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Health Insurance

The Trade-Off Between Risk Pooling and Moral Hazard

Willard G. Manning, M. Susan Marquis

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PREFACE

Choosing economically optimal health insurance coverage involves a trade-off between risk reduction and the overuse of health care. The economic purpose of insurance is to reduce financial uncertainty or risk—the more health insurance lowers the risk, the greater will be the increase in social well-being. But increases in health insurance also increase the amount of medical care demand, because insurance lowers the out-of-pocket cost of health care—the larger the demand response of medical care to cost sharing, the greater the decrease in social well-being, due to the purchase of too much health care.

This study examines this trade-off empirically by estimating both the demand for health insurance and the demand for health services. It relies on data from a randomized controlled trial of the cost sharing's effects on the use of health services and on the health status for a general, nonelderly (under age 65) population.

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SUMMARY

The choice of an economically optimal health insurance package involves a trade-off between the gains from reducing families' financial risks and the losses from inappropriate incentives for the purchase of more health care. The economic purpose of insurance is to reduce financial uncertainty or risk. Other things being equal, individuals are generally willing to pay more than an actuarially fair amount to reduce the risk of a large financial loss caused by a possible future occurrence of illness and the resultant medical care expense. The greater the aversion to risk, the more health insurance will increase social well-being.

Increases in health insurance, however, also affect the allocation of health care resources. Cost sharing decreases the out-of-pocket price paid by the patient, which increases the amount of medical care (moral hazard). Because consumers would not purchase this additional care if they had to pay its full cost, the value of the extra services to consumers falls short of the social cost of producing that care. The larger the response of health care to cost sharing, the greater the decrease in social well-being resulting from more health insurance.

Our study examines this trade-off using data collected in the RAND Health Insurance Experiment. The study presents estimates of both the demand for health insurance and the demand for health services. These estimates provide the basic empirical building blocks for assessing the trade-off between the welfare gains resulting from risk sharing and the welfare loss resulting from moral hazard.

The results suggest that the optim[illegible]insurance rate (percentage of the health care bill paid directly by [illegible]ents) should be about 50 percent. Although this estimate is higher than the 30 percent now paid out of pocket, the estimated economic loss from the discrepancy is quite modest. However, there is a substantial economic loss for up to 40 million Americans resulting from the absence of insurance.

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I. INTRODUCTION

Social choices about health insurance involve a trade-off between the gains from risk reduction and the losses from inappropriate incentives for the purchase of more health care (Arrow, 1963, 1971, 1973, 1976; Zeckhauser, 1970). The economic purpose of insurance is to reduce financial uncertainty or risk.[1] Other things being equal, individuals are generally willing to pay more than an actuarially fair amount to reduce the risk of a large financial loss caused by the possible future occurrence of illness and the resultant medical care expense. The greater the aversion to risk, the more health insurance will be purchased to reduce the risk faced by the consumer. This reduced risk will increase his sense of well-being, and hence increase social well-being.

Increases in health insurance, however, also affect the allocation of health care resources. Cost sharing decreases the out-of-pocket price paid by the patient, which increases the amount of medical care demanded (moral hazard). Because consumers would not purchase this additional care if they had to pay its full cost, the extra services' value to consumers falls short of the social cost of producing that care. The larger the response to cost sharing, the greater the decrease in social well-being resulting from more health insurance.

Many believe that this trade-off is not appropriately balanced and that U.S. families are, in general, overinsured (Feldstein, 1973; Feldstein and Friedman, 1977). The tax subsidy to the purchase of health insurance is cited as a cause of the inappropriate trade-off (Pauly, 1986).[2] However, the best compromise between avoiding risk and providing incentives for consumers to be cost-conscious in the purchase of health care is unknown.

PAST STUDIES

The few studies on this trade-off have had to invoke varying assumptions about the degree of risk aversion and the price elasticity

[1]For this paper, we do not consider the use of insurance as a Pigouvian subsidy to correct for externalities or other market imperfections, or as a method for redistributing income. To the extent that such concerns require less cost sharing, our estimates below should be a lower bound on insurance generosity.

