A RAND NOTE

CHOICE UNDER UNCERTAINTY AND THE DEMAND FOR HEALTH INSURANCE

M. Susan Marquis, Martin R. Holmer

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N-2516-HHS

Prepared for

The U.S. Department of Health and Human Services

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PREFACE

This Note uses data on families' preferences for insurance to estimate and compare several models of decisionmaking under risk. By characterizing health insurance as a risky prospect and specifying structural models of prospect choice, the models estimated here differ from previous empirical models of health insurance demand in that they can be used to analyze choice among any number of arbitrarily defined plans. The ability to generalize beyond the number and type of plans present in the data is essential for policy analysis, because it permits the examination of policy options outside current experience.

The work reported here was prepared as part of the RAND Health Insurance Experiment, which is supported under a grant from the U.S. Department of Health and Human Services.

The results of the work reported in this Note were used by the Office of the Assistant Secretary for Planning and Education, Department of Health and Human Services, to predict the amount of employee contributions to flexible spending accounts in a Congressionally mandated study of the health care cost containment and tax revenue effects of flexible spending accounts.

SUMMARY

Expected utility theory is the most widely used model of decisionmaking under risk, but recent evidence has called into question its ability to describe people's choices in risky situations, ones in which there are several financial consequences.

This study contrasts the expected utility model of choice under risk with an alternative model that allows choice patterns different from those predicted by expected utility. The alternative model, which we call the expected value model, incorporates many of the assumptions about how individuals evaluate risky alternatives offered by Kahneman and Tversky (1979) in developing prospect theory. The expected value model differs from expected utility theory in several ways. The expected value theory assumes that people evaluate changes in net income rather than the final net income level, that gains and losses are evaluated asymmetrically, and that families exhibit risk seeking behavior in the domain of losses.

Parameters of the expected utility model and the expected value model were estimated on data collected as part of the RAND Health Insurance Experiment. The data are families' reported preferences for hypothetical supplementary health insurance policies. A comparison of the ability of the two models to describe the reported preferences indicated that the expected value model is superior to the expected utility model.

Parameter estimates from both models suggest that individuals are highly risk averse and that the demand for health insurance is quite price inelastic. The estimated parameters of the expected value model also suggest that the displeasure individuals feel in losing money is greater than the pleasure associated with a gain of the same amount. One implication of this result is that there is some inertia in the choice of health insurance plan; that is, there is a tendency to stay with the current coverage. This persistence in health plan choice has been empirically observed. A second implication is that individuals are more responsive to decreases than to increases in the price of

insurance. Eliminating the current tax-favored status of employer paid health insurance premiums, therefore, may be less effective in encouraging people to assume a greater degree of the risk of their medical care bills than the subsidy was in encouraging the purchase of more insurance.

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I. INTRODUCTION

Individuals must often make choices in the face of risk--situations in which there are several possible financial consequences. The most widely used theory of decisionmaking under risk is expected utility theory. Since its classic statement by von Neumann and Morgenstern (1944), there has been a consensus among economists that people not only should but do make choices under risk according to expected utility theory. However, recent evidence has called into question the ability of expected utility theory to describe people's choices among risky alternatives. Psychologists, perhaps the most notable being Kahneman and Tversky (1979), have developed to a fine art the ability to specify alternatives capable of eliciting choices that are anomalous to expected utility theory. Economists, for example those following Grether and Plott (1979), have also produced evidence contradicting expected utility theory. The anomalous evidence has been sufficient to generate reflective articles (e.g. Arrow, 1982; and Smith, 1985), major reviews (Schoemaker, 1982; Machina, 1983; Slovic and Lichtenstein, 1983), and several new theories that seek to explain the evidence that expected utility theory cannot (e.g. Machina, 1982; Chew, 1983; Loomes and Sugden, 1982; Bell, 1982; Kahneman and Tversky, 1979; Heiner, 1983, 1985).

Recent empirical work on health insurance demand has also cast doubt on the ability of expected utility theory to predict people's choices among risky alternatives. A lack of individual plan choice data led early researchers--Feldstein and Friedman (1977) and Keeler, Morrow, and Newhouse (1977)--to follow Arrow (1963) in using expected utility theory to predict a family's choice of health insurance plan. In these studies demand for a particular insurance plan is calculated from the predictions of a theoretical-choice simulation model, in which each family selects the plan that maximizes its expected utility, given its assumed degree of risk aversion and expectations of medical expenses. Results from both studies suggest that health insurance demand is very sensitive to price changes generated by tax policy. But empirical

research using individual plan choice data conducted by Holmer (1984) and Marquis and Phelps (1985) finds demand to be fairly insensitive to price changes caused by tax policy.[1] The magnitude of the discrepancy between the studies that assume expected utility theory and those that estimate reduced-form demand functions raises the possibility that people do not select health insurance plans according to expected utility theory.

This study contrasts the expected utility model of choice under risk with an alternative model that allows choice patterns that differ from those predicted by expected utility theory. The alternative model, which we call the expected value model, incorporates many of the assumptions about how individuals evaluate risky alternatives offered by Kahneman and Tversky (1979) in developing prospect theory. The two models are compared by examining how well they describe families' preferences for supplementary health insurance. The expected value model has substantially superior predictive capability to the expected utility model in a choice situation where the risky alternatives are not manufactured to generate anomalies, but represent everyday decisions facing a growing fraction of the U.S. population.

Section II describes the different theories of decisionmaking under risk. The data are described in Sec. III and the estimation methods are detailed in Sec. IV. Section V presents results from contrasting the alternative decisionmaking models. The implications of these results for the study of health insurance demand are developed in Sec. VI. The final section highlights the major findings of this study and discusses the need for further empirical testing of alternative theories of decisionmaking under uncertainty using data generated from a wide variety of choice situations.

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[1] See Holmer (1984) for a more detailed description of these theoretical and empirical studies of health insurance demand.

II. ALTERNATIVE MODELS OF CHOICE

DECISIONMAKING UNDER RISK

This study evaluates alternative models of decisionmaking under risk. In such decision situations, the individual chooses one among several risky alternatives or prospects. A prospect is said to be risky because its realization is one of many possible outcomes or results.

Every theory of decisionmaking under risk contains assumptions about how people evaluate the outcomes of a prospect, how they form expectations about the likelihood of different outcomes, and how they choose among risky prospects. The models we will consider share the same basic decision paradigm: Each prospect can be characterized by a desirability or attractiveness score. The desirability of each prospect is defined as the weighted sum of the value of each outcome where the weights are the decisionmaker's expectations about the likelihood of the outcome. The decisionmaker chooses the prospect with the highest score.

We will evaluate two models of choice under risk--one based on expected utility theory, the other based on aspects of prospect theory. Expected utility theory and prospect theory differ in their assumptions about how people weight and evaluate the outcomes.

In expected utility theory, the weights are the objective probabilities of the occurrence of the outcome. In prospect theory, the weight is a transformation of the objective probability that allows for misperception and fallible judgment by the decisionmaker.

In expected utility theory, the outcomes evaluated are final wealth (or income) positions. Each outcome or wealth (or income) level is evaluated according to a utility function. Most applications of expected utility theory further assume that people are risk averse,[1] or equivalently that the utility function by which outcomes are evaluated is concave. The expected utility of any prospect--its overall attractiveness--is the sum of the utility of each possible outcome multiplied by the probability that the outcome will occur.

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[1]A person is risk averse if he or she prefers a certain prospect to any risky prospect with the same mathematical expectation of the outcome.

In prospect theory, outcomes are evaluated according to a value function, which differs from the utility function of expected utility theory in several ways. Outcomes are gains or losses relative to some reference, rather than final wealth as in expected utility theory. Further, riskless components of a prospect are evaluated separately from the risky components, rather than integrating both components with one's assets. Prospect theory assumes that people exhibit risk-seeking[2] behavior for losses--that is, the value function contains some convex segments for negative outcomes. It also hypothesizes that the function is steeper for losses than gains--that is, the displeasure associated with a loss is greater than the pleasure associated with a gain of the same amount.

The assumptions incorporated in the value function of prospect theory can explain behavior that has been observed in both laboratory and field studies and that runs counter to the predictions of conventional expected utility theory. Studies of preferences for disaster insurance as well as experimental laboratory studies have shown risk-seeking behavior in choices between prospects with negative outcomes (Schoemaker, 1982; Kahneman and Tversky, 1979), contrary to the standard assumption of risk aversion in expected utility theory. Kahneman and Tversky also observe that people often ignore components that alternative prospects share and emphasize the elements that distinguish prospects. This phenomenon, which they term the isolation effect, leads to the conclusion that value is defined on gains and losses, not final wealth positions that include current assets. Many of these elements of prospect theory's evaluation model have also appeared in earlier modifications of expected utility theory. For example, Markowitz (1952) was the first to suggest that utility be defined on gains and losses, and he and others have proposed that the utility function contains convex segments.

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[2]A risk-seeking individual, for example, would prefer a 1 in 10 chance of losing $1000 to paying a $100 insurance premium to protect against the loss. A risk-averse individual would prefer to pay the premium because the mathematical expectation of the losses are equal in each case, but there is less risk or variance in outcomes if the insurance is purchased.

This study contrasts the expected utility model of choice under risk with a model that incorporates the evaluation function of prospect theory. The latter, which we call the expected value model, retains the assumption from expected utility theory that people's expectations about the likelihood of different outcomes are objective probabilities rather than the decision weights of prospect theory.

