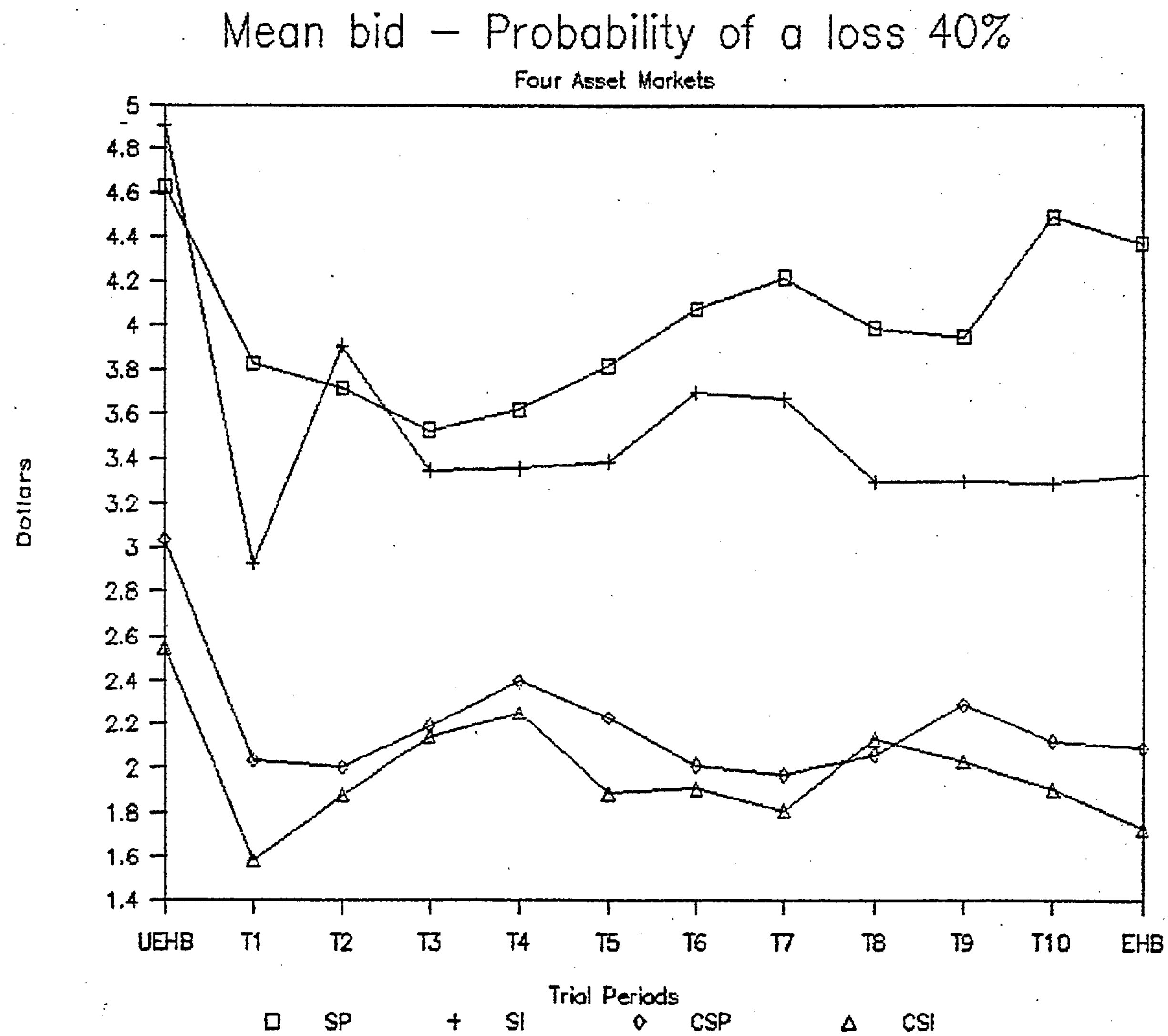

Mean bid – Probability of a loss 40%
Four Asset Markets
Dollars
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
Trial Periods
SP
SI
CSP
CSI

Figure 2.7

economic value of risk **reductions.**[16]

2.4.2.3 Self-Protection vs. Self-Insurance

Two aspects define risk: the probability and severity of an undesirable event. Individuals and collective agencies reduce risk by decreasing either aspect. Self-protection decreases probability, and self-insurance decreases severity. Given one can discriminate between self-protection and self-insurance expenditures, is one reduction scheme preferred to another? Current theory yields an ambiguous answer. In section 2.4.1, we argued that the risk-averse or risk-neutral individual will value self-protection more than self-insurance since self-protection guarantees a monetary gain. Boyer and Dionne (1983) argue that a risk averse consumer will always prefer self-insurance to self-protection, however, since the former is more efficient in terms of risk reduction. Alternatively, Chang and Ehrlich (1985) argue that self-insurance is not always preferred to self-protection since both must be equally desirable in terms of marginal contribution to expected utility.

Ultimately, most questions are answered empirically. Our results indicate that for the four probability periods the mean bids for self-protection exceed that for self-insurance. A Wilcoxon rank sum test at the 95% confidence level indicates that the experienced hypothetical bids for private self-protection are significantly different from the bids for private self-insurance for all lottery periods [20% Z = 2.595: 10% Z = 2.837; 1% Z =

3.214; 40% Z = 1.990]. Respondent's were willing to pay more for private mechanisms that influence probability than mechanisms that influence severity. Respondents were not willing to pay more, however, for collective mechanisms that influence probability relative to severity. A Wilcoxan rank sum test at the 95% confidence level indicates the experienced hypothetical bids for collective self-protection are not statistically significant from collective self-insurance for all probability periods [20% Z = 0.059; 10% Z = 1.289; 1% Z = 1.702; 40% Z = 1.718].

2.4.2.4 Risk Premium

Expected utility has been criticized for observed violations of the independence axiom [see Machina (1982, 1983)]. Both psychologists and economists have observed systematic violations of the "linearity in probabilities" property of the independence axiom. Studies have found individuals oversensitive to changes in the probability of low probability events, and undersensitive to large probability events. This violation is particularly damaging since it implies non-recovery of the von Neumann-Morgenstern expected utility function.

To determine if respondents in the experimental asset markets overemphasize small probabilities and underemphasize large probabilities, we examine the individual's risk preference in terms of a risk premium. A risk premium is the amount above expected consumer surplus the risk averse individual is willing to pay ex ante to eliminate the risk of losing $L of their assets.[17] If the individual overemphasizes small probabilities, then the risk premium for eliminating a 1% probability of a loss should exceed the risk premiums for a 10%, 20% and 40% probability. Table 2.3 reports the summary statistic for the four asset markets over the four lottery periods. The individual is risk averse (neutral/lover) if the ratio of bid to expected consumer surplus is greater (equal to/less) than unity. Figure 2.8 illustrates the results for the combined asset markets for the four lottery periods. Respondents were initially extremely risk averse, overestimating the 1% probability of a loss in the initial inexperienced hypothetical bid. With repeated market exposure through ten nonhypothetical trials, however, the overestimation declined. Although the risk premium for the 1% probability for the experienced hypothetical bid is still larger than the other probability periods, oversensitivity declines rapidly with market experience.[18] The results support Plott and Sunder's (1982) argument that for a well-defined, mature market environment, expected utility is "not universally misleading about the nature of human capabilities and markets" (p. 692).

2.5 Conclusions

We separate our conclusions into two areas: (a) alternative asset market mechanisms to elicit the economic value of reduced risk, and (b) rapid value formation and the second chance bid.