[2]The subsidy comes about because employer payments for insurance are not treated as employee income for tax purposes.

of health care demand. Feldstein and Friedman (1977) calculated the optimal coinsurance rate under varying assumptions about these parameters and investigated how changes in tax policy regarding employer-paid health insurance premiums affected the optimum. Uncertainty about the value of the key parameters, however, led to estimates of the optimal coinsurance rate that differed by 70 percent, even for a given tax policy. Using a similar range of assumptions about the degree of risk aversion and the price elasticity of health care demand, Feldstein (1973) estimated the welfare effects of increases in the coinsurance rate. Although his qualitative conclusion about the levels of insurance that would improve social welfare was insensitive to variations in the parameters, the gain's estimated magnitude was quite sensitive to these variations.

Since that time, analyses from the RAND Health Insurance Experiment (HIE), a randomized trial in health insurance, have reduced the uncertainty about the effect of insurance on the demand for health services (Newhouse, 1981; Newhouse et al., 1982; Keeler et al., 1982, 1988; Manning et al., 1987; Manning, forthcoming). However, few studies quantify how individuals value reductions in risk using data on individual preferences for health insurance. The only previous empirical estimates are Friedman's (1974), based on observed plan choices by federal employees, Marquis and Holmer's (1986); and van de Ven and van Praag's (1981). The latter two studies used responses to hypothetical plan options.

THE CURRENT STUDY

This study's purpose is to obtain estimates of both the demand for health insurance and the demand for health services—estimates that will allow us to assess the trade-off between risk sharing and incentives for overuse of health care. Our method differs from earlier work in that it uses consumer choice theory to integrate the demand for services ex post with the demand for insurance ex ante. Our approach to estimating how consumers value reductions in financial risk differs from that of Marquis and Holmer in that it assumes that utility is defined as a function of health (or health care) and other goods, rather than solely as a function of nonhealth consumption. Although the latter is a widely used and numerically much more tractable assumption, it is unnecessarily restrictive. Our approach differs from Friedman's in that we obtain estimates both of the losses from moral hazard and of risk aversion.

Our method differs from that of van de Ven and van Praag in several ways. First, we obtain a direct estimate of the demand for health services as a function of price (not just deductibles or coinsurance rates). Thus, we can obtain a direct estimate of the deadweight loss from moral hazard. Second, our estimation methods are inherently more robust than the adjusted tobit model used by van de Ven and van Praag. That model is known to behave very poorly in the face of even minor departures from the underlying assumptions (see Manning et al. [1986] and Duan et al. [1984, 1985]).

In this study, we use survey responses to hypothetical insurance offers collected as part of the HIE to estimate how much individuals are willing to pay to reduce the risk of health expenditures. We also obtain estimates of the effect of out-of-pocket costs on the demand for health services.[3] Our estimates provide the basic empirical building blocks for assessing the trade-off between the welfare gains due to risk sharing and the welfare loss due to moral hazard. Such information will aid in identifying problems of overinsurance and underinsurance and in designing appropriate policy responses.

Estimates of the welfare loss due to moral hazard are obtainable by using price elasticity estimates from several studies of the demand for medical care; see Newhouse (1981) for a review of that literature. With the exception of estimates based on the HIE, estimates of the price elasticity and the welfare losses from moral hazard may be too high because of possible adverse selection in nonexperimental insurance coverage—that is, more generous coverage will be confounded with sicker populations, leading to an overestimate of the price response. By using data from a randomized trial, we avoid this selection problem.

Estimates based on nonexperimental studies are also biased because they use price variables based on first- or last-dollar price or an average out-of-pocket cost measure (see Newhouse, Phelps, and Marquis [1980] for further details). By using information on coinsurance rates, deductibles, and upper limits on out-of-pocket expenditures, our methods yield consistent estimates of the demand for health care and for health insurance.

The next section describes the HIE and the data we use in this study. Section III summarizes the economic and statistical methods we employed. Section IV contains the results, and the final section discusses the implications of our empirical findings.