The models are compared by examining how well they describe families' preferences for supplementary health insurance plans. The uncertain outcomes families face are levels of spending on medical care. For both the expected utility and the expected value models, a family's expectation about its use of medical care under all of the insurance plan options is assumed to be based on experiences given its current level of insurance coverage. That is, we assume that a family's ex ante perceptions about the distribution of health care services it will use are not altered by the level of insurance it contemplates purchasing. Although the empirical evidence leaves little doubt that actual medical care demand increases as the level of insurance coverage increases, it is the perceived price elasticity of the demand for medical care, not the actual elasticity, that is appropriate in analyzing the choice of insurance coverage. Perceived values of the elasticity of demand for medical care are probably lower than the actual values (Feldstein and Friedman, 1977). We assume that the perceived elasticity is zero.[3]

The remainder of this section specifies the expected utility and expected value models of the choice of supplementary insurance plans.

EXPECTED UTILITY MODEL

Expected utility theory can be used to specify a model of the choice of supplementary health insurance plan in the following way: Assume that a family is covered by a health insurance plan that limits the family's annual out-of-pocket expenditure to L_0. The family can

[3]In our model, the actual elasticity of the demand for medical care could affect insurance choices over time in the following way: Families that alter the amount of insurance coverage they purchase in this period will respond by altering their demand for medical care. This alters the expectations the families use in evaluating all insurance options in the next period.

purchase supplementary insurance to reduce the maximum out-of-pocket expenditure. Let j index the supplementary plan options available to the family, with j = 0 representing the decision not to purchase a supplementary plan. L_j denotes the maximum out-of-pocket expenditure if supplementary plan option j is chosen. (The nature of the supplementary plans is discussed in the next section.) A supplementary plan's premium is denoted by h_j and thus $h_0 = 0$.

Let i index discrete levels of out-of-pocket medical expenses, e_{i0}, that are expected to occur with probability p_i, when a family does not purchase a supplementary plan. Since the supplementary plans simply offer a lower out-of-pocket expense limit, L_j, out-of-pocket expenses when covered by supplementary plan j, e_{ij}, can be expressed as $\min(e_{i0}, L_j)$. Given the occurrence of out-of-pocket medical expense level e_{ij}, nonmedical consumption is given by:

$$n_{ij} = y - h_j - e_{ij}, \tag{2.1}$$

where y denotes family disposable income.

This level of consumption is assumed to be evaluated by the utility function of the form:

$$U(n) = -\exp[-an], \text{ where } a > 0. \tag{2.2}$$

This utility function, which is commonly used in studies of health insurance demand, implies constant, absolute risk aversion--that is, risk aversion does not vary with income.[4] The expected utility of choosing supplementary plan option j, EU_j, is expressed as follows:

$$EU_j = \Sigma_i p_i U(n_{ij}). \tag{2.3}$$

The family will choose the supplementary plan that yields the highest EU_j.

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[4]However, as we note in Sec. IV, we also estimated utility functions in which the risk parameter, a, was allowed to vary with income. However, we found that income did not significantly affect the shape of the utility function.

Two properties of the utility function in Eq. (2.2) warrant discussion. First, with a constant absolute risk aversion utility function the relative attractiveness of two insurance plans is the same whether one compares the expected utility of the level of nonmedical consumption or the expected utility of changes in nonmedical consumption where the change is measured against a world with no illness. Second, the function as shown in Eq. (2.2) suggests that utility depends only on nonmedical consumption. The consumption of medical care also should affect well-being. However, if utility is separable in medical and nonmedical consumption, and if the perceived elasticity of demand for medical care is zero as we assume, then the expected utility due to medical care consumption is the same for all insurance plans.[5] The insurance choice depends only on a comparison of the expected utility due to nonmedical care consumption.

EXPECTED VALUE MODEL

An expected value model is specified using the following postulates of prospect theory about the evaluation of outcomes: (a) Value is a function of the gain or loss in nonmedical consumption measured from some reference, rather than a function of the level of nonmedical consumption; (b) the value function is asymmetric, steeper for losses than gains; (c) the value function is usually concave for gains, often convex for losses; and (d) riskless elements of a prospect are valued separately from the uncertain elements of a prospect (the segregation hypothesis). This list of postulates includes only some of the assumptions of prospect theory. Several of the theory's assumptions about the evaluation of outcomes--that losses are valued greater than gains, for example--can be tested empirically.

Using the definition of nonmedical consumption in Eq. (2.1), the gain in nonmedical consumption associated with the choice of plan j when plan k is the reference can be expressed as follows:[6]

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[5]The concluding section briefly discusses the implications of our assumption that the perceived elasticity is zero.

[6]As noted earlier, because we assume constant risk aversion, the expected utility maximizer also evaluates gains and losses in nonmedical expenditure, where gains and losses are evaluated relative to a world

$$g_{ijk} = (n_{ij} - n_{ik}) = (h_k - h_j) + (e_{ik} - e_{ij}). \tag{2.4}$$

If g represents a generic gain, then the value function is assumed to have the following form:

$$V(g) = \begin{cases} 1-\exp[-a_1 g] & \text{if } g \geq 0 \\ -(1-\exp[a_2 g]) & \text{if } g^* < g < 0 \\ -(1-\exp[a_2 g^*]) + (1-\exp[-a_3(g - g^*)]) & \text{if } g \leq g^*. \end{cases} \tag{2.5}$$

That is, following Kahneman and Tversky (1979, pp. 278-279) the value function is assumed concave (exhibits risk aversion) for positive gains, convex (exhibits risk seeking) for small losses, and concave again for large losses, where the boundary between "large" and "small" losses is given by g^*. A value function of this form is illustrated in Fig. 1.

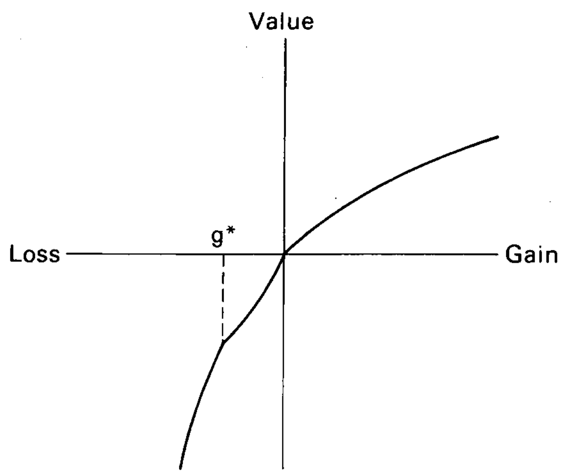

Fig. 1 -- Illustrative value function

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with no illness. By contrast, in the expected value model a family is assumed to have a given expectation about its illness distribution, and to perceive gains or losses in nonmedical consumption arising because of differences between a health insurance plan option and a reference plan in the premium and cost-sharing requirements.

According to the postulated segregation effect, riskless elements of a prospect are evaluated separately from the risky components. From Eq. (2.4), the known or riskless component of the prospect is the change in the premium payment $(h_k - h_j)$, and the risky component is the uncertain change in out-of-pocket expenditures $(e_{ik} - e_{ij})$. Therefore, given the assumption that people's expectations about the likelihood of different outcomes are the objective probabilities of the expected utility model, then the expected value of accepting the offer of supplementary plan j given reference plan k, EV_j, is expressed as follows:

$$EV_j = V(h_k - h_j) + \Sigma_i p_i V(e_{ik} - e_{ij}). \tag{2.6}$$

The family will purchase the plan yielding the highest expected value.

In addition to the expected value model, we investigated other prospect evaluation models that represent intermediate departures from the expected utility model. These models invoke alternative assumptions about whether gains and losses are evaluated symmetrically or differently and whether risky and riskless outcomes are segregated or integrated in the evaluation. When gains are integrated, the value function is applied to the net income change as given in Eq. (2.4), rather than separately to the certain and uncertain components.

III. EXPERIMENTAL DATA

THE HEALTH INSURANCE EXPERIMENT

The data used in this study were collected as part of the RAND Health Insurance Experiment (HIE), a controlled trial to evaluate the effects of varying the generosity of insurance coverage. Details of the design of the experiment have been given elsewhere (Newhouse et al., 1981). Only a few of the central features of the study design are noted here.

Families participating in the HIE came from six sites--four metropolitan areas and two rural sites. About 70 percent of families participated for three years, the rest for five years. Those enrolled in the HIE were representative of the population within the sites subject to a few restrictions: Families headed by persons age 62 or older were ineligible. The disabled eligible for Medicare were excluded as were persons eligible for the military medical care system and persons receiving Supplemental Security Income. Families with annual income exceeding $54,000 (1982 dollars) were also ineligible; this excluded about 3 percent of families initially contacted.

Families enrolled in the HIE were assigned to an experimental health insurance plan. The plans varied across two dimensions: the coinsurance rate (the share of medical expenses the family paid) and an upper limit on annual out-of-pocket expenses. The coinsurance rates were 0 (or free care), 25, 50, or 95 percent. The out-of-pocket expenditure limit, also called the Maximum Dollar Expenditure (MDE), placed a limit on the risk a family faced in any one year. If the family's cost-sharing in a year equaled its MDE, any additional medical care used in that year was fully paid for by the insurance. The family's MDE was either 5, 10, or 15 percent of the family's income, or a fixed dollar family maximum of $1000, whichever was smaller.[1]

[1]In some sites and years, the maximum MDE was $750 for families with 25 percent coinsurance.