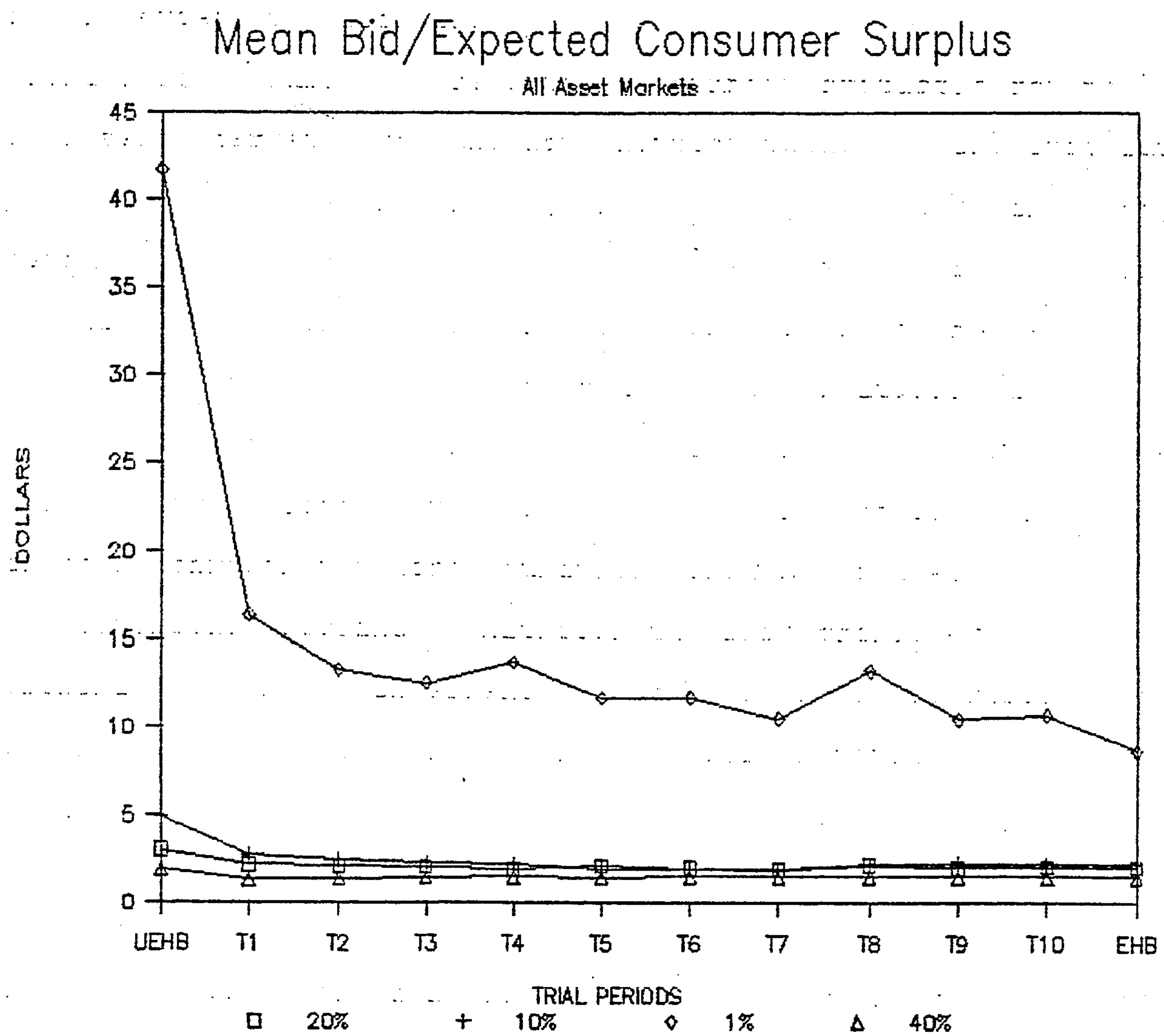
First, four experimental asset markets with one risk

TABLE 2.3
Summary Statistic of Risk Preference and Risk Premium
of Experimental Markets with One Risk Reduction Mechanism

	Probability of a Loss	Inexperienced Hypothetical Bid Mean/ES[a]	Average Nonhypothetical Bid Mean/ES	Experienced Hypothetical Bid Mean/ES
1. Self-Protection (Private)	20%	3.35[b]	2.93	3.45
	10%	5.74	3.48	4.04
	1%	54.60	15.60	16.20
	40%	2.31	1.97	2.19
2. Self-Insurance (Private)	20%	3.93	2.56	2.44
	10%	5.80	2.18	2.26
	1%	37.00	1.79	1.41
	40%	2.46	1.73	1.67
3. Self-Protection (Collective)	20%	2.77	1.27	1.00
	10%	5.48	1.60	1.51
	1%	55.80	16.84	15.52
	40%	1.52	1.06	1.04
4. Self-Insurance (Collective)	20%	1.81	1.26	1.11
	10%	2.50	1.40	0.86
	1%	19.40	15.40	1.40
	40%	1.28	0.98	0.87

[a] - ES represents expected consumer surplus ES = $1, $.5, $.05, and $2 for lottery period = 20%, 10%, 1%, and 40%;

[b] - Mean/ES > 1(=1/ < 1) implies risk aversion (neutrality/lover).



Mean Bid/Expected Consumer Surplus
All Asset Markets
DOLLARS
45
40
35
30
25
20
15
10
5
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIAL PERIODS
20%
10%
1%
40%

Figure 2.8

reduction mechanism are considered to determine a value for reduced risk. Our results indicate private probability-influencing self-protection provides an upper bound on value, while collective severity-influencing self-insurance provides the lower bound. The significant differences in value estimates by the four asset markets indicate the current focus on collective self-protection in field experimentation determines only one of four possible risk reduction value estimates. Future field contingent valuation should consider the other three asset markets as alternative mechanisms to reveal value for reduced risk. By doing so a more comprehensive view of value will be obtained.

Second, the four asset markets with immediate market information feedback induced rapid learning. Usually value formation was complete after one or two additional market trials. This result indicates enhanced accuracy of demand revealing mechanisms such as contingent valuation with the addition of a second chance bid. A second chance bid will allow the individual to adjust their initial value estimate after being provided with experimenter-controlled information on the market implications of their initial bid. Such information could include the mean or median bid of other individuals, the reigning market price in terms of Vickrey or Smith auction mechanisms, and the monthly or annual impact of their bid.[19] In addition, a second chance bid may reduce the biases associated with valuing hypothetical assets. Our results indicate that after one or two trials, experienced hypothetical bids did not differ significantly from nonhypothetical bids.

Note, however, these results must be qualified for use in valuing nonmarket risks of one percent or less. The robustness of predictability and value formation decline for three of four asset markets during the 1% lottery period. The addition of a second chance bid, however, will still induce value formation to a degree closer to predicted by expected utility theory.

Endnotes

1. Hypothetical asset valuation is the case where the purchases of self-protection or self-insurance are purely imaginary. No real money is exchanged, the subject's bid for risk reductions is not binding, and the outcome of the lottery is not resolved. Nonhypothetical asset valuation is precisely the opposite. All bids are binding, the lottery is resolved, and real money is exchanged between experimenter and subject.

Hypothetical bids are categorized as either inexperienced or experienced. An inexperienced hypothetical bid is the initial bid of the experimental session before any actual nonhypothetical trials are run. An experienced hypothetical bid is the final bid of the lottery period after the subject has "experienced" ten nonhypothetical trials.

The inexperienced hypothetical bid comes the closest to the bids obtained in field contingent valuation surveys.

2. Rowe et al. (1980) first used the idea of presenting market information to respondents to allow for bid adjustment. However, since Rowe et al. the use of market information for bid adjustment has been neglected. Our results indicate this neglect is unjustified, and further field experimentation on a second-chance bid is warranted.

3. A second-chance bid differs from traditional iterative bidding schemes. Iterative bidding simply determines if the individual will pay an additional fixed increment above the initial bid. No additional information is provided [see Durden

and Shogren (1988)].

4. Schulze et al. (1986) only consider one of the four markets described in this paper, private self-insurance. The economic conditions were deliberately replicated, thereby providing an independent data set to verify or refute Schulze et al's results. Future experiments will examine economic valuation given differing parameter set.

5. Risk was reduced to zero to act as a boundary point for future experiments. Reducing risk to zero creates the so-called "certainty" effect [Kahneman and Tversky (1979)] in which individual's are willing to pay more for, say a 10% risk reduction if P = 10% and was reduced to 0%, than if P = 30% and reduced to 20%.

6. Since Vickrey's (1961) initial utilization, the second-price auction mechanism has well known demand revealing properties. The subject's dominant strategy is to reveal full preferences since the subject does not pay what they bid. Incentives for false bids do not exist.

7. See Smith (1977) and Banks et al. (1986) for a discussion of unanimity and the collective provision of goods.

8. Bennett (1987) found student responses statistically insignificant from respondents representative of the general population. This suggests experimentation may be "satisfactorily performed using student groups" (p. 367).

9. As shown in Bishop (1982), the expected consumer's surplus for a binary lottery equals the difference between the maximum

lottery income (M + G) and the expected value of the lottery $EV = P(M - L) + (1 - P)(M + G)$. Such that

$$ES = (M + G) - P(M - L) - (1 - P)(M + G) = P(L + G)$$

where ES is the expected consumer surplus. For example, in the 20% lottery period,

$$ES = (10 + 1) - .2(10 - 4) - .8(10 + 1) = \$1.$$

10. Ehrlich and Becker (1972) pose the question: can you define a state of the world that is independent of human actions? The answer is yes, but such a state is not what economists should be concerned with. This point can be illustrated using an example in Ehrlich and Becker. Consider the probability that a bolt of lightning will burn a house down. The probability of the event occurring can be influenced by the owner placing a lightning rod on his roof. This state of the world is not independent of human actions. The state of the world can be redefined to be independent of human actions if the state is the probability that lightning strikes the house. Humans have no control over that event. However, as economists, we should not be concerned with the probability that a lightning bolt strikes, but with the probability that the house burns down. In other words, the outcome and the probability of its occurrence is what we must consider. This outcome is not independent of human actions.

11. For a risk neutral individual, the utility terms are linear such that $\mathbf{s_t} = P[L + G]$ and $\mathbf{Z_t} = PL$, which implies that $\mathbf{s_t} > \mathbf{Z_t}$. For a risk averse individual, we note that $\mathbf{s_t} = M + G - \mathbf{U^{-1}[EU]}$ and $\mathbf{Z_t} = M + G - \mathbf{U^{-1}[EU} + P[U(M + G - Z) - U(M - Z)]]$. Since

$P[U(M + G - Z) - U(M - Z)] > 0$ and U^{-1} is concave increasing, then $s_t > Z_t$.

12. Forsythe et al. (1982) note the frustrating "open problems that are being encountered in almost all experimental work where the costs of conducting experiments places a significant constraint on the number of observations" (p. 549). Given the sample size of n=30 for each asset market, one must heed Forsythe et al.'s warning that "statistical tests we report should be regarded more as measures than classical hypothesis tests" (p. 549).