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[3]Earlier HIE-based estimates of this price response and of the welfare loss from moral hazard (Manning et al., 1987) rely either on a preliminary version of the model proposed here (Manning, forthcoming) or on the much more complicated episodic analysis (Keeler et al., 1982, 1988).

II. EXPERIMENTAL DESIGN AND DATA

DESIGN

The HIE was a randomized trial in alternative health insurance arrangements.[1] Between November 1974 and February 1977, the HIE enrolled families in six sites: Dayton, Ohio; Seattle, Washington; Fitchburg, Massachusetts; Franklin County, Massachusetts; Charleston, South Carolina; and Georgetown County, South Carolina.

Experimental Insurance Plans

Families participating in the experiment were randomly assigned to one of 14 different fee-for-service insurance plans.[2] The fee-for-service insurance plans had different levels of cost sharing that varied over two dimensions: the coinsurance rate, and an upper limit on out-of-pocket expenses. The coinsurance rates (percentage paid out of pocket) were 0, 25, 50, or 95 percent for all health services. Each plan had an upper limit (the maximum dollar expenditure, or MDE) on out-of-pocket expenses of 5, 10, or 15 percent of family income, up to a maximum of $1000 in then-current dollars (that is, unadjusted for inflation). Beyond the MDE, the insurance plan reimbursed all expenses in full. One plan had different coinsurance rates for inpatient and ambulatory medical services (25 percent) than for dental and ambulatory mental health services (50 percent). Finally, on one plan the families faced a 95 percent coinsurance rate for outpatient services, subject to a $150 annual limit on out-of-pocket expenses per person ($450 per family); in essence, this plan has an individual deductable.

For the analysis at hand, we use those plans in which each member of the family faced the same coinsurance rate (proportion of the bill paid out of pocket by the family) for all health services (including dental, medical, and mental health care), subject to an upper limit on fam-

[1]Newhouse (1974) and Brook et al. (1979) provide fuller descriptions of the design. Newhouse et al. (1979) discuss the measurement issues for the second generation of social experiments (to which the HIE belongs). Ware et al. (May 1980) discuss many aspects of data collection and measurement for health status.

[2]Use of medical services on the two prepaid group practice insurance plans are reported in Manning et al. (1984). Participants in these two plans are excluded from this analysis.

ily out-of-pocket expenses.[3] For the plans we examine here, the coinsurance rates vary from 25 to 95 percent; the MDE varies from 0 to 15 percent of income. See Newhouse (1974) and Newhouse et al. (1981) for further details. All plans covered the same wide variety of services.[4]

Families were enrolled as a unit, with only eligible members participating. No choice of plan was offered; the family could either accept the experimental plan or choose not to participate.[5]

We assigned families to treatments using the Finite Selection Model (Morris, 1979). This model is designed to achieve as much balance across plans as possible while retaining randomization—that is, it reduces correlation of the experimental treatments with health, demographic, and economic covariates.

Threats to Randomization

Two potential threats to the balance of health and other characteristics across the insurance plans exist: nonrandom refusal of the offer to participate, and nonrandom attrition from the study. Families were always better off financially for accepting the enrollment offer because of the lump-sum payment mentioned above. Moreover, because of a bonus for completion, they were always better off completing the study. Hence, there is a theoretical presumption of no bias from refusal or attrition.

Nevertheless, refusals of the plan offer varied from 6 percent on the free plan to 23 percent on the 95 percent coinsurance plans in the

---

[3]We exclude one free fee-for-service and two free health maintenance organization (HMO) plans, an individual deductible plan, and one plan with differing coinsurance rates for medical, dental, and mental health care. We exclude the free plans because they do not contain internal limits; the plan with different coinsurance rates for different services, because we want to keep the analysis tractable; and the individual deductible plan, because of the complex interplay of individual and family use in a plan with a deductible of $150 per person or $450 per family.

[4]See Clasquin (1973) for a discussion of the reasons for the HIE structure of benefits. Nonpreventive orthodontia and cosmetic surgery (not related to preexisting conditions) were not covered.