SUPPLEMENTARY INSURANCE PLANS

At the end of their participation in the HIE, each family, excepting families with free care, was presented with hypothetical offers to reduce the amount of its MDE by one-third, by two-thirds, and by 100 percent (full coverage).[2] The offers stipulated a premium that the family would have to pay for the supplemental insurance coverage, and the family was asked whether it would buy the supplemental insurance plan at the quoted premium. The premium quotes were generated using an algorithm that depended on the family's coinsurance rate and MDE. The algorithm was designed to generate premium quotes that were uniformly distributed on the interval ranging from 10 to 100 percent of the offered reduction in the MDE.

The supplementary health insurance plan choices were obtained in mail questionnaires, which were sent to each family head; thus two sets of responses were received from families with two heads. This study uses the responses to 3135 supplementary plan offers given by 705 families.[3] The dollar reduction in MDE and the associated premium quote, both adjusted to 1982 dollars, for the 3135 supplementary health insurance plan offers are summarized in Table 1.

In addition to these plan choices and the family attributes routinely available from HIE questionnaires, the choice theories discussed above require data on out-of-pocket medical expense expectations and disposable income. The remainder of this section

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[2]The offers were worded as follows: "Suppose you were enrolled in a national health insurance plan just like the Family Health Protection Plan, and you had the same Maximum Dollar Expenditure (MDE), which is $___ per year for your family. If you could lower the MDE to $___ by paying a fee of $___ per year, would you do it or not?"

[3]This study's analysis is limited to responses obtained from families assigned to an experimental insurance plan that specified one coinsurance rate for all services. We excluded responses to the supplementary plan offers obtained from 621 families assigned to plans that imposed different coinsurance rates for dental and outpatient mental health care than for other services or that required different coinsurance rates for inpatient and outpatient services. Families with these more complex HIE plans were excluded from the study sample because of the difficulty in imputing out-of-pocket expense expectations when the coinsurance rate varies across types of medical services.

Table 1

SUPPLEMENTARY HEALTH INSURANCE PLAN OFFERS[a]
(Number of offers)

Premium	Reduction in Out-of-Pocket Expenditure Limit: $300 or Less	$300-$600	$600-$900	$900 or More	Total Offers	Percent of Offers
$50 or less	370	143	0	2	515	16.4
50-100	145	362	0	0	507	16.2
100-200	51	361	155	10	577	18.4
200-400	1	127	331	353	812	25.9
400-800	0	4	104	452	560	17.9
800 or more	0	0	0	164	164	5.2
Total offers	567	997	590	981	3135	100.0
Percent of offers	18.1	31.8	18.8	31.3	100.0	

[a]Both premium and out-of-pocket expenditure limits are in 1982 dollars.

describes how these data are constructed using information available from HIE questionnaires.

OUT-OF-POCKET EXPENDITURE EXPECTATIONS

When a family decides to purchase supplementary insurance, it is uncertain about the future occurrence of illness, the use of medical services, and hence the financial consequences of purchasing the plan or forgoing the purchase. The distribution of the family's expected total expenditure for medical care determines the distribution of expected out-of-pocket expenses under each supplementary insurance option. A probability distribution representing expectations about total medical expenditure is imputed to each family based on the family's reported level of expected expenditure and the observed distribution of total expenditures made by other families with the same expected expenditure and attributes.

The imputation of total expenditure distributions was based on a two equation regression model to explain observed annual health care expenditure. The first equation is a probit equation for the probability that the family has nonzero expenditure in a year. The second equation is a linear regression for the logarithm of total annual expenditure for families with positive expenditure. The explanatory variables in each equation included the family's previous estimate of how much it would spend during the year (expected expenses);[4] indicator variables for the experimental insurance plans; race; age, education, and gender of the family head; family size and income; and indicator variables for the sites.

The annual expenditure model was estimated using expenditure data for all families in the first year of the experiment in each site. Separate models were fitted for single-person families and for families of two or more. The estimated equations are shown in Tables 2 and 3.

Given the annual expenditure model and attributes of the family at the time the supplementary plan offers were made, repeated drawings from the distribution of disturbances from the expenditure model are taken to generate a family's expected total expenditure distribution for the year following the supplementary insurance plan selection. For each replicate, the family's total expenditure, E, is:

$$E = 0 \text{ if } \Phi(x\gamma + u) < .5,$$
$$E = \exp(x\beta + v) \text{ if } \Phi(x\gamma + u) \geq .5,$$

where x denotes the family's attributes including reported expected expenditure, γ and β the parameter estimates from the probit and linear

[4]The expected expense question was: "Of course, nobody knows what will happen, but we would just like your best guess on how much your own personal health care will cost during the next 12 months. Include doctors, dentists, clinics, medical tests or x-rays, prescription drugs--the total of all expenses for your own personal health during the next 12 months. Include both what you are likely to pay, and also what will be paid by insurance, Medicare, Medicaid or others." Questions were asked for each family member; answers were given in one of 11 fixed interval categories. The family's expected expenditure was obtained by using the midpoint of the response category for each family member and aggregating across all family members.

Table 2

EXPECTATIONS IMPUTATION: PROBIT EQUATION FOR PROBABILITY OF NONZERO MEDICAL EXPENDITURE[a]

Variable	Single Person Family Coefficient	Single Person Family t	Families of Two or More Coefficient	Families of Two or More t
Intercept	-1.754	-1.55	-0.774	-0.48
Ln (Expected expenses)	0.387	3.94	-0.068	-0.52
Ln (Family income)	0.096	0.84	0.255	1.68
Education Head (years)	0.037	1.03	0.035	0.89
Age Head	0.001	0.18	0.001	1.51
Indicator = 1 if male head	-0.635	-3.37	0.18	0.68
Indicator = 1 if nonwhite	-0.495	-1.71	0.776	-3.00
Ln (Family size)	--	--	0.584	1.99
Plan indicators				
1 if 25% coinsurance	-0.972	-0.32	-0.926	-1.73
1 if 50% coinsurance	-0.210	-0.54	-1.225	-2.23
1 if 25% for medical, 50% for dental & mental	-0.049	-0.14	-1.159	-2.01
1 if 95% coinsurance	-0.341	-1.38	-1.480	-3.08
1 if 95% outpatient, 0% inpatient	-0.339	-1.42	-1.397	-2.82
Site indicators				
1 if Seattle	-0.337	-1.29	0.457	1.62
1 if Massachusetts	0.274	1.04	0.715	2.37
1 if South Carolina	-0.558	-1.49	0.232	0.76

[a]Omitted plan indicator is 0 percent coinsurance plan; omitted site indicator is Dayton. Income and expenditures are in 1982 dollars.

regression, u is drawn from a standard normal distribution, v is drawn from the least squares residuals, and Φ denotes the standard normal cumulative distribution function. An examination of the least squares residuals, v, revealed heteroskedasticity by experimental plan. Therefore, in constructing the expenditure distribution for a family, v is drawn from the subset of least squares residuals for the experimental plan to which the family was assigned. For each family, 500 replicates were generated to create the distribution of annual total medical expenditure.

Table 3

EXPECTATIONS IMPUTATION: LOG MEDICAL EXPENDITURE REGRESSION[a]

	Single Person Family		Families of Two or More	
Variable	Coefficient	t	Coefficient	t
Intercept	4.325	4.57	2.599	3.92
Ln (Expected expenses)	0.439	5.72	0.392	8.15
Ln (Family income)	-0.009	-0.10	0.127	1.91
Education Head (years)	-0.017	-0.62	0.006	0.56
Age Head	-0.001	-0.11	0.011	3.14
Indicator = 1 if male head	-0.323	-2.10	-0.005	-0.04
Indicator = 1 if nonwhite	0.367	1.26	-0.492	-3.83
Ln (Family size)	--	--	0.302	3.10
Plan indicators				
1 if 25% coinsurance	-0.462	-1.99	-0.438	-3.78
1 if 50% coinsurance	-1.125	-3.56	-0.515	-3.57
1 if 25% for medical, 50% for dental & mental	-0.382	-1.38	-0.278	-2.07
1 if 95% coinsurance	-0.841	-4.23	-0.878	-8.85
1 if 95% outpatient, 0% inpatient	-0.781	-4.04	-0.395	-4.13
Site indicators				
1 if Seattle	0.028	0.13	0.294	2.96
1 if Massachusetts	0.039	0.19	0.205	2.20
1 if South Carolina	0.249	0.66	-0.193	-1.42

[a]Dependent variable is Ln (Family expenditures) conditional on having nonzero expenditures. Omitted plan indicator is 0 percent coinsurance plan; omitted site indicator is Dayton. Income and expenditures are in 1982 dollars.

For each family, an expected out-of-pocket expenditure distribution for each of the four supplementary insurance plan options (no supplementation and each of the three supplementary plans) was constructed by applying the cost-sharing provisions of the option to each observation in the total expenditure distribution. A family's expected out-of-pocket expenditure distribution for each supplementary option is represented by a 16 category, discrete probability distribution, which tabulates the frequency of out-of-pocket expenses in \$100 intervals from \$0 to \$1600.[5]

[5]The maximum out-of-pocket expense for any family is \$1600 in 1982 dollars.

DISPOSABLE INCOME

Information about the family's gross income was collected in a personal interview administered before the experimental phase of the HIE. The family's gross income (adjusted to 1982) was apportioned into wages, property income, and nontaxable income based on allocations given in Table 740, *Statistical Abstract of the United States, 1981*. The family's federal income tax was computed by adding the apportioned wages and property incomes and applying average tax rates given in Table 437 of *Statistical Abstract of the United States, 1982-83*. Payroll taxes were estimated applying the 1982 payroll tax rates to imputed wages. If the family contained one adult, the maximum wage subject to the payroll tax was $32,400; if two or more adults it was $64,800. These tax estimates were then subtracted from gross income to produce the family's disposable income.