13. See Fisher (1988) for an overview of the problems associated with valuing health risk from a policymaker's viewpoint.

14. Schulze et al. (1986) attributed the problems associated with low probability lotteries to problems of (a) framing of decision problem, and (b) the so-called gambler's fallacy--adjusting the probability of a loss upward with repeated desirable outcomes.

15. There was one exception: self-insurance and collective self-insurance at the 1% lottery period (Z = 0.576). The remaining statistics for self-insurance versus collective action are 20% Z = 4.142; 10% Z = 3.882; and 40% Z = 3.996. The statistics for self-protection are 20% Z = 5.073; 10% Z = 3.374; 1% Z = 1.936; and 40% Z = 4.883.

16. Bennett (1987) also recognized this point in an experimental study on strategic behavior and the valuation of nonmarket assets. The upper and lower bounds of value conform to Bohm's (1984) notion of an interval approach to the valuation of

nonmarket assets. The interval approach allows for greater flexibility in allocation decisions since benefit estimates are presented as confidence intervals based on controlled behavioral incentives to over- or underestimate true value.

17. See Bishop (1982) for a derivation of the risk premium RP such that

$$\mathbf{RP_t = s_t - ES} \quad \text{or} \quad \mathbf{RP_t = Z_t - ES.}$$

18. Kunreuther et al. (1985) noted the substantial empirical evidence suggesting individuals are unwilling to insure or protect themselves against low probability/high severity events. In light of this finding, our results support a notion of preference reversal in that the willingness to pay a risk premium was the highest for the low probability lottery. Yet apparently this behavior is reversed in real-world risks such as seat belts and federally subsidized flood insurance [Kunreuther et al. (1985)].

19. Brookshire and Coursey (1987) have extended aspects of the Smith Auction process to a field study on the value of tree density in a public park. No actual auction was conducted, rather elements of the Smith auction were presented to respondents. These elements include information on what other respondents were bidding, and the costs of providing alternative tree density levels.

CHAPTER 3

Experimental Markets with Two Risk Reduction Mechanisms*

3.1 Introduction

This chapter examines experimental markets with two sequential mechanisms to reduce risk. The experiments determine if and how private and collective risk reduction behave as substitutes. We examine the robustness of collective option payments relative to private self-protection or self-insurance. In doing so, traditional views of supply-side option value or risk premium are reevaluated both theoretically and empirically.

Weisbrod (1964) expanded the scope of benefit-cost analysis by examining the potential relevance of exogenous ex ante consumer uncertainty for measures of economic efficiency. He argued that a complete analysis must account for risk preference as reflected by a risk premium (option value) the difference between the maximum a risk averse individual would be willing to pay to retain the option of using a future good (option price) and the expected value of ex post consumer surplus.[1] The latter is a traditional Marshallian or Hicksian measure while the former includes a risk premium because the consumer is required to make a decision before the state of nature or its associated outcome is revealed. Most of the abundant environmental economics literature on option value has sought to establish whether it is negative, positive, or zero, which would respectively imply that the traditional measures of environmental protection and improvement are positively, negatively, or not at all **biased.**[2] It is generally agreed that the sign of option value is indeterminant for a risk-averse consumer. A major exception, as Bishop (1982) and Smith (1983) have shown, is that option value will be positive when demand is certain and supply uncertainty is **eliminated.**[3]

The option value literature, however, invariably assumes that the individual consumer treats the probability and severity of provision of a undesired good as exogenous, i.e., his private influence over an uncertain outcome is presumed to be predetermined or nonexistent. Exogeneity is by no means an obvious assumption and it is not difficult to find perfectly reasonable, everyday counter-examples. For example, when a potable water supply is uncertain, individuals often choose to provide self-protection in the form of bottled water, water filters or both [see Smith and Desvousges (1986b)]. Other examples of self-protection include purchases of air purifiers and conditioners to increase the likelihood of acceptable air quality, and the construction of air vents and isolation panels to reduce the likelihood of radon contamination [Smith and Johnson (1988)]. These and similar examples of environmental quality issues conform to what Mohring and Boyd (1971) and Cornes and Sandler (1986, Chap. 7) term impure public goods which have benefits that are only partially rivalrous or excludable.

Since Ehrlich and Becker's (1972) seminal article, the importance of endogenous probability and severity has become increasingly apparent in many areas of economic, including liability analysis [e.g., Shavell (1983)], safety issues [Peltzman (1975)], non-Nash behavior [Shogren (1987)], and political voting [Austen-Smith (1987)]. The purpose of this chapter is to reexamine supply-side option value, given endogenous probability and severity. We design four experimental asset markets with two mechanisms to reduce risk.

Contrary to traditional arguments, we argue that the prospective removal of supply uncertainty does not necessitate a positive option value, given that the level of uncertainty is at least partially dependent on the consumer's choice of actions.[4] Since an individual who is an efficient provider of self-protection will have a wider variety of ex ante and ex post choices [Spence and Zeckhauser (1972)], the likelihood of a small option price, and consequently, a trivial or negative option value is increased. Therefore, any concept of ex ante valuation must include both self-protection or self-insurance and option price payments in order to avoid misestimating actual economic benefits of collective supply of a nonmarketed environmental good.[5]

The experimental markets provide weak support for our argument. Each individual provided two sequential bids for private and collective auctions. To test our hypothesis we examined the collective bid of the highest bidder in the private auction. In 100% of the cases, the highest bidder's private bid exceeded the expected consumer surplus, implying a positive option value or risk premium. In only 62.5% of the cases did the highest bidder's collective bid exceed expected surplus. Therefore, even though the bidder was willing to pay a risk premium, for 37.5% of the cases their option value for collective reduction was negative.

Other results of the experiment with two risk reducing mechanisms include findings of an insignificant difference between bids for probability-influencing self-protection and severity-influencing self-insurance, slower learning and value adjustment relative to experimental markets with one risk reduction mechanism, nonlinearity in probability providing further evidence for violation of the independence axiom of expected utility theory, and mixed evidence of a significant difference in values for private risk reduction mechanisms relative to collective mechanisms.

Chapter 3 proceeds as follows. Section 3.2 examines self-protection, self-insurance and option value. Section 3.3 describes the experimental design and procedures. The experimental results are presented in Section 3.4. Finally, the conclusions are in Section 3.5

3.2 Self-Protection, Self-Insurance, and Option Value

Most individuals perceive that they can exercise substantial control over their lives, including the ability to do something about many of the uncertainties which they face [Perlmuter and Monty (1979); Stallen and Tomas (1984)]. As the option value literature universally recognizes, one form of control is the use of market insurance to redistribute income and associated consumption opportunities toward undesirable prospective outcomes. Given that insurance prices are actuarially fair and that the marginal utility of income is decreasing, insurance would be acquired in those amounts that make the individual indifferent as to which of a set of feasible states of nature ultimately occurs [Ehrlich and Becker (1972)]. No matter what the realized state of nature, the ex post compensation which the insurance supplies maintains the ex ante utility level. Questions of ex ante versus ex post valuation therefore become irrelevant.

With imperfect contingency markets, consumers are not fully insured. Ex ante willingness-to-pay then becomes relevant. Since fair contingent claims markets rarely if ever exist for environmental goods, ex ante measures are especially appropriate for these goods. If the individual is provided the opportunity to make option payments for environmental goods, the efficiency with which he can allocate his wealth among states of nature is enhanced [Cook and Graham (1977)]. An ex ante value measure then refers to the minimum ex ante expenditures the consumer must make in order to maintain his expected utility when the probability of a future state of nature changes. However, nowhere does the option value literature explicitly recognize that economic agents can influence the probabilities of identifiable states of nature through the adoption of what Ehrlich and Becker (1972) and

Laffont (1980) term acts of self-protection or self-insurance.[6]

For simplicity, consider an individual under a given liability regime who is uncertain about which of two mutually exclusive and jointly exhaustive states of nature will occur.[7] This individual, whose preferences and income are independent of these states, makes an atemporal choice in a von Neumann-Morgenstern framework where his expected utility is an increasing, strictly concave, and differentiable function of his wealth. Thus, in the absence of self-protection, self-insurance or an option payment, expect utility, EU, is

$$EU = P_oU(M - L) + (1 - P_o)U(M + G) \tag{3.1}$$

where E is an expectations operator, $P_o (0 \leq P_o \leq 1)$ is the individual's initial degree of belief that as loss of L will occur, $1 - P_o$ is his degree of belief in the occurrence of a gain G, and $U(M + G) > U(M - L)$. Given concavity of the utility function, option price, X, is then that ex ante sure payment, which holds expected utility constant when the probability of a loss being realized has changed;[8] that is, following Freeman (1985):

$$PU(M-L-X) + (1-P)U(M+G-X) = P_oU(M-L) + (1-P_o)U(M+G) \tag{3.2}$$

where $P > P_o$. In accordance with the traditional option value literature, the payment of X secures access to the benefits of the predetermined probability, P, of the desirable state, $U(M + G)$ [Smith (1985), p. 304)]. Typically, the desirable state is represented as a pure public good which is independent of any individual's actions, and which the relevant collective agency finances by sure payments from everyone.