[5]To reduce refusals, families were given a lump-sum payment greater than the worst-case outcome in their experimental plans relative to their previous plan. The lump-sum payment was an unanticipated change in income and should negligibly affect the response to cost sharing. Manning et al. (forthcoming) show that these payments had no measurable effect. The family's nonexperimental coverage was maintained for the family by the HIE during the experimental period, with the benefits of the policy assigned to the HIE. If the family had no coverage, the HIE purchased a policy on its behalf. Thus, no family could become uninsurable as a result of participation in the study.

non-Dayton sites (see Brook et al., 1983).[6] Analysis of these refusals to participate indicate that the only significant difference between those people who accepted and those who rejected the offer was that the latter had lower education and income. Our analysis controls for income and education. We found no evidence that those who rejected the offer to participate were sicker, nor that there was an interaction between plan, sickness, and refusal of the offer.

Sample

The HIE sample was a random sample of each site's population, but the following groups of people were not eligible: those 62 years of age and older at the time of enrollment; those with incomes in excess of $25,000 in 1973 dollars (or $58,000 in 1984 dollars; this restriction excluded 3 percent of the families we contacted); those eligible for the Medicare disability program; those institutionalized for indefinite periods; those in the military, or their dependents; and veterans with service-connected disabilities. Table 2.1 gives the enrollment sample size for each plan in each site.

Table 2.1

ENROLLMENT SAMPLE

	Site						
Plan	Dayton	Seattle	Fitch-burg	Franklin County	Charles-ton	George-town County	Total
Free	301	431	241	297	264	359	1893
25 percent CR	260	253	125	152	146	201	1137
50 percent CR	191	0	56	58	26	52	383
95 percent CR	280	253	113	162	146	166	1120
Individual deductible	105	285	188	220	196	282	1276
Total	1137	1222	723	889	778	1060	5809

NOTE: CR = coinsurance rate.

[6]Data on refusals from Dayton are incomplete and hence have not been analyzed; the refusal of the enrollment offer across all plans in Dayton, however, was only 7 percent. Additionally, we have compared the group that enrolled on all plans with the group that completed baseline interviews but did not enroll. The only significant difference was that children are overrepresented by a modest amount in the group that enrolled (Morris, 1985). No significant preexperimental differences were found for self-reported use and health status (Morris, 1985). Our analysis explicitly controls for age.

We have included data on all families and individuals for the period during which they participated in the study for analysis of exceeding the MDE. However, for some parts of the analysis, we have excluded part-year individuals. Our demand model is basically a log model, which does not convolute. (For example, the sum of two log normal variables is not itself log normal.) However, given the attrition bias results mentioned above, we do not expect that the omission will introduce any appreciable bias.

We have included in the health services demand analysis all families and individuals for each full year they participated. We collected the data used to estimate the demand for health insurance (described below) at the end of a family's participation. For this analysis, therefore, we have included only those families who remained in the experiment for the entire period of participation. We also include only families in plans with a nonzero coinsurance rate, up to a family maximum; we exclude families enrolled in the free plan and the individual deductible plan. Table 2.2 provides the estimation sample sizes for the health care and insurance demand analyses.

DATA

Dependent Variables

We focus primarily on the use of health services, on whether a family exceeds the upper limit on out-of-pocket expenditures during the course of the year, and on responses to hypothetical questions about willingness to purchase supplemental insurance coverage.

Table 2.2

ESTIMATION SAMPLE

	Analyses			
	Health Care Demand		Health Insurance Demand	
Plan	Family-Years	Person-Years	Families	Observations[a]
25 percent CR	662	1852	214	968
50 percent CR	384	1113	135	592
95 percent CR	1085	3101	349	1518
Total	2131	6066	698	3078

NOTE: CR = coinsurance rate.

[a]In the health insurance demand analysis, we have multiple responses from each family head; these responses comprise the observations in the model.

Use of Health Services. The health services we consider include all inpatient services, all drugs and supplies, and all outpatient dental, medical, and mental health care.[7] We derived all the measures of health care use from claims data, which also permit us to know whether a family has exceeded its MDE.