IV. MODEL SPECIFICATION AND ESTIMATION METHODS

DISCRETE CHOICE MODEL

Following McFadden (1981), a probabilistic choice model is specified and estimated for each evaluation model discussed in Sec. II. The desirability index of family m for supplementary health insurance option j is the sum of a nonstochastic term (N_{jm}), which is determined by the particular evaluation model under consideration, and a stochastic term (w_{jm}), which represents the influence of unobserved attributes on a family's assessment of the desirability of an option. Depending on the evaluation model under consideration, the N_{jm} term may correspond to expected utility in Eq. (2.3), expected value in Eq. (2.6), or to one of the intermediate evaluation models. The desirability of plan j for family m can be expressed as follows:

$$D_j = N_{jm} + w_{jm}. \tag{4.1}$$

Assuming families choose the plan option that is the most desirable, the probability of family m choosing plan j over the no supplementary health insurance option (j=0) can be expressed as

$$\begin{aligned} \text{prob}\{\text{family m chooses plan j}\} &= \text{prob}\{D_{jm} > D_{0m}\} \\ &= \text{prob}\{N_{jm} + w_{jm} > N_{0m} + w_{0m}\} \\ &= \text{prob}\{N_{jm} - N_{0m} > u_m\}, \text{ where } u_m = w_{0m} - w_{jm}. \end{aligned}$$

Assuming that u_m is drawn from a normal distribution with mean 0 and variance σ^2, the choice probability becomes:

$$\text{prob}\{\text{family chooses Plan j}\} = \Phi\{\beta[N_{jm} - N_{0m}]\}, \tag{4.2}$$

where Φ is the standard normal cumulative distribution function and $\beta = 1/\sigma$.

Equation (4.2) is similar to a standard probit model, except that the $(N_{jm} - N_{0m})$ is a nonlinear function of the family's expectations about their medical expenses as well as the unknown parameters of the evaluation model. The exact form of the difference in the nonstochastic terms depends on the particular evaluation model under consideration. For each evaluation model, the parameters of the evaluation function and the β of Eq. (4.2) can be estimated using maximum likelihood methods.

ECONOMETRIC ISSUES

Heteroskedasticity

The discrete choice model specified in Eq. (4.2) assumes that the u_m have constant variance equal to $1/\beta^2$. However, preliminary model estimation suggested quite strongly that the model's error was heteroskedastic, with the variance of u_m increasing as $(N_{jm} - N_{0m})$ increases. Equivalently, this implies that the variance of u_m increases (and hence β decreases), the greater the expected change in outcomes from the purchase of supplementary plan j. To account for the heteroskedasticity, the β parameter of Eq. (4.2) is assumed to depend on the supplementary plan premium and the expected decrease in out-of-pocket medical expenses from purchasing the plan. In the expected utility model, in which outcomes are specified as net income levels, β is also allowed to vary with the level of disposable income. The specific form of β is:

$$\beta = \beta_0 \bullet [h_j + E(e_{i0} - e_{ij})]{**}\beta_1 \bullet 10{**}(y/1000 \bullet \beta_2), \qquad (4.3a)$$

for the expected utility model, and

$$\beta = \beta_0 \bullet [h_j + E(e_{i0} - e_{ij})]{**}\beta_1. \qquad (4.3b)$$

for all other discrete choice models, where E(x) denotes the mathematical expectation of x given the expectations p.

A heuristic explanation of the estimated β is that it is a scale factor such that if the ratio of the desirability of purchasing a supplementary plan to the desirability of not purchasing the plan for

family m, (N_{jm}/N_{0m}), is the same as the ratio for another family n, (N_{jn}/N_{0n}), then the scaled difference in desirability for family m, $(\beta[N_{jm} - N_{0m}])$, is approximately the same as the scaled difference for family n, $(\beta[N_{jn} - N_{0n}])$.

Intrafamily Correlation

The discrete choice model in Eq. (4.2) also assumes that the u_m are independent across observations. However, as described above, the HIE dataset used in this study contains multiple observations for each family head, each observation representing the response to a different supplementary plan offer. The assumption of independence is therefore untenable because the stochastic terms in the responses to plan offers j' and j* from family head m, denoted $u_{m'}$ and u_{m*}, are clearly correlated. To see this, note that because $u_{m'} = w_{0m} - w_{j'm}$ and $u_{m*} = w_{0m} - w_{j*m}$, the covariance of $u_{m'}$ and u_{m*} is as follows:

$$\mathrm{cov}(u_{m'}, u_{m*}) = \mathrm{var}(w_{0m}) - \mathrm{cov}(w_{0m}, w_{j'm}) - \mathrm{cov}(w_{0m}, w_{j*m}) + \mathrm{cov}(w_{j'm}, w_{j*m}). \qquad (4.4)$$

It seems likely that a family head who attaches greater than average desirability to one plan ($w_{j'm}$ positive) will also attach greater than average desirability to other plans (w_{j*m} positive); hence, the covariances on the right hand side of Eq. (4.4) will be nonzero. However, even if the stochastic terms, w_{jm}, across the multiple observations for a family head are independent, the stochastic errors, u, are not independent because they all depend on depend on w_{0m}. Ignoring the correlation among the u will yield statistically inconsistent estimates of the standard errors; as a result, inferential statistics will be too large.

A discrete choice model that assumes a multivariate normal distribution for the u is more appropriate than the univariate distribution that we have assumed. However, to avoid the computational expense of the multivariate model, we have employed a correction technique described by Duan (Duan et al., 1982). The parameters of the discrete choice model and their standard errors were initially estimated assuming independence of the observations. The intrafamily correlation

among the u was then estimated from a random subsample of two responses from each family head; the estimated correlation ranged from 0.63 to 0.70, depending on the evaluation model under consideration.

For families with two heads, we also had responses from both heads, and the errors in responses from different members of one family are also correlated. This correlation was only slightly lower than the correlation of errors in responses from a single member. An upper bound adjustment for the standard errors obtained from the univariate model was computed by assuming that the estimated correlation among responses from one family member applied to all responses from the family. All the t and χ^2 statistics reported here have been corrected for intrafamily correlation using the estimated adjustment factor.

ESTIMATION METHODS

Estimation of the parameters of the discrete choice model described by Eqs. (4.2) and (4.3) was carried out using Bronwyn Hall's (1978) MAXLIK version 1.0, a general purpose program for maximum likelihood estimation. For the expected value model, the inflection point in the region of losses, g^*, was specified as a linear function of disposable income, $g^* = -\gamma_0 - \gamma_1 \cdot y$. Maximum likelihood parameter estimates were obtained from a grid search over the γ, which involved repeated maximum likelihood estimates given each grid value of the γ parameters.

The estimates presented in the following sections are based on discrete choice models with constant risk parameters for all families. In results not reported here, models that allowed the risk parameters to vary with family attributes (disposable income, family size, age and gender of the family head) were also estimated; however, the coefficients on the family attributes were not significantly different from zero in a statistical or practical sense.

Except for the expected utility model, the evaluation models assume that a prospect's outcomes are evaluated as gains or losses relative to some reference plan. The expected value of a supplementary plan option can vary considerably depending on the family's reference. The estimates reported assume that the HIE experimental plan is the reference. An alternative assumption that the reference was complete supplementation or full coverage was tested; the fit of these models was

significantly inferior to those that assumed the experimental plan to be the reference.

Before estimating the models, we randomly allocated the observations into two subsamples: an estimation subsample containing 1564 responses to the supplementary offers and a prediction subsample including the remaining 1571 responses. The parameter estimates for each of the discrete choice models were calculated using the estimation subsample. Using the models fitted on the estimation subsample, the probability that the supplementary plan would be purchased is predicted for each observation in the prediction subsample, and these predicted values are compared with the actual responses to determine the goodness of fit of the discrete choice models, each one of which is specified using a different evaluation model.

EVALUATION METHODS

In comparing the discrete choice models, classical likelihood ratio tests cannot be used because the models are not all nested. However, for choosing the most adequate model among a set of competing models, rather than significance testing, the different likelihood values give an indication of how closely the models fit the sample observations (Cox, 1962). Based on information theory, Akaike (1973) proposed a criterion for choosing among competing models that incorporates the tradeoff between goodness of fit and the parsimonious use of parameters. The Akaike Information Criterion (AIC) is given by $-\ell + k$, where ℓ is the logarithm of the likelihood function and k is the number of estimated parameters. The decision rule is to select the model with the smallest AIC.

Another method of evaluating the model specifications involves comparing how well the models fitted with the estimation subsample predict the plan choices of those in the forecast subsample. The criteria used to evaluate the predictions are the net bias and the sum of squared residuals (SSR).[1]

[1]Amemiya (1981) discusses the merits of the SSR and other scalar criteria that have been proposed for choosing among alternative qualitative response models.