More realistically, one might view the individual as one of a collection of potential beneficiaries, any one of whom by increasing the size of a voluntary option payment can enhance the probability of a gain G. Similarly the individual might improve his probability of privately commanding G or reduce the severity of the loss by adopting assorted self-protection or self-insurance strategies. The collective and private alternatives are unlikely to be perfect ex ante substitutes for him, if only because of differences in his ability to influence the probability of the desirable state. For example, contributions to the construction of a public water treatment plant might make it more likely that everyone will get "safe" drinking water. Alternatively, an individual could accomplish the same end for himself alone by purchasing a water filter for his home. The current theoretical and empirical option value literature has not explicitly recognized the implications of substitution possibilities.[9]

When opportunities are available to make a probability-influencing option payment or to engage in self-protection or self-insurance the left-hand-side of (3.2) can be rewritten as:

$$EU = P(s,X)U(M-L(Z)-s-Z-X) + (1-P(s,X))U(M+G-s-Z-X) \tag{3.3}$$

where s is self-protection expenditures, and Z is self-insurance, P(s,X) is differentiable and increasing in s and X, and L(Z) is differentiable in Z. The individual then selects $s \geq 0$, $Z \geq 0$, and $X \geq 0$ to maximize (3.3). Both self protection, self-insurance and option price are ex ante payments that maintain expected utility. Defining W_1 = M-L-s-Z-OP and W_2 = M+G-s-Z-OP, the following first-order Kuhn-Tucker conditions result, given that the unit price of self-protection is independent of option payments:

$$EU_s = P_x[U(W_1)-U(W_2)] - PU_{W1} - (1-P)U_{W2} \leq 0,$$

$$s \geq 0, \; s[EU_s] = 0 \tag{3.4}$$

$$EU_Z = -PU_{W1}[1 + L_Z] - (1-P)U_{W2} \leq 0,$$

$$Z \geq 0, \; Z[EU_Z] = 0 \tag{3.5}$$

$$EU_x = P_x[U(W_1) - U(W_2)] - PU_{W1} - (1-P)U_{W2} \leq 0 \tag{3.6}$$

$$X \geq 0, \; X[EU_x] = 0$$

Subscripts denote relevant partial derivatives. The terms $P_s[\cdot]$ and $P_x[\cdot]$ in (3.4) and (3.6) represent the expected marginal utilities of a change in the subjective probability of L. The U_{Wi} (i = 1,2) terms are the marginal costs, in terms of altered money incomes. If the expected marginal utilities or marginal benefits of the probability change equal the marginal costs of s or x, then an interior solution to the individual's utility maximization problem is implied. In this case, the individual makes a payment for the collectively supplied good and purchases some private self-protection as well. The relative amounts of option payments self-protection, and self-insurance expenditures will depend upon their relative marginal productivities in securing increases in P or decreases in L.

For example, consider a comparison of private and collective self-protection. If the marginal costs of a decreased money income exceed the marginal benefits of a probability increase in G such that

$$PU_{W1} + (1-P)U_{W2} > P_s[U(W_1) - U(W_2)] \tag{3.7a}$$

or

$$PU_{W1} + (1-P)U_{W2} > P_x[U(W_1) - U(W_2)] \tag{3.7b}$$

then a corner solution is obtained, implying that either the option price payment or self-protection or both will be zero. If the individual can always produce a given probability increase at less cost by using self-protection than by making an option payment, he will do so. A similar point applies to his contributions to any prospective collectively supplied probability improvements. Basically, by introducing self-protection in an option value discussion, one allows the individual to substitute between own and the collective provision of a desirable state of nature. Because it expands the consumer's choice set and thereby improves his ability to allocate risk among states, an opportunity to self-protect reduces his demand for collective provision of the desirable state.[10] Since discrepancies in utilities are reduced among states, option prices, as is evident from expression (3.6), must fall. The value of altering the uncertainty associated with a lottery on a desirable state is reflected in the individual's option payments <u>and</u> in his willingness-to-pay for self-protection. Consequently, any concept of option value which refers only to collective provision of a good may result in underestimates of the actual ex ante value that individuals attach to the prospective provision of desirable states;.

If the availability of self-protection can reduce option price then it can also impact option value. Recall the definition of option value, OV:.

$$OV = X - ES. \tag{3.8}$$

As in Cook and Graham (1977); ES, expected consumer surplus, is the consumer's ex ante benefit from having an entitlement to the desirable state, and X, option price., is the above-mentioned gain from an increase in the ability to reallocate income among states. Graham (1981, p. 72) demonstrates that the use of ES to measure ex ante value is correct if and only if complete contingent claims markets exist. Marshall (1976) shows that such markets imply that risk must be exogenous. It follows that ES does not vary with self-protection efforts.

If self-protection is an efficient choice for the consumer, then, in accord with the argument surrounding (3.7), option price, as customarily defined, can be small or zero. A glance at (3.8) immediately reveals.that a small or a zero option price causes a smaller or even a zero or a negative option value. It follows that large or even positive option values can exist only when the individual is an inefficient self-protector, or if he is uninformed about opportunities for self-protection. For example, large scale disasters such as the Chernobyl nuclear accident do not create much opportunity for efficient self-protection. Iodine tablets can be ingested to reduce the probability of illness, but in general private actions may prove too expensive and complicated to be economically feasible. A collective agency may prove a more efficient provider given scale economies. In addition, if the individual is uninformed about self-protection, he is more likely to demand collective provision as reflected by a higher option price.

If efficient self-protection is available however, the collective agency may find it more cost-effective to provide information than to provide the desired good itself. In the case of Radon gas, such information programs have yielded promising results [see Smith and Johnson (1988)].

The preceding results reenforce the findings of Freeman (1985) about ambiguities in the sign of supply-side option value when a residual uncertainty remains about the provision of the desirable state even after some collective act has been undertaken. However, Bishop (1982), Brookshire, et al. (1983), Goddeeris (1983), and Freeman (1985) have shown that, under conditions where degrees of belief are predetermined, the sure prospective provision of a collectively supplied desirable state of nature results in a strictly positive option value for a risk-averse **individual.**[11] Even this single case of determinacy fails to hold when self-protection is available. For example, in the perfectly plausible case where $ES \geq s > X$, then (3.8) becomes

$$OV = X - ES < 0. \tag{3.9}$$

In the extreme case where the individual would prefer not to have any collective provision whatsoever, (3.8) is

$$OV = -ES < 0. \tag{3.10}$$

More generally, the individual's ability to endogenize risk through self-protection implies that collectively supplied risk reductions may be redundant, thereby providing no additional welfare benefits.

The results are similar when comparing self-insurance to collective risk reduction. The tradeoff between private and collective action still exists. In the next section, we describe the experimental markets used to examine the tradeoff in detail.

3.3 Experimental Design and Procedures

Four experimental markets where both private and collective mechanisms for risk reduction were examined. The economic conditions and parameters of the markets exactly match the four asset markets presented in Chapter 2, except for one key feature. Now, private and collective mechanisms to reduce risk were available in one market. Two of the four experimental markets examined the tradeoff between private and collective self-protection. The remaining two markets examined the tradeoff between private and collective self-insurance. The experiments are described below.

(a) Each experiment had a fixed group of subjects (n=6) given an identical bundle of assets, \$M.

(b) Each asset market consisted of four binary lottery periods (P, -\$L; 1-P, +\$G). Each lottery period was consistent across asset markets.

(c) Each binary lottery period consisted of twelve bidding auctions: one inexperienced hypothetical auction, five private nonhypothetical auctions, five collective non-hypothetical auctions, and one experienced hypothetical auction. Each subject reported eight hypothetical bids, twenty private non-hypothetical bids, and twenty collective non-hypothetical bids for a reduction in risk.

(d) The four asset markets were defined in terms of both private and collective reductions in risk. Markets SPCSP and CSPSP are the markets of private and collective provision of self-protection. Markets SICSI and CSISI are the markets of private and collective provision of self-insurance.

(e) All four markets were constructed such that there are five non-hypothetical bidding trials. Each bidding trial elicits two bids, a private and a collective bid. The private bid is organized as a Vickery sealed-bid second-price auction, and the collective bid is organized as a sealed-bid Smith Auction [see Chapter 2 for description of Vickery and Smith Auction mechanisms].

(f) For markets SPCSP and SICSI, at the beginning of each bidding trial, the subject first stated his bid for private risk reduction. The winner (the highest bidder) and the price of protection or insurance (the second highest bid) was posted as public information. The winner purchases the private self-protection or insurance, and is guarantee 100% coverage. No random draw to determine the outcome of the lottery, however, is made at this time.

Next the subjects report their bid for a collective reduction in risk. The winner of the private reduction was not excluded from the collective bidding auction, and was required to report a collective bid. If the sum of the bids equals or exceeds the costs of providing a 100% reduction in risk, then an adjusted (or average) bid is posted as the reigning price, of protection or insurance. Acceptance by the collective of the price occurs only if all members agree. If at least one subject disagrees, then or if the sum of bids does not exceed costs, then a collective provision is rejected. Communication among subjects is forbidden. The experimenter sets the costs $C of 100% risk reduction equal to the sum of expected consumer surplus given the lottery period. Costs were not posted.

At this point if necessary, a controlled draw from an urn (P red chips (1-P) white chips) determined the results of the binary lottery.

(g) Markets CSPSP and CSISI are constructed in the reverse of markets SPCSP and SICSI. The markets were reversed to determine if the order of bidding influenced the value of a reduction in risk.