Insurance Choice Data. Because the HIE randomly assigned families to experimental insurance plans, we cannot estimate risk aversion using actual choices of health insurance plans. Instead, we use data on families' preferences among a set of hypothetical insurance plans. At the end of the experiment, we presented each family (except for those on the free care plan) with hypothetical offers to purchase supplementary insurance to reduce the amount of their upper limit on out-of-pocket expenditures (that is, stop-loss) for its HIE insurance plan. The offers stipulated a premium the family would have to pay for the supplementary insurance; we asked the family whether it would buy the supplementary plan at the quoted premium. Each family received hypothetical offers to reduce the maximum by one-third, by two-thirds, and by 100 percent (full coverage). We worded the offers 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?

We designed an algorithm to generate premium quotes that were uniformly distributed on the interval ranging from 10 to 100 percent of the offered reduction in MDE.

Because our data consist of responses to hypothetical insurance offers, a question might arise as to whether the models to be estimated in this study would predict actual behavior. Studies in both the marketing and economic literature offer some indirect evidence that stated preferences do predict actual behavior (see, for example, Granbois and Summers [1975]; Wolf and Pohlman [1983]). Split-sample comparisons show the predictive validity of responses about hypothetical health insurance plan offers (Hershey et al., 1985). Early estimates of health insurance demand using the HIE hypothetical data produced estimates of the price elasticity of demand for health insurance that compared favorably with recent empirical studies that use actual health insurance plan choice data; see Marquis and Phelps (1987) and Marquis and Holmer (1986) for these comparisons.

[7]Expenditures include out-of-pocket payments and payments by the insurance carrier.

Finally, in a congressionally mandated study of the health care cost containment and tax revenue effects of flexible spending accounts (FSAs) (U.S. Department of Health and Human Services, 1985), the risk-aversion parameters estimated by Marquis and Holmer were used to predict the amount of employee contributions to FSAs. The predictions appeared valid in that they agreed with data on actual employee FSA contributions made available by a few employers offering FSAs.

Independent Variables

Our estimation controls for the coinsurance rate and the MDE for each insurance plan, for health status, for sociodemographic and economic measures, and for the families' own assessments of how much they expected to spend.

Insurance Plan Variables. Each insurance plan is represented by a coinsurance function and an MDE function (adjusted for inflation; see Sec. III for details).

Measures of Health Status. We use three measures of health status to increase the precision of our estimates of the consumption of medical services:

- The General Health Index (GHINDX) is a continuous score (0–100) based on 22 questionnaire items for individuals aged 14 and over and 7 items for children (aged less than 14). It measures perceptions of health at the present, in the past, and in the future; the items also measure resistance to illness and health worry. GHINDX refers to health in general and does not specify a particular component of health.[8]
- The physical—or role limitations—measure is scored dichotomously (PHYSLM: 1 = limited, 0 otherwise) to indicate the presence of one or more limitations due to poor health. It is based on 12 questionnaire items for adults and 5 items for children measuring four categories of limitations: self-care (eating, bathing, dressing); mobility (confined, or able to use public or private transportation); physical activity (walking, bending, lifting, stooping, climbing stairs, running); and usual role activities (work, home, school).[9]
- The Mental Health Inventory (MHI) for adults is a continuous score (0–100) based on 38 questionnaire items measuring both psychological distress and psychological well-being as reflected in anxiety, depression, behavioral and emotional control,

[8]Ware, 1976; Davies and Ware, 1981; and Eisen et al., 1980.

[9]Stewart et al. (1977, 1978, 1981a, 1981b), and Eisen et al. (1980).

general positive affect, and interpersonal ties.[10] A similar construct has been developed for children aged 5 to 13 based on 12 questionnaire items (Eisen et al., 1980).

Each measure is based on a self-administered Medical History Questionnaire for individuals 14 years or older. Measures for children are based on questionnaires filled out by parents.

Based on HIE analyses that indicate no effect of insurance plan on health status, we decided to use an individual's average health status over as many as six measurements rather than just the value at entry to the study. Averaging yields a more reliable assessment of health status because it reduces the fraction of total variance resulting from measurement error.