The net bias is defined as follows:

$$\text{net bias} = (1/n)\Sigma(Y_i - p_i), \tag{4.5}$$

where Y_i is 1 if family head i responded that he or she would purchase the supplementary plan offer and 0 otherwise, p_i is the predicted probability that he or she purchases the plan, and n is the number of observations in the prediction subsample (1571). The sum of squared residuals is defined as:

$$SSR = \Sigma(Y_i - p_i)^2. \tag{4.6}$$

These prediction measures provide another indication of the relative performance of the discrete choice models, but they do not give a formal test of one model specification over another. A procedure used by Duan et al. (1982) has therefore been employed here, for a formal test. This procedure consists of a binomial sign test to detect consistent patterns in the relative performance of across subgroups of the prediction subsample. To use the test, the prediction subsample is randomly split into 30 subgroups. For each subgroup, the SSR is calculated for each of the estimated models. The sign test counts the number of subgroups for which the SSR of one model is lower than that of the other model. Under the null hypothesis of no difference in the predictive capabilities of the two models, the count follows a binomial distribution with probability 0.5 and sample size 30. Counts that are significantly higher or lower than 15 are taken as evidence that one model's predictive capability is better or worse than the other's.

V. MODEL COMPARISONS AND PARAMETER ESTIMATES

Table 4 shows the Akaike Information Criterion (AIC) for seven discrete choice models, among which are the expected utility model (A1) and the expected value model (C3). The minimum AIC decision rule implies that the model specified using expected value theory, (C3), is the best model among this set of alternatives. The model that is specified using expected utility theory (A1) dominates only models B1 and C1, in which outcomes are perceived as gains and losses in net income as measured against the reference plan, but symmetry in the evaluation of gains and losses is imposed. Relative to the expected utility model, improvements in the AIC are obtained when the outcome evaluation function permits different responses to gains and losses (models B2 and C2). Models B3 and C3 produce further improvements by allowing risk-seeking behavior with respect to small losses (under about 100 1982 dollars).

The net bias and SSR evaluated on the full prediction subsample are given in Table 5 for each model, and the subgroup sign tests for SSR are presented in Table 6. The rank of the models' predictive performance corresponds to their estimation subsample AIC ranking reported above. The discrete choice models that permit risk-seeking for small losses (C3 and B3) predict significantly better than the other models (see Table 6) and also yield average predicted offer-acceptance probabilities that are quite close to the observed prediction subsample mean (see Table 5). The models that assume families are always risk averse but evaluate gains differently than losses (C2 and B2) are also significantly superior to the expected utility model. Although the models that incorporate the segregation effect hypothesized by Kahneman and Tversky (1979) yield a smaller net bias and SSR than the models that assume integrated gains (See Table 5), the segregation effect does not produce significantly better predictions (see Table 6).

The values of criteria for selecting among competing models calculated on both the estimation subsample (AIC) and prediction subsample (net bias and SSR) indicate that the superior model departs in

Table 4

AKAIKE INFORMATION CRITERION[a] FOR ALTERNATIVE MODEL SPECIFICATIONS

Outcome Evaluation Function	Outcome (x) Evaluated		
	Net Income[b] (A)	Integrated Gains[c] (B)	Segregated Gains[d] (C)
(1) Concave, 1 parameter			
$1-\exp(-ax)$	968.7	997.6	998.7
(2) Concave, positive and negative outcomes valued differently			
$1-\exp(-a_1x)$ if $x \geq 0$, $1-\exp(-a_2x)$ if $x < 0$	--	934.4	931.6
(3) Concave for positive and large negative outcomes, convex for small negative outcomes			
$1-\exp(-a_1x)$ if $x \geq 0$, $-(1-\exp(a_2x))$ if $x^* < x < 0$, $-(1-\exp(a_2x)) +\{1-\exp[-a_3(x - x^*)]\}$ if $x \leq x^*$	--	925.4	914.8

[a]AIC equals $-\ell + k$ where ℓ is the logarithm of the likelihood function and k is the number of estimated parameters.

[b]Net income is disposable family income net of health-related expenses (health insurance premiums and out-of-pocket medical expenses).

[c]Integrated gains are identical to changes in net income.

[d]Segregated gains means that the riskless component of a prospect is evaluated separately from the uncertain component. See Eq. (2.6).

Table 5

MEAN PREDICTED PROBABILITY OF ACCEPTING PLAN OFFER, NET BIAS, AND SUM OF SQUARED RESIDUALS FOR PREDICTION SAMPLE[a]

Characteristics of Evaluation Function	Predicted Probability of Purchase (%)	Net Bias (%)	SSR
C3: Expected Value Model 3 Parameter, Segregated Gains	62.6	-1.1	314.09
B3: 3 Parameter, Integrated Gains	62.3	-1.4	314.83
C2: 2 Parameter, Segregated Gains	61.3	-2.4	323.42
B2: 2 Parameter, Integrated Gains	61.1	-2.6	324.33
C1: 1 Parameter, Segregated Gains	50.7	-13.0	361.14
B1: 1 Parameter, Integrated Gains	50.9	-12.8	361.71
A1: Expected Utility Model 1 Parameter, Net Income	57.9	-5.8	348.88
Prediction Subsample	63.7	--	--

[a]Model reference (e.g., C3) refers to designation used in Table 4.

several ways from expected utility theory: Gains and losses in net income are evaluated asymmetrically and families are risk seeking in the domain of small losses.

In Sec. VI, the expected utility and expected value models are used to simulate the health insurance plan choices that representative families would make when offered different combinations of plans and to examine how changes in the effective cost (the premium net of any tax subsidy) of plans would affect those choices. The expected value model used in these simulations (model C3) incorporates the assumption that the riskless and uncertain components of a prospect are evaluated separately. This segregated gains version performed better than the integrated gains version of the same model, although the two were not significantly different.

Table 6

SIGN TESTS FOR SUM OF SQUARED RESIDUALS OF ALTERNATIVE MODEL SPECIFICATIONS USING 30 SUBGROUPS OF PREDICTION SUBSAMPLE[a]

First Model Evaluation Function	Second Model Evaluation Function	Number Where Model A SSR Less than Model B
C3: Expected Value Model, 3 Parameter, Segregated Gains	B3: 3 Parameter, Integrated Gains	15
	C2: 2 Parameter, Segregated Gains	25[b]
	B2: 2 Parameter, Integrated Gains	24[b]
	C1: 1 Parameter, Segregated Gains	28[b]
	B1: 1 Parameter, Integrated Gains	29[b]
	A1: Expected Utility Model	29[b]
B3: 3 Parameter Integrated Gains	C2: 2 Parameter, Segregated Gains	27[b]
	B2: 2 Parameter, Integrated Gains	26[b]
	C1: 1 Parameter, Segregated Gains	30[b]
	B1: 1 Parameter, Integrated Gains	30[b]
	A1: Expected Utility Model	29[b]
C2: 2 Parameter, Segregated Gains	B2: 2 Parameter, Integrated Gains	13
	C1: 1 Parameter, Segregated Gains	26[b]
	B1: 1 Parameter, Integrated Gains	26[b]
	A1: Expected Utility	26[b]
B2: 2 Parameter, Integrated Gains	C1: 1 Parameter, Segregated Gains	30[b]
	B1: 1 Parameter, Integrated Gains	28[b]
	A1: Expected Utility	29[b]
A1: Expected Utility Model, 1 Parameter, Net Income	C1: 1 Parameter, Segregated Gains	20[b]
	B1: 1 Parameter, Integrated Gains	20[b]
C1: 1 Parameter, Segregated Gains	B1: 1 Parameter, Integrated Gains	17

[a]Model reference (e.g., B3) refers to the designation used in Table 4.

[b]Significant at 0.05 level. Count needed for significance level of .05 is 20; for significance level of .01 it is 22.

The parameter estimates for the two models used in the simulations are given in Table 7.[1] The parameter estimates for the expected value model suggest that families refuse to worry about losses that are smaller than \$100; the a_2 coefficient is zero indicating that the value of losses smaller than g^*, or 100, is also zero. For larger losses, however, the value function is steeper than the value function in the region of gains. This finding empirically appears to support prospect theory's postulate that losses loom larger than gains; the displeasure associated with a loss exceeds the pleasure associated with a gain of the same amount. However, the result is also compatible with another hypothesis advanced by Kahneman and Tversky (1979) that they refer to as the certainty effect. According to the hypothesis, outcomes that are considered certain weigh more heavily than outcomes that are only possible. In the supplementary insurance offers we analyze, all losses are certain premium expenditures, whereas all gains are the uncertain reductions in out-of-pocket medical care expenditures. Thus, we cannot disentangle the hypothesized certainty effect from the overweighting of losses relative to gains with the available data.

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[1]Parameter estimates for the other prospect evaluation models are available on request.

Table 7

MAXIMUM LIKELIHOOD PARAMETER ESTIMATES FOR THE EXPECTED UTILITY AND EXPECTED VALUE MODELS (t-statistics in parentheses are adjusted for intrafamily correlation)

Model: $\Pr(\text{Accept offer } j) = \Phi[\beta(EU_j - EU_0)]$ or $\Phi[\beta(EV_j - EV_0)]$	Estimated Parameters		
Expected Utility Model	β_0	β_1	β_2
$\beta = \beta_0 \bullet (h_j + E(e_{i0} - e_{ij}))^{**}\beta_1$	234.53	-0.767	0.482
$\bullet 10^{**}(\beta_2 \bullet y/1000)$	(1.37)	(6.78)	(5.72)
$U(n) = 1 - \exp(-a \bullet n)$	a		
	exp(-6.788)		
	(38.42)		
Intrafamily correlation	ρ		
	0.70		
Expected Value Model	β_0	β_1	
$\beta = \beta_0 \bullet (h_j + E(e_{i0} - e_{ij}))^{**}\beta_1$	1858.113	-0.908	
	(0.95)	(10.49)	
$V(g) = 1 - \exp(-a_1 g)$ if $g \geq 0$,	a_1	a_2	a_3
$-(1 - \exp(a_2 g)$ if $g^* < g < 0$,	exp(-7.566)	0	exp(-7.631)
$-(1 - \exp(a_2 g^*))$	(5.44)		(11.1)
$+ \{1 - \exp(-a_3(g - g^*))]\}$ if $g \leq g^*$	g^*		
	-100		
	$(\chi^2 = 17.1)$		
Intrafamily correlation	ρ		
	0.63		

VI. HEALTH INSURANCE DEMAND

These estimated discrete choice models can be used in various ways to study the character of health insurance demand. This section presents some demand results implied by the expected value model, compares them with results implied by the expected utility model and those from previous insurance demand studies, and reconsiders the findings of early theoretical and empirical studies of health insurance demand.