As before, five bidding trials were run. First the collective bidding auction was run, then if necessary the private bidding auction. If the subjects collectively purchased the self-protection or insurance, the private auction was unnecessary. If, however, the collective purchase was vetoed, then the subjects competitively bid for a private reduction in risk. A controlled draw then determined the outcome of the binary lottery.

(h) Initial assets \$M were reinitialized at the start of each bidding auction, thereby avoiding capital gains and losses across bidding auctions.

(i) No other market insurance was available. No transaction costs other than the price of self-protection or self-insurance were present. Appendix B contains the actual instructions.

The subjects were students at Appalachian State University, and were considered inexperienced bidders. The experimental parameters were identical to the experiment in Chapter 2: \$M = \$10, L = \$4, G = \$1, P = .2, .1, .01, or .4, and C = \$6, \$3, \$.3, or \$12.

3.4 Experimental Results

3.4.1 Private and Collective Risk Reduction

Table 3.1 summarizes the results for all experimental markets with two risk reduction mechanisms over all lottery periods. The first two columns describe the four experimental markets (SPCSP, CSPSP, SICSI, and CSISI) and the four lottery periods (20%, 10%, 1%, and 40%). The table reports two measures of central tendency for each bid (inexperienced hypothetical bid, average private nonhypothetical bid, average collective

Table 3.1
Summary Statistic of Experimental Markets
with Two Risk Reduction Mechanisms

Market[a]	Probability of a Loss	Inexperienced Hypothetical Bid (UEHB)			Average Nonhypothetical Private Bid (TRA)			Average Nonhypothetical Collective Bid (TRB)			Experienced Hypothetical Bid (EHB)		
		Mean	Median	Variance	Mean	Median	Variance	Mean	Median	Variance	Mean	Median	Variance
1. SPCSP[b]	20%	2.50	2.00	3.45	1.84	1.50	1.16	1.34	1.00	0.76	1.65	1.80	1.17
	10%	2.37	1.63	5.27	1.50	1.28	1.21	1.89	0.75	1.46	1.33	1.00	1.82
	1%	1.97	0.50	9.29	0.81	0.30	1.53	0.51	0.14	0.85	0.79	0.13	3.53
	40%	2.93	2.48	5.32	2.64	2.71	0.98	1.95	1.94	0.72	2.64	2.50	1.85
2. CSPSP	20%	2.40	2.00	2.63	1.50	1.37	0.59	1.72	1.57	1.07	1.82	1.50	2.59
	10%	2.36	1.63	5.13	1.21	1.12	1.00	1.84	1.06	3.50	1.36	0.88	2.32
	1%	2.53	0.75	12.38	0.59	0.19	0.54	1.22	0.40	4.06	1.09	0.13	2.91
	40%	2.45	2.00	2.61	1.92	1.63	1.09	1.87	1.29	2.05	1.97	1.55	3.73
3. SICSI	20%	2.78	2.13	3.58	2.50	2.25	2.19	1.96	1.64	1.55	2.72	2.50	3.29
	10%	2.12	1.45	3.90	1.95	1.25	3.37	1.20	0.86	1.40	2.15	1.03	4.97
	1%	1.43	0.38	5.65	1.03	0.32	2.31	0.50	0.21	0.42	1.45	0.30	6.06
	40%	3.71	3.68	5.15	2.97	2.85	1.17	2.16	2.25	1.60	3.17	2.75	2.13
4. CSISI	20%	2.40	2.00	3.66	1.83	1.70	0.53	1.73	1.65	1.28	1.91	1.75	1.97
	10%	2.03	1.00	6.37	0.87	0.75	0.53	0.84	0.57	1.08	1.00	0.75	1.52
	1%	1.64	0.25	10.49	0.23	0.12	0.08	0.32	0113	0.26	0.61	0.10	3.37
	40%	3.26	3.00	5.13	2.08	2.19	0.87	2.07	2.04	0.99	2.61	2.63	3.13

[a] n=30 for each experimental market

[b] SPCSP - Private Bid then collective Bid for self-protection; CSPSP - collective Bid then private Bid for self-protection; SICSI - Private Bid then collective Bid for self-insurance; CSISI - collective Bid then private Bid for self-insurance.

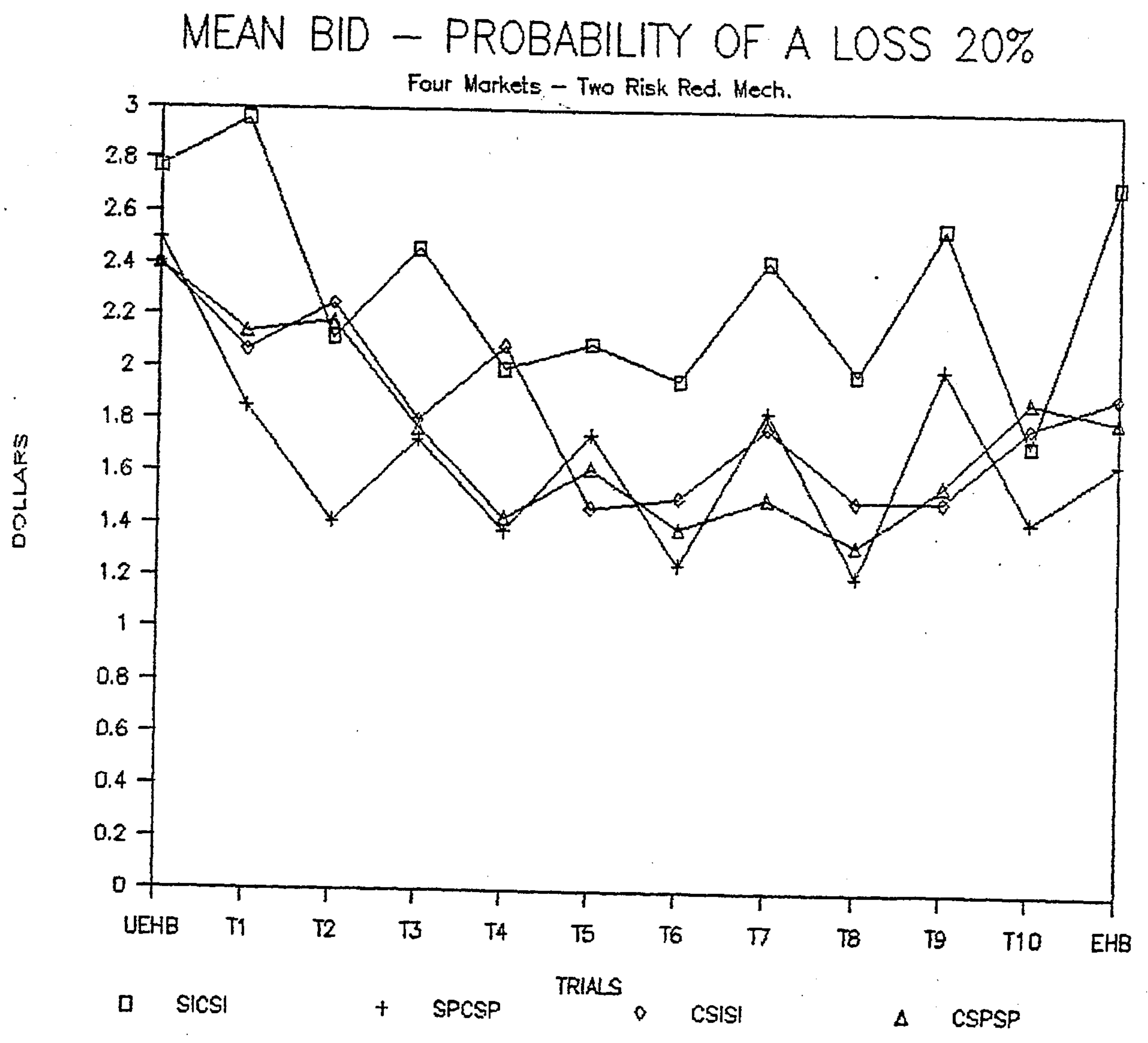
NOTE: We do not accept the null hypothesis that the population mean is zero at the .01 level using a one-tailed test for all UEHB, TRA, TRB, and EHB across markets and probability periods. The one exception is we cannot reject the null hypothesis for the EHB bid for 1% probability period in the CSISI market.

nonhypothetical bid, and experienced hypothetical bid), the estimated mean and median bids in dollars; and one measure of dispersion, the estimated variance.

Figures 3.1 through 3.4 illustrate the mean bids over the trial periods for the experimental markets. For example, in-Figure 3.1 for markets SPCSP and SICSI, T1 and T2 reflect the mean bid for private and collective self-protection (SP) or self-insurance (SI) for trial period 1. T3 and T4 are the mean private and collective bids for trial period 2. The pattern continues for five trial periods. For market CSPSP and CSISI, T1 and T2 reflect the mean collective then the private bids for self-protection or self-insurance. Examining Figures 3.1 through 3.4 one notes the jagged pattern of bids over trial periods.

A Wilcoxon rank sum test was conducted to determine if a significant difference exists between the average nonhypothetical private bid (TRA) and collective bid (TRB) for the five trial periods over each market [see Siegal (1956) for a description of the Wilcoxon test]. Table 3.2 presents the results of the Wilcoxon test. Note that the order of presentation of private and collective bids was important in inducing significantly different TRA and TRB bids. If the private bid is present first (markets SPCSP and SICSI), then there is a significant difference in 100% of the cases. This result is consistent with the findings in Chapter 2 where private risk reduction was significantly greater than collective markets.