Anticipated Expenditures. A unique feature of the HIE data set is that it provides information about a family's anticipations of what its health care spending will be in the future. *Anticipated expenses* were asked about just prior to enrollment in the study and at the study's conclusion.[11] The question was asked for each family member; answers were given in one of 11 fixed-interval categories.

We converted the response for each person into a dollar figure by calculating HIE participants' mean observed expenditures on the 25 percent coinsurance plan whose observed expenditures were in each of the 11 intervals. We calculated the interval means for subgroups of individuals defined on the basis of site, age (younger than age 18, 18 or older), and single individual versus family (if age 18 or older). We then assigned the subgroup observed mean for an interval to an individual with the same demographic characteristics who anticipated expenditures in that interval. Finally, we summed individual anticipated expenditures to obtain a family measure of anticipated expenses.

The measure of anticipations we use in the demand model is the residual from a regression of the log of anticipations on all other measures in the demand model. Thus, the measure reflects what is known to the family about its health care needs that we cannot predict based on observable site, demographic, health status, and other characteristics. Thus, by construction, this measure of unexplainable anticipated expenditures is uncorrelated with age, sex, income, health status, and other observed characteristics.

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[10]Veit and Ware (1983); Ware et al. (1979, May 1980; November 1980); and Williams et al. (1981).

[11]The anticipated expense question was: "Of course, nobody knows for sure 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."

Other Covariates. The model includes covariates for age, sex, race, family income, and family size. With the exception of family size and income, the data were collected before or at enrollment in the study. The value for family size varies by year. Family income is the value for the preceding calendar year; this value was the one used in computing the MDE.

Unit of Analysis. The unit of analysis is a family-year for the question of exceeding the MDE; for the hypotheticals and demand for insurance, the family. We use the year as the time frame because the upper limit on out-of-pocket expenses is annual. We use the family as the unit of observation because exceeding the MDE depends on the sum of health expenditures for all family members—and because the hypothetical insurance plan would cover all members.

III. ECONOMIC AND STATISTICAL METHODS

To examine the trade-off between the benefits from risk pooling and the losses from moral hazard, we must estimate the demand for health services and the demand for health insurance as functions of coinsurance rates, deductibles, and upper limits on out-of-pocket expenditures (such as the HIE's MDE). Estimates of these demand functions are recoverable from HIE claims data on the use of health services and the likelihood of exceeding the MDE, and from the responses to questions about supplementing insurance.

We rely on the economic proposition that choices about consumption of health services depend on the same variables and parameters as do choices about insurance. The only major difference between the demand for health insurance and the demand for health services is that the choice of insurance is made *before* uncertainties are resolved, while choice about consumption tends to be made *after* major uncertainties are resolved. For example, a person buys health insurance to protect against the financial consequence of a possible future illness, but the purchase of health care services occurs after the illness occurs.[1]

We can easily see this difference if we use the indirect utility (IU) function. The indirect utility function is the maximum utility possible for a given set of prices and income.[2] The demand function for health services is derivable from the indirect utility function by Roy's Identity. The demand function is the negative of the partial derivative of the indirect utility function with respect to the out-of-pocket price of health care divided by the partial with respect to income (net of any insurance premiums) (Roy, 1947; Hausman, 1981).

The demand for health insurance depends on the expected indirect utility (EIU) function. The expected indirect utility is just the expected value of the indirect utility function over various states, sick and well, where the indirect utility for each state is weighted by its probability of occurring. A consumer will purchase an insurance policy if its expected indirect utility exceeds that of the next-best policy. For example, the consumer will select a simple deductible plan over no insurance if the expected utility is higher with the purchase. The consumer pays a premium if insurance is purchased, whether or not he is sick. But if he is sick enough to have medical expenditures in excess

[1]This simple example ignores any residual uncertainty about the illness' extent.