DEMAND PREMIUM

One way to characterize health insurance demand is by a plan's demand premium, the premium level that would leave a family indifferent between the plan and no insurance. Demand premiums are estimated by finding the premium level at which the expected utility or expected value of purchasing the plan equals the expected utility or expected value of forgoing the purchase. Demand premiums for full insurance are calculated for two families. The "healthy" family faces an even chance of having no medical expenses and of having $1000 (1982 dollars) in medical expenses; on average this family would expect to have $500 in medical expenses. The "sick" family has a 90 percent chance of incurring medical expenses of $1000 and a 10 percent chance of having no expenses; this family's expected medical expenses are $900.

Using the expected utility model, the demand premium for the healthy family is $634, and for the sick family it is $938. Because the fitted utility function assumes a diminishing marginal utility of income, the expected utility maximizer will pay some amount above the actuarial value of the plan to eliminate the uncertainty. This amount, however, falls as the loss becomes more certain.

The demand premium implied by the expected value model varies substantially with the reference plan against which gain and losses are measured. With a reference of no insurance, the demand premium for the healthy family is $480 and for the sick family it is $740. When complete insurance is the reference, the premium is $618 for the healthy

family and $1311 for the sick family. If a family's reference is no insurance, the buy decision consists of a certain loss of the premium and uncertain gains in reimbursed medical expenses. Since losses loom larger than similar sized gains, the demand premium for a reference of no insurance is less than the mathematical expectation of medical expenses. When the reference is full coverage, however, the out-of-pocket expenses the family would face in giving up the coverage are viewed as losses, whereas the gain is the saving in premium; the premium, or gain, must exceed the expected value of the more highly weighted losses.

One implication of this result is that there is some inertia or persistence in the consumer's choice of health insurance plan because plans that are held are more highly valued than equivalent plans that have not been purchased.[1] Studies of consumers' choice of insurance plan have observed the tendency for individuals to choose the same plan year after year (Marquis, Kanouse, and Brodsley, 1985; Neipp and Zeckhauser, 1986). The tendency to remain with the incumbent plan may explain observed purchases of insurance that appear to be financially unattractive (Marquis, Kanouse, and Brodsley, 1985)--at least to the expected utility maximizer. In fact, with a reference of full coverage, the sick family would persist in purchasing the coverage at a premium of $1311, which exceeds the maximum medical expenditure the family would face without the coverage. Although such a result would not obtain from the standard expected utility model, Thaler (1980) among others suggests that people want full coverage to avoid having to make tradeoffs between health care and money. A high deductible policy exposes consumers to psychic costs of decisionmaking, because it leaves them open to many decisions regarding the costs and benefits of medical services purchased before the deductible. Purchasing full coverage avoids these psychic costs. The psychic costs that would be incurred by dropping the coverage (reflected in the overweighting of the losses) may be enough that the consumer prefers to keep the coverage even at substantial premiums.

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[1]Thaler (1980) calls this the "endowment effect."

There are some reasons why our models might yield overestimates of the demand premium. With a reference of full coverage, the gains (premium reductions) are the certain outcome. With our fitted expected value model, these gains are not weighed as heavily as the (uncertain) losses. However, as we observed in the previous section, our estimate of the degree to which families overweight losses relative to gains includes any overweighting of certain outcomes relative to uncertain outcomes. The more dominant the certainty effect in this estimate, the more we underweight the value attached to the certain gains and the smaller should be the estimated demand premium for a reference of full coverage. If the certainty effect accounts entirely for the apparent overweighting of losses in our estimation data, the demand premium for a reference of full coverage would equal the demand premium for a reference of no coverage.

In addition, the estimate of risk aversion for both the expected utility and expected value models assumes that families perceive a zero price elasticity of demand for medical care when they make the insurance purchase decision. The value of insurance is all attributed to the value of the financial risk avoided. If, however, a family knows that it will consume more medical care when it purchases additional insurance, a part of the value of the insurance will be the value of the additional care it expects to purchase; only a part of the value will be due to the risk avoided. In this case, the assumption of a zero perceived price elasticity of medical care demand will produce overestimates of the degree of risk aversion and of the demand premiums. Some further implications of this assumption for our empirical results are discussed in the concluding section.

MONTE CARLO SIMULATION OF PLAN CHOICE

Methods

The demand premium concept is quite limited because it provides no information about actual plan choices. A more powerful use of the estimated discrete choice models involves conducting a series of Monte Carlo simulations to estimate plan choice patterns and price elasticities.

The models estimated in this study differ from previous empirical models of health insurance demand in that they can be used to analyze plan choice among any number of arbitrarily defined health insurance plans. This ability to generalize beyond the number and type of plans present in the data is directly related to the model's characterization of a health insurance plan as an uncertain or risky prospect and the estimation of a structural model of prospect choice.

The pattern of choice among any number of arbitrarily defined health insurance plans can be predicted using the following demand simulation methodology, which is specified more completely in Holmer (1985). First, the coverage provisions of each plan are specified. The family's expectations of out-of-pocket medical expenses under each plan are taken to be the actual distribution of out-of-pocket expenses among all families with similar attributes. This expense distribution is generated by a Monte Carlo simulation of a medical episode model estimated with HIE data using statistical methods described in Keeler and Rolph (1982). With these expectations, the scaled expected value or scaled expected utility (i.e., $\beta \bullet EU$ or $\beta \bullet EV$) of each plan is calculated with the estimated discrete choice model. And finally, a multivariate normal error (generated from a distribution with zero mean and a covariance matrix with ones on the diagonal and the model's estimated intra-family correlation coefficient off the diagonal) are added to the scaled expected value (or utility) for each plan. The resulting sum represents the desirability (or "random utility" in the terminology of discrete choice models) of the plan, and the family is assumed to choose the most desirable plan.

Choice patterns are predicted here with this simulation methodology for a few different choice situations and family types using both the expected value and expected utility models. The hypothetical health insurance plans used in these simulations have comprehensive coverage (medical, dental, mental, and preventive care) with family deductibles ranging from zero to one thousand (1983) dollars. The deductible is also the out-of-pocket expense limit since there is assumed to be no cost-sharing beyond the deductible.

The standard family assumed in the simulations has (1983) income of \$25,000 and three members--a husband and wife who are 32 years old, high school graduates, and not black, and a daughter who is 10. This family's average annual medical expenses would approximately equal the mean expenses of all families (insurance units with two or more members) covered by employer-sponsored health insurance, if they all were covered by the same plan. A larger family is also assumed in the simulations; it is the same as the standard family except that it contains two additional children, a nine year old son and an eight year old daughter.

The simulations adopt varying assumptions about tax policy regarding health insurance premiums and about the level of marginal tax rates in order to estimate the response of health insurance demand to price changes caused by tax policy. In the case of a complete tax subsidy a plan's effective cost is (1 - t) times the premium, where t denotes the family's marginal tax rate. The standard and larger families are assumed to face a marginal tax rate of either 30 percent or 45 percent, depending on the simulation. The premiums of the plans are assumed to be at the level that would just cover (excluding administrative costs) plan outlays if all plan enrollees were identical to the standard family. Plan choice differences between the standard and larger family can therefore be interpreted as the effects of a shift in medical expense expectations.

Predicted Choice Probabilities

Predicted choices between a \$0 deductible and a \$1000 deductible insurance plan among samples of 4000 families are displayed in Table 8; the premiums for the plans are \$3448 and \$1635, respectively. The pattern of choices predicted from both the expected utility model and the expected value model are presented, and for the latter case we contrast the predicted assumptions under alternative assumptions about the reference plan. Results are given adopting varying assumptions about tax policy and marginal tax rates in order to assess the response of insurance demand to changes in price.

Table 8

PREDICTED CHOICE OF A $0 DEDUCTIBLE PLAN OVER A $1000 DEDUCTIBLE PLAN AMONG 4000 FAMILIES[a]
(Percent purchasing the $0 deductible plan)

Tax Policy Assumed	No Tax Subsidy	Full Subsidy at 30% Tax Rate	Full Subsidy at 45% Tax Rate
Expected Utility Model			
Standard family	0.0	7.4	37.4
Larger family	0.0	13.4	47.4
Expected Value Model			
$1000 deductible reference			
Standard family	11.6	26.4	38.0
Larger family	13.6	29.8	41.4
$0 deductible reference			
Standard family	38.4	44.6	50.7
Larger family	42.4	49.6	56.1

[a]Premium for the $0 deductible plan is $3448, and for the $1000 deductible plan it is $1635.