If the collective bid is presented first, however, as in



MEAN BID — PROBABILITY OF A LOSS 20%
Four Markets — Two Risk Red. Mech.
DOLLARS
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SICSI
SPCSP
CSISI
CSPSP

Figure 3.1

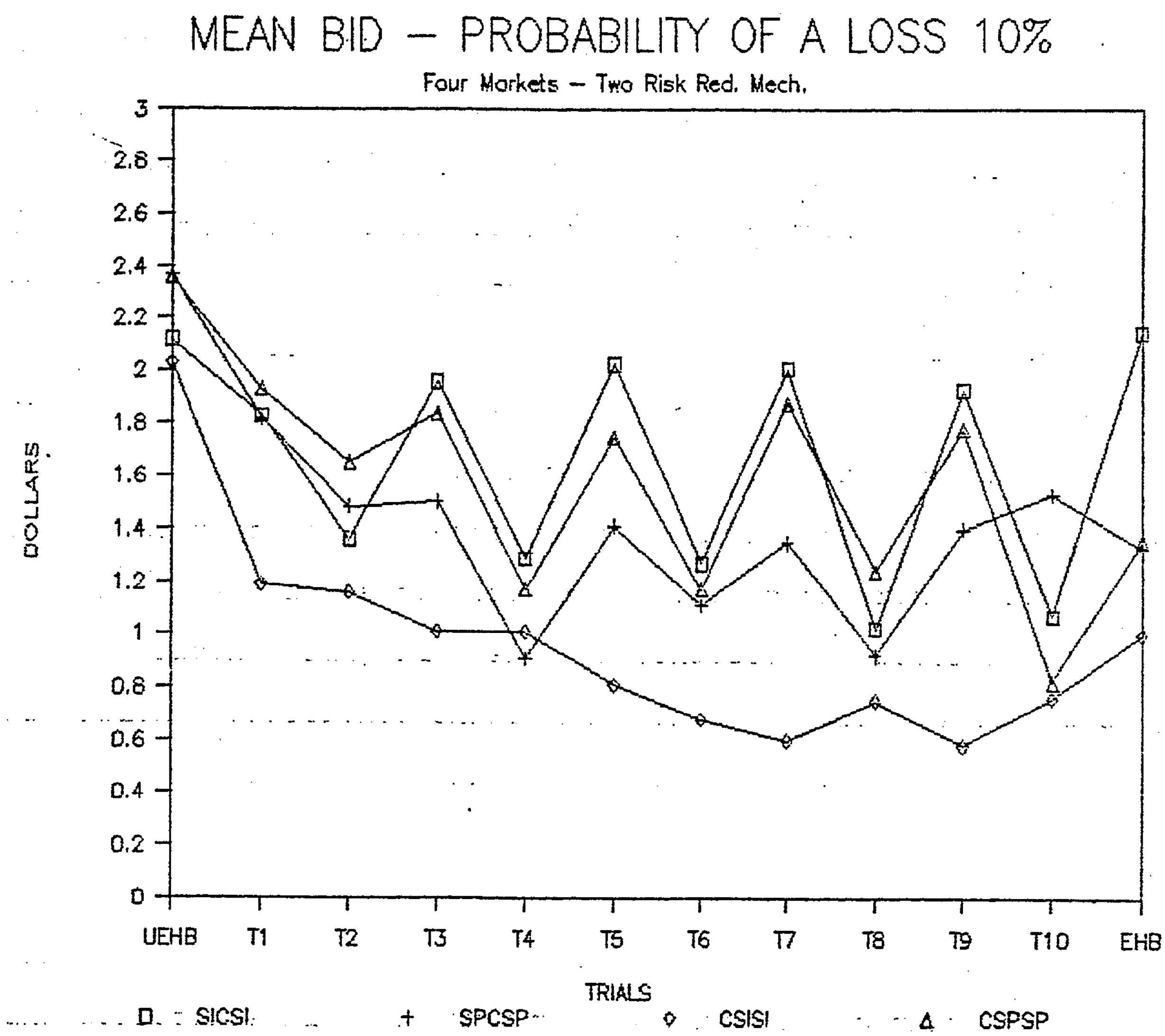
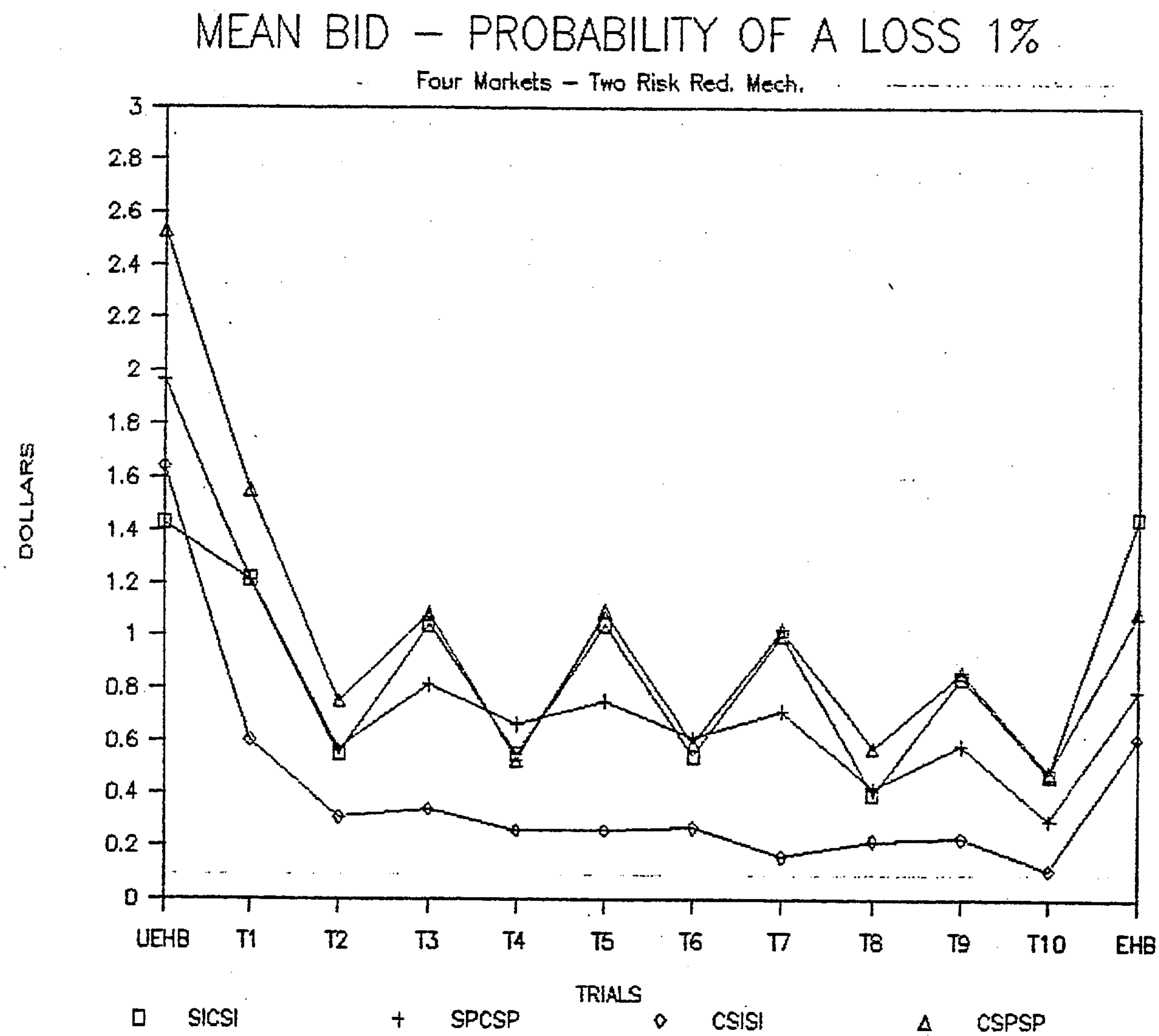
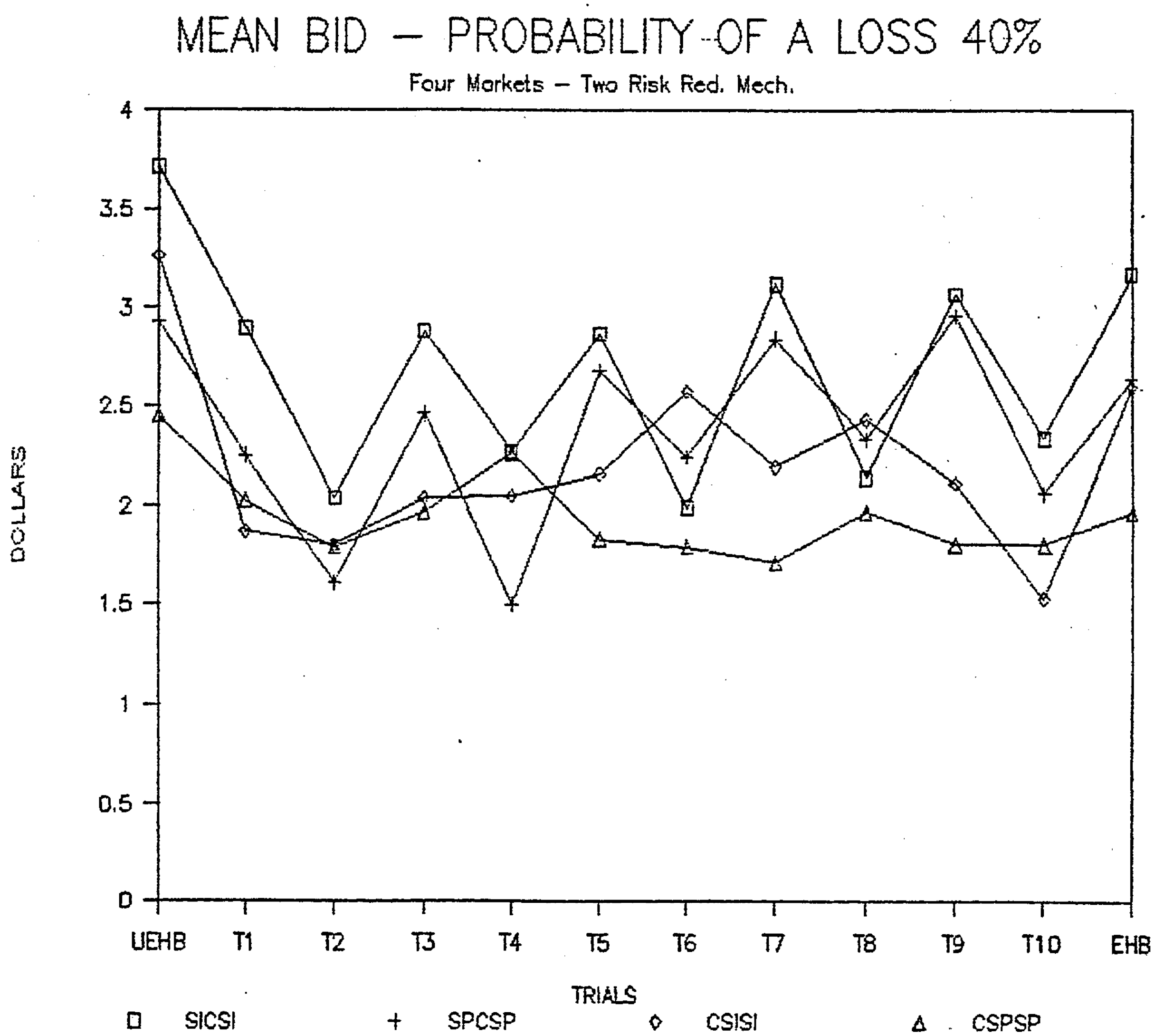