[2]Including the effect of factors, such as health status, which may affect the consumer's welfare.

of the deductible, he will pay less out of pocket for medical care if he is insured. If the consumer is risk averse, he will be willing to pay more than the actuarially fair price for a policy in order to avoid the risk of a larger loss.

Thus, the demand for insurance is based on the maximization of the indirect utility function ex ante—before the consumer knows whether he will be sick or well. Once the consumer knows whether he is sick or well, he selects the demand for health services that maximizes his satisfaction ex post. Except for the questions of risk versus certainty and of which insurance policy the consumer is facing, we are dealing with the same indirect utility function.[3]

Next we will describe the steps in the estimation process, then we will discuss problems and limitations in the proposed approach.

THE THEORETICAL MODEL

The general approach is to use the data on the use of health services and the likelihood of exceeding the MDE to estimate the demand for health services. We do this by using the indirect utility function (that is, the maximum utility possible for given prices and income). This analysis of exceeding the MDE yields estimates of the indirect utility function that are valid up to a monotonic transformation. We use the answers to the insurance hypotheticals about supplementation to estimate the risk-aversion parameters, given the parameter estimates for the demand for health care from the analysis of decisions about exceeding the MDE.

Below, *ex ante* refers to the demand for health insurance, while *ex post* refers to the observed demand for health care.

Step 1. Estimating the Demand for Health Services. Estimating the demand for health services is more complicated than is estimating the demand for many commodities. Individuals do not face a constant out-of-pocket price for health care. Typically, the more they use, the less they pay for each new unit of service because they will exceed deductibles and upper limits on out-of-pocket expenses. Estimating demand as a function of average out-of-pocket price, first-dollar price, or last-dollar price will yield biased estimates of the price response (Keeler, Newhouse, and Phelps, 1977; Newhouse, Phelps, and Marquis, 1980; Taylor, 1975). However, we can obtain consistent estimates of the price response and the demand function by using either the episodic model developed by Keeler et al. (1982, 1988) or the

[3]Technically, we need only a monotonic transformation of the same indirect utility function for the ex post demand analysis for health care.

indirect utility approach, then estimating the price response from the likelihood of exceeding the MDE. This was our approach.

To illustrate the proposed method, we will use the specific indirect utility function that corresponds to a demand function with constant price and income elasticities.[4] Assume that the indirect utility function for x (health care) and all other goods as a composite (g) is:

$$IU = -p^{\alpha}e^{z\beta + \theta} + I^{\delta}, \tag{1}$$

where p is the price of x, the price of g is normalized to 1, I is income, z includes observed patient characteristics, and θ is an unobserved error. For what follows, we will treat θ as stochastic.[5]

If we treat the decision to exceed the MDE as occurring after the patient knows the state of the world, we can simplify the modeling tremendously.[6] The patient exceeds the MDE if his overall utility is higher with the lower price, after paying a lump sum amount equal to the MDE. The patient exceeds the MDE if an index function, obtained by subtracting the indirect utility from being under the MDE with price p and income I from the indirect utility when the MDE is exceeded with price 0 and income I - MDE, exceeds zero.[7] That is, the patient exceeds the MDE if

$$\alpha\, \ell n(p) + z\beta - \delta\, \ell nI - \ell n\delta - \ell n(MDE/I) + \theta > 0. \tag{2}$$

See App. A for a derivation based on Manning (forthcoming). Equation 2 is equivalent to a probit regression model if the unobserved error term θ is normally distributed.

The corresponding demand function for health care (x), derived by Roy's Identity, is:

$$\ell n(x) = (\alpha - 1)\, \ell n(p) + (1 - \delta)\ell n(I) + z\beta + \theta. \tag{3}$$

[4]More general utility functions can be estimated using the over-the-MDE—or Burtless and Hausman's—methodology without altering the qualitative patterns. In the current analysis, we also allowed the price elasticity to vary with income, health status, and other covariates, but we could not detect a statistically significant departure from the model underlying Eq. 1.

[5]Health care is of direct utility here, rather than an intermediate good. This assumption can be relaxed to include the usual household production function approach.

[6]We avoid the complicated decision making as people find out whether they are sick or not and how costly an illness will