The most striking aspect of the results from the expected utility model is that there is no demand for unsubsidized full insurance, even though premiums are actuarially fair, among both the sample of standard families and the sample of larger families that have higher medical expenses than the standard families. This result may at first appear to be at variance with our estimates of demand premiums, which indicated that the family's demand premium exceeds the mathematical expectation of the risk, and with theoretical research, which shows that a risk-averse individual will demand full insurance coverage at actuarially fair insurance premiums. However, unlike much previous research, in which actuarially fair premiums were defined without regard to the utilization effect (or moral hazard) of insurance, the medical episode model that we have used to simulate expenditure distributions under each plan does recognize that families' use of health care services increases as the generosity of their insurance increases. Therefore, premiums for the

full coverage plan are based on a higher rate of health care spending than premiums under the $1000 deductible plan. The difference in the premiums between the full coverage plan and the deductible plan includes both the expected reduction in out-of-pocket risk to the family from having full insurance and the additional risk to the insurer from the demand induced by the more generous coverage. As a result, the premium for the full coverage plan is $1813 higher than the premium for the deductible plan, even though the family's maximum risk under the deductible plan is only $1000. Therefore it is not surprising that the expected utility model predicts that no families are willing to purchase the full coverage.[2] If tax policy subsidizes insurance and the family faces a marginal tax rate of 30 percent, the cost of eliminating a $1000 deductible is $1269 ((1 - .30) × 1813) and the expected utility model still predicts little demand for the full coverage plan. However, if the family faces a 45 percent tax rate, the effective difference in the premiums of the two policies falls to $997 ((1 - .45) × 1813); the expected utility model predicts substantial demand for the full coverage plan at this level of additional cost.

The expected value model also predicts little demand for unsubsidized full insurance when the deductible plan is the reference. While demand is increased by a premium subsidy, the magnitude of the increase is small relative to the expected utility model.

In contrast, when the reference plan is full coverage, the expected value model predicts that almost 40 percent will continue to purchase full coverage in preference to a $1000 deductible plan, even though the differential cost is $1813. As noted earlier, inertia and psychic costs of decisionmaking, which can be modeled as overweighting of losses relative to gains in the expected value model, may be factors contributing to the substantial predicted demand at the high premium cost. The response of demand to tax policy is smaller under the assumption that full coverage is the reference than under the assumption

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[2]Given our assumption that the insurer has perfect information about the actual price elasticity but the family's perceived elasticity is zero at the time the insurance plan choice is made. Different results would obtain with different assumptions about the family's and insurer's perceptions of the elasticity of demand.

that less generous insurance is the reference. Given the current level of insurance coverage, eliminating the tax subsidy to employer-paid insurance premiums may be less effective in encouraging people to assume a greater degree of the risk of their medical care bills than the subsidy was in encouraging the purchase of more insurance.

The predicted demand derived from the expected value model is higher at every level of the premium subsidy than that based on the expected utility model, even though demand premiums estimated earlier were higher for the expected utility model than for the expected value model when the deductible plan is the reference. The demand premium estimates, however, are based only on the deterministic portion of the probabilistic choice model, which reflects the average value or utility attached to a plan by similar families. The simulation results, however, also account for variability among similar families in their evaluation of prospects.

In the discrete choice models, the variance in prospect evaluation is estimated by one divided by the scale factor, β (see Table 7). The estimated β for the expected utility model is much larger, hence the variance in prospect evaluation smaller, than for the expected value model; the expected utility model suggests more uniform behavior among similar families than the expected value model. With the expected utility model, therefore, a prospect that is unattractive to the average family will be unattractive to most families. However, the greater variability in prospect evaluation estimated for the expected value model suggests that some families will probably find a prospect desirable even if the average family does not. The difference in the estimated variability in prospect evaluation using the two models explains why we observe that some families demand full coverage at unsubsidized premiums using the expected value model, even though the purchase is unattractive to the average family, but do not observe any demand using the expected utility model.

It also explains in part the greater demand response to the tax subsidy predicted with the expected utility model than with the expected value model. When the price of full-coverage begins to approach the level that makes the purchase attractive to the average family, there will be large shifts in demand using the expected utility model because

families' evaluations of prospects are estimated to be quite uniform. However, the response will be more gradual using the expected value model because of the variability among families in prospect evaluation. The superiority of the expected value model in explaining the choices of the prediction subsample, described in Sec. V, suggests that there is greater variability among families in prospect evaluation than we estimated using the expected utility model.

Predicted choice probabilities among several plans, rather than just two, are shown in Table 9 for a sample of 4000 standard families. The results are based on the expected value model assuming full-coverage to be the reference plan. With the expanded menu of plan choices, the response to changes in the level of the tax subsidy is even smaller than the response when the choice is limited to two plans. At all levels of the subsidy, the intermediate plans in Table 9 are more attractive (have a higher expected value) than the full-coverage or $1000 deductible plan. The limited menu of choices given in Table 8, therefore, forces a choice between the two fairly undesirable plans. In this case, a premium subsidy causes a large shift in plan choices among families who would prefer an intermediate deductible plan with or without the subsidy.

Table 9

PREDICTED CHOICES AMONG SIX DEDUCTIBLE OPTIONS BY 4000 FAMILIES: STANDARD FAMILY, FULL COVERAGE REFERENCE EXPECTED VALUE MODEL
(Percent purchasing)

		Tax Policy Assumed		
Plan Premium	Plan Deductible	No Tax Subsidy	Full Subsidy, 30% Tax Rate	Full Subsidy 45% Tax Rate
$3448	$ 0	7.3	9.9	12.3
2783	200	37.6	37.6	37.9
2395	400	21.7	20.8	19.8
2077	600	15.1	14.4	13.7
1832	800	10.9	10.5	9.9
1635	1000	7.4	6.8	6.4

Elasticity Estimates

Concepts. The differences in predicted plan choice patterns between the expected utility and the expected value model translate into different estimates of the price sensitivity of health insurance demand. Following several recent empirical estimates, we will examine estimates of how premium expenditures respond to changes in the tax subsidy.

A family's expected premium payment, E, is given by

$$E = \Sigma_j\, c_j\, h_j,$$

where c_j is the probability of purchasing plan j and h_j is the premium of plan j. Let the rate of premium subsidy be represented by s where s equals (1 - t) under a complete subsidy and 1 if there is no subsidy. The effective premium for plan j is therefore sh_j. The elasticity of demand with respect to the subsidy, γ, is defined as:

$$\gamma = [\partial E/\partial s][s/E] \text{ with } E = \Sigma_j c_j h_j. \tag{6.1}$$

This elasticity concept measures how the demand for insurance changes when the prices of all insurance plans change proportionately. Relative to the price of other *goods*, the price of each insurance plan is changed; but relative to the price of other *plans*, the price of each health insurance plan is unchanged. Because this concept has been used in other empirical work, we will report the elasticity estimates using this concept, which we term the absolute price elasticity. However, before reporting the results, we show how the absolute price elasticity is related to own- and cross-price elasticity of the purchase probabilities for each plan.

Discrete choice models generate stochastic demand curves of the following form:

$$c_j = c_j(sh_1,\ldots,sh_j,\ldots,sh_J) \text{ for } j = 1,\ldots J. \tag{6.2}$$

For a large group of families with the same attributes, the aggregate demand for a plan is proportional to the plan's choice probability.

Considering each plan as a commodity would lead to a price elasticity of demand defined as follows:

$$\varepsilon_{jk} = (\partial c_j/\partial sh_k)(sh_k/c_j). \tag{6.3}$$

The elasticities in Eq. (6.3), which we will call relative price elasticities, measure how demand for a plan changes when only one insurance plan price is changed, so that the relative prices of plans are changed.

The relationship between the absolute and relative price elasticities can be determined by differentiating Eq. (6.1) and substituting Eq. (6.3). Since $[\partial(sh_j)/\partial s] = h_j$, the relationship between the two elasticity concepts is as follows:

$$\gamma = \Sigma_j \Sigma_k \varepsilon_{jk} \pi_j, \tag{6.4}$$

where the share of expected premium accounted for by plan j, $c_j h_j/E$, is denoted by π_j.

An empirical example may be helpful in grasping the nature of this relationship. Consider a menu with the reference plan 1 being the \$400 deductible plan in Table 9 and plan 2 the \$200 deductible. Assume a sample of 4000 standard families who are expected value maximizers with a 1 percent tax rate and a complete premium subsidy. Elimination of the premium subsidy can be thought of as comprising two steps: the elimination of the subsidy for plan 1 and the elimination of the subsidy for plan 2. The shift in choice patterns caused by each step considered in isolation can be used to compute (arc) relative price elasticities. The own relative price elasticities are $\varepsilon_{11} = -3.2$ and $\varepsilon_{22} = -7.5$, and the cross relative price elasticities are $\varepsilon_{12} = +4.4$ and $\varepsilon_{21} = +6.0$. Direct computation of the (arc) absolute price elasticity, however, yields an estimate of about -0.06, which is what Eq. (6.4) predicts using these ε estimates and the corresponding π values. The low value of the absolute price elasticity conceals the fact that a change in the relative price of a health insurance plan causes fairly large shifts in plan choice patterns. So whether health insurance demand is fairly price sensitive depends in part on the type of price change a family

experienced and on whether change in expected premium or aggregate plan demand is used to measure the demand response to the price change.

Estimates. Using Eq. (6.1) the plan choice predictions from Tables 8 and 9 are transformed into the (arc) absolute price elasticities shown in Table 10. The estimated discrete choice model specified with expected value theory generates absolute price elasticities of health insurance demand that range from -.04 to -.15 when the reference plan is full coverage. As was suggested by Tables 8 and 9, a broader range of plan choices reduces the price sensitivity of health insurance demand.