MEAN BID — PROBABILITY OF A LOSS 10%
Four Markets — Two Risk Red. Mech.
DOLLARS
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SICSI
SPCSP
CSISI
CSPSP

Figure 3.2



MEAN BID – PROBABILITY OF A LOSS 1%
Four Markets – Two Risk Red. Mech.
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
DOLLARS
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SICSI
SPCSP
CSISI
CSPSP

Figure 3.3



MEAN BID – PROBABILITY OF A LOSS 40%
Four Markets – Two Risk Red. Mech.
DOLLARS
4
3.5
3
2.5
2
1.5
1
0.5
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SICSI
SPCSP
CSISI
CSPSP

Figure 3.4

Table 3.2
Summary Statistic of the Wilcoxon
Rank-Sum Test Between the
Average Nonhypothetical Private (TRA)
and Collective (TRB) Bids

Experimental Market[a]	Probability of a Loss	Test Statistic	Observed Significance Level
SPCSP	20%	-3.347**	.00
	10%	-3.347**	.00
	1%	-2.403*	.02
	40%	-3.643**	.00
CSPSP	20%	-1.476	.09
	10%	-1.678	.09
	1%	-1.935*	.05
	40%	-0.714	.48
SICSI	20%	-2.664**	.01
	10%	-2.664**	.01
	1%	-3.095**	.00
	40%	-2.869**	.00
CSISI	20%	-1.038	.30
	10%	-1.038	.30
	1%	-1.416	.16
	40%	-0.669	.50

[a]SPCSP or SICSI - private then collective self-protection or self-insurance
CSPSP or CSISI - collective then private self-protection or self-insurance
*-significant at 5% level
**-significant at 1% level

markets CSPSP and CSISI, then in only 12.5% of the cases did the TRA and TRB bids differ. In these markets, private bids are biased downward. If the group purchased collective risk reduction, then the need for private protection is totally eliminated resulting in a downward bias of zero private bids.

In terms of the inexperienced hypothetical bid (UEHB) and the experienced hypothetical bid (EHB), the order of private and collective bids was relatively unimportant. Table 3.3 presents the results of the Wilcoxon rank-sum tests comparing UEHB and EHB between markets SPCSP and CSPSP and markets SICSI and CSISI. For the UEHB bid, no significant difference existed. For the EHB bid, a significant difference was found in 37.5% of the cases, but in no consistent pattern across lottery periods.

Figures 3.5 and 3.6 are representative comparisons of the private and collective bids in experimental markets with one and two risk reduction mechanisms. For example, Figure 3.5 examines self-protection bids for the 20% lottery period for markets SP--private bids, CSP--collective bids, SPCSP--private then collective bids, and CSPSP--collective then private bids. The experiments with one mechanism (SP and CSP) provide bounds on the value for reduced risk in which generally the values in markets with two mechanisms stay between.

3.4.2 Risk Premium or Option Value

One of the main purposes of the experimental markets with two risk reduction mechanisms is to examine how a substitutable

Table 3.3
Summary Statistic of the Wilcoxon Rank Sum
Test Between Experimental Markets for
Inexperienced and Experienced Hypothetical
Bids (UEHB and EHB)

		UEHB		EHB	
Experimental Markets[a]	Probability of a Loss	Test Statistic	Observed Significance Level	Test Statistic	Observed Significance Level
SPCSP vs. CSPSP	20%	0.074	.94	0.126	.90
	10%	-0.037	.97	0.578	.56
	1%	-0.727	.47	0.952	.34
	40%	0.298	.77	2.505**	.01
SICSI vs. CSISI	20%	0.983	.33	1.889	.06
	10%	1.083	.28	2.009*	.04
	1%	0.715	.48	2.135*	.03
	40%	1.040	.30	1.379	.17

[a]SPCSP or SICSI - private then collective self-protection or self-insurance
CSPSP or CSISI - collective then private self-protection or self-insurance
*-Significant at 5% level
**-Significant at 1% level

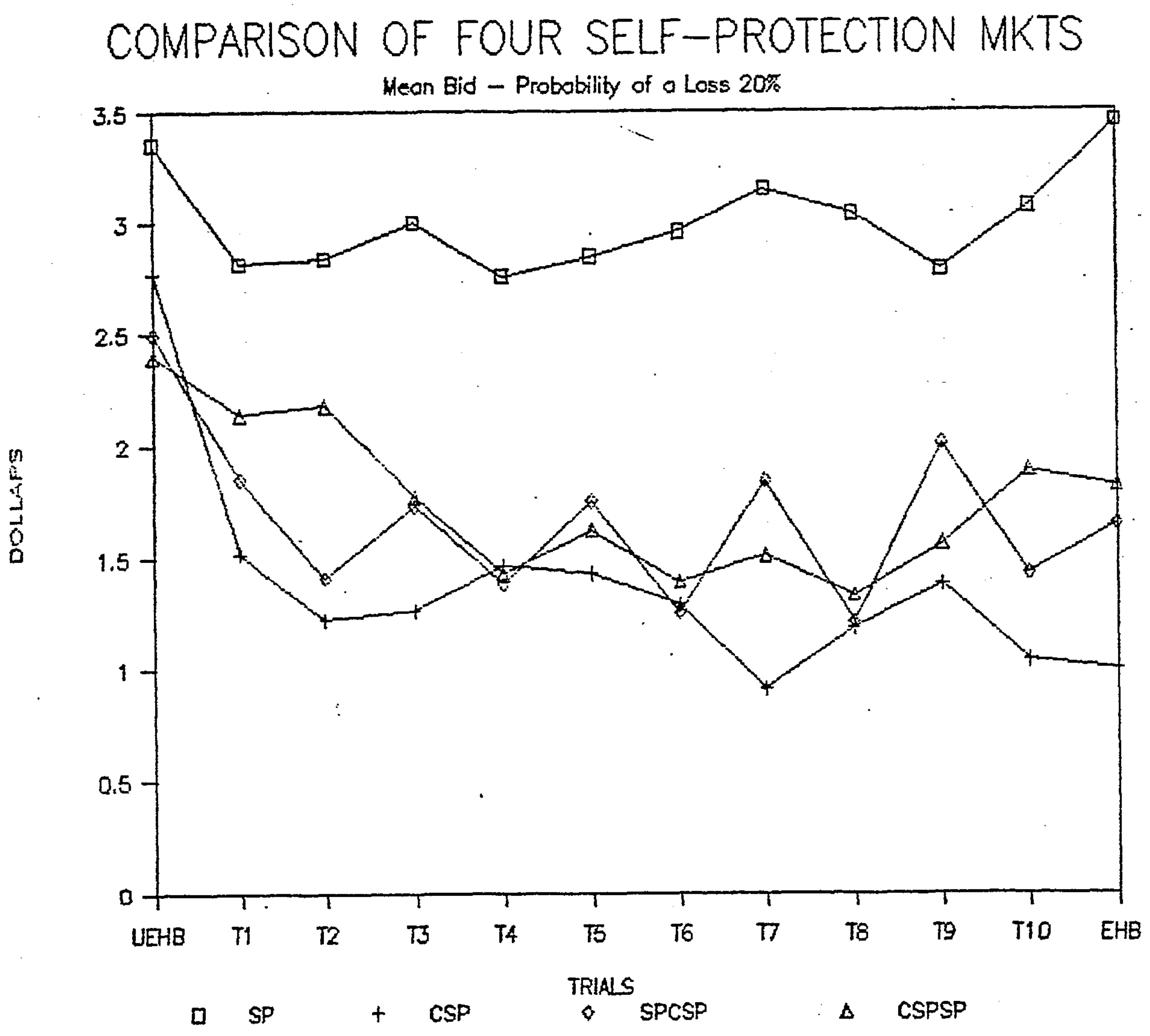
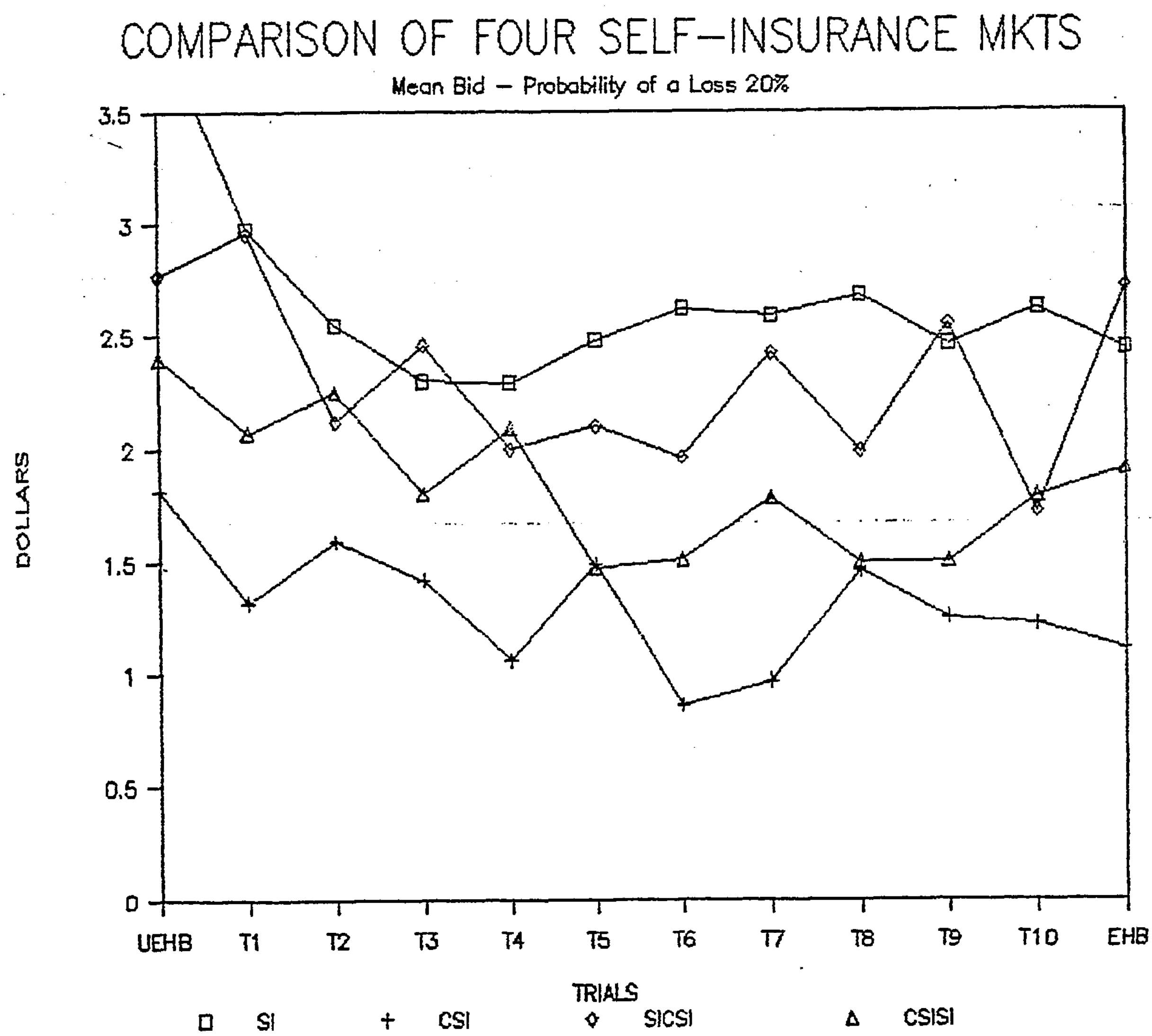

COMPARISON OF FOUR SELF-PROTECTION MKTS
Mean Bid — Probability of a Loss 20%
DOLLARS
3.5
3
2.5
2
1.5
1
0.5
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SP
CSP
SPCSP
CSPSP

Figure 3.5



COMPARISON OF FOUR SELF-INSURANCE MKTS
Mean Bid — Probability of a Loss 20%
DOLLARS
3.5
3
2.5
2
1.5
1
0.5
0
UEHB
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
EHB
TRIALS
SI
CSI
SICSI
CSISI

Figure 3.6

private mechanism affects bids for collective action. Recall the argument made earlier that if the individual is an efficient provider of private risk reduction, then their value for collective action could be less than expected consumer surplus or even equal to zero. Consequently, the individuals risk premium or option value for collective risk reduction will be negative. A positive option value would hold them only if the individual is an inefficient provider of private protection or in uninformed about private opportunities.

Table 3.4 presents the summary statistic of the average individual's risk preference and risk premium in markets with two mechanisms. No general patterns can be observed for the average individual in regard to private and collective nonhypothetical bid risk premiums. One does note that risk premiums across all cases decline with repeated trials. The individuals became less risk averse after acquiring more market experience. One also notes that the average individual overestimated the 1% probability of a loss. The risk premium significantly exceeded the other lottery periods in every case. Although learning over repeated trials did decrease the risk premium for a 1% probability, it remained significantly higher than the other lotteries were for the final experienced hypothetical bid (EHB). This result is consistent with observed violation of the linear in probabilities necessary for the independence axiom assumption required for expected utility theory as discussed in Chapter 2.

To examine how private substitutes affect bids for

Table 3.4
Summary Statistic of Risk Preference and Risk Premium
of Experimental Markets with Two Risk Reduction Mechanisms

Bid Market[c]	Probability of a Loss	Unexperienced Hypothetical Bid Mean/ES[a]	Nonhypothetical Private Bid Mean/ES	Nonhypothetical Collective Bid Mean/ES	Experienced Hypothetical Mean/ES
1. SPCSP	20%	2 50[b]	1.84	1.34	1.65
	10%	4.74	3.00	3.78	2.66
	1%	39.40	16.20	10.20	15.80
	40%	1.47	1.32	0.98	1.32
2. CSPSP	20%	2.40	1.50	1.72	1.82
	10%	4.72	2.42	3.68	2.72
	1%	50.60	11.80	24.40	21.80
	40%	1.23	0.96	0.94	0.99
3. SICSI	20%	2.78	2.50	1.96	2.72
	10%	4.24	3.90	2.40	4.30
	1%	28.60	20.60	10.00	29.00
	40%	1.86	1.49	1.08	1.59
4. CSISI	20%	2.40	1.83	1.73	1.91
	10%	4.06	1.74	1.68	2.00
	1%	32.80	4.60	6.40	12.20
	40%	1.63	1.04	1.04	1.31

[a]ES represents expected consumer surplus. ES = \$1, \$.5, \$.05, and \$2 for lottery period 20%, 10%, 1%, and 40%.

[b]Mean/ES > 1 (=1/<1) reflects risk aversion (neutrality/Lower).

[c]SPCSP or SICSI - private then collective self-protection or self-insurance
CSPSP or CSISI - collective then private self-protection or self-insurance

collective action, we can examine the bidding pattern of the highest bidder in the private Vickery auction. For markets SPCSP and SICSI one would expect, ex ante, that since the highest bidder of the private market is guaranteed full protection or insurance with 100% certainty, his or her subsequent bid for collective reduction would be small or zero. For markets CSPSP and CSISI, one would expect a low collective bid if the individual planned on being the highest bidder in the private auction. The experimental results provide weak support for this hypothesis. Table 3.5 presents the collective bid of the highest bidder in the private auction. In 100% of the cases the highest bidder's private bid exceeded the expected consumers surplus implying a positive option value. However, the highest private bidder's collective bid exceeded expected consumer surplus 62.5% of the cases. In 37.5% of the cases, the collective bid of the highest private bidder was less than or equal to expected consumer surplus, implying a negative option value.

The results are not particularly robust in supporting our hypothesis of substitutable risk reduction mechanisms. There are four potential explanations for this result. First, the collective mechanism was a Smith auction with unanimity voting rules. Any negative vote would veto the purchase of a collective risk reduction. In nearly 91% of the cases, the highest bidder used his veto power to cancel any collective action. The highest bidder would have bid on collective action knowing he or she could reject any price for collective risk reduction.