Table 10

ESTIMATED ABSOLUTE PRICE ELASTICITIES

	Standard Family	Larger Family
Family at 30 percent tax rate		
Expected value model: Full coverage reference		
Choice between deductibles of $0 and 1000	-0.13	-0.15
Choice among deductibles of $0, 200, 400, 600, 800, and $1000	-0.04	--
Expected value model: $1000 deductible reference		
Choice between deductibles of $0 and $1000	-0.38	-0.41
Expected Utility Model		
Choice between deductibles of $0 and 1000	-0.22	-0.39
Family at 45 percent tax rate		
Expected value model: Full coverage reference		
Choice between deductibles of $0 and $1000	-0.16	-0.17
Choice among deductibles of $0, 200, 400, 600, 800, and $1000	-0.05	--
Expected value model: $1000 deductible reference		
Choice between deductibles of $0 and $1000	-0.40	-0.41
Expected utility model		
Choice between deductibles of $0 and 1000	-0.59	-0.72

A change in reference from full coverage to the $1000 deductible plan increases the magnitude of the estimated elasticity to about -.4. The expected utility model yields elasticities that range from about -.1 to -.7, depending on the family tax rate and medical expense expectation.

The elasticity estimates generated by the discrete choice models estimated in these studies are consistent with other recent empirical work. Marquis and Phelps (1985) estimated a reduced-form model of the demand for supplementary health insurance using the same HIE data used here. Based on their estimates of the probability of purchasing full coverage at various subsidy levels, the elasticity of premiums with respect to the subsidy rate is -.3.[3]

Although both the estimates reported here and the estimate by Marquis and Phelps are based on hypothetical data, they are similar to elasticity estimates based on observed insurance purchases. Recent studies by Holmer (1984), Farley and Wilensky (1985), and Taylor and Wilensky (1983) have estimated the price elasticity of demand to be in the range of -.2 to -.4. There is only one empirical study with results at variance with this consensus. Phelps (1963, 1976, 1982), using cross-section survey data from 1963, estimates the price elasticity to be -2.8. However, absent data on families' marginal tax rates or actual administrative loading fees, he had to rely on an imperfect proxy measure of the price of insurance in estimating the demand elasticity.

In contrast to the results of this study and other recent empirical evidence, the early theoretical studies of health insurance demand found the demand to be very responsive to changes in price caused by changes in tax policy. These early estimates by Feldstein and Friedman (1977) and by Keeler, Morrow and Newhouse (1977) were based on a model of insurance plan choice derived from expected utility theory, and assumptions about the degree of risk aversion and the distribution of medical expenditure expectations.

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[3]The estimate is the arc elasticity using predicted probabilities of purchasing full coverage for loading fees of 0 and -30% given in Marquis and Phelps (1985) and unpublished data on the actuarial values for the full coverage and the basic experimental plans.

What explains the discrepancy between the elasticity estimates from the theoretical studies and the recent empirical work? One likely source of discrepancy is in the degree of risk aversion assumed in the early studies. Our estimated expected utility model has a coefficient of absolute risk aversion of about 0.00113 for 1982. By comparison, Friedman (1974), in the only other empirical study to use data on health insurance plan choice in the United States to estimate an expected utility model, found a 1968 absolute risk aversion coefficient of 0.00260, which deflates to 0.00094 in 1982. These estimates are in sharp contrast to the assumptions made in the early theoretical studies and suggest that families are more risk averse than those studies assumed. An early estimate of the health insurance demand response to elimination of the tax subsidy by Feldstein and Friedman assumes risk aversion coefficients that deflate to 0.00004, 0.00012, and 0.00020 in 1982. And Keeler, Morrow, and Newhouse, in their study of the likely demand for supplementary health insurance under national health insurance, assume coefficients of absolute risk aversion that deflate to 0.00028 and 0.00111 in 1982. Because the price sensitivity of the demand for insurance increases as the degree of risk aversion falls (Feldstein and Freidman, 1977), these early studies concluded that demand for health insurance is more sensitive to price changes than recent empirical studies have found.[4]

[4]The estimates from these earlier studies do not incorporate variability between otherwise similar families in choice. The inclusion of a stochastic element in our choice models also reduces the elasticity.

VII. CONCLUDING REMARKS

This study has used data on families' preferences for supplementary insurance to estimate several models of decisionmaking under risk. By characterizing health insurance as a risky prospect and specifying structural models of prospect choice, the estimated models differ from previous empirical models of health insurance demand in that they can be used to analyze choice among any number of arbitrarily defined plans. The ability to generalize beyond the number and type of plans present in the estimation data is essential for policy analysis, because it permits the examination of options outside current experience. In fact, the expected value model estimated here has been used to predict the amount of employee contributions to flexible spending accounts (FSAs) in a Congressionally mandated study of the health care cost containment and tax revenue effects of FSAs (U.S. Department of Health and Human Services, 1985).

Because the estimation data consist of responses to hypothetical insurance offers, one might question how well the estimated models will predict actual behavior. Some indirect evidence comes from studies in both the marketing and economic literature indicating that stated preferences do predict actual behavior (see for example Granbois and Summers, 1975; Wolf and Pohlman, 1983). Furthermore, as noted in the previous section, the estimated models produced price elasticity estimates quite consistent with recent empirical studies that use actual health insurance plan choice data. Finally, more direct evidence comes from the application of the estimated expected value model to predict contributions to FSAs; the predictions appeared valid in the sense that they are in agreement with data on actual employee FSA contributions made available by a few employers offering FSAs (U.S. Department of Health and Human Services, 1985).

In light of evidence suggesting expected utility theory is inadequate in accounting for observed behavior in choices involving uncertainty, several alternative theories have been advanced. However, to our knowledge, there has been no previous systematic econometric testing of alternative theories using a common database.

This study indicates that the expected value model, which incorporates assumptions from Kahneman and Tversky's (1979) prospect theory about how individuals evaluate risky prospects, is superior to the expected utility model in predicting choices among prospects. Both assume people have objective expectations about outcome probabilities. The expected value model differs from the expected utility model in assuming that prospects are evaluated as gains and losses from a reference plan rather than as final wealth states, that the evaluation of gains and losses is asymmetric, and that individuals exhibit risk-seeking behavior in the domain of losses. Although the results reported in this study support the validity of these assumptions, additional empirical testing of the two models using data on individuals' preferences in other risky choice situations is desirable before rejecting the ability of the expected utility model to predict choices made in a wide range of realistic situations.

Furthermore, our analysis assumes that the perceived price elasticity of demand for medical care at the time of the insurance plan choice is zero. That is, families do not know, or do not take into acount in making a plan choice, that the amount of insurance purchased will alter the demand for medical care. Both the validity of this assumption and its implications for the results reported here are not fully known and require additional empirical investigation.

If the perceived elasticity is not zero as we have assumed, then the value of the additional medical care that the family expects to consume when more generous insurance coverage is purchased will be a component of the family's evaluation of a plan. This component is excluded from our estimation of both the expected utility model and the expected value model. Whether including the value of additional medical care would change the ranking of the two models in terms of predictive power is an issue for future empirical work.

The assumption of a zero perceived price elasticity of medical care in the estimation would lead us to overestimate the degree of risk aversion in both the expected utility or expected value model, if indeed families are aware that their plan choice will affect the amount of care they consume. A part of the attractiveness of a supplementary plan is

due to the value of the expected additional care, whereas our models attribute the attractiveness of a plan entirely to the value of the financial risk avoided. If there is less risk aversion than we estimate, then other things constant, the price elasticity of the demand for health insurance is greater than we estimate. However, for a given degree of risk aversion, the price elasticity of demand for health insurance falls as the perceived elasticity of demand for medical care increases (see Table 2 in Feldstein and Freidman, 1977). That is, a more elastic perceived demand for health care would generate a lower estimate of risk aversion; these changes have opposite effects on the elasticity of demand for health insurance. Consequently, there is an uncertain net effect of the assumption that families perceive a zero price elasticity of medical care demand on our simulation estimates of the price elasticity of demand for health insurance and our simulation of tax policy effects. The similarity of our estimate of the price elasticity of demand for health insurance with the reduced form estimate by Marquis and Phelps (1985) using the same data, however, hints that the net effect of the two changes on the elasticity is small. Another area for further study is empirical estimates of alternative levels of risk aversion and the perceived elasticity of medical care demand that are compatible with observed behavior and an investigation of their countervailing effects on the elasticity of health insurance demand.

In addition, other competing evaluation models require testing. The assumptions about prospect evaluation incorporated in the expected value model represent only one of several alternative theories that have been offered. For example, Loomes and Sugden (1982) propose a modified utility function in which the utility of any outcome of a prospect is transformed according to the regret or rejoicing the individual expects to experience once the consequences of the choice are known. Alternatively, Machina (1982) and Chew (1983) suggest that utility is transformed according to a weighting function that depends on both the outcome of the prospect and the probability that the outcome will occur, and that individuals maximize expected weighted utility.

Unfortunately, these theories are not yet developed in a form that readily translates into a parametric specification. Some effort was made to specify and estimate the prospect evaluation functions suggested

by these theories. None of these estimated models explained plan preferences significantly better than the expected utility model. We hope that these preliminary efforts will prompt others to empirically validate expected utility theory and alternative theories using data about decisionmaking in a variety of real-world choice situations.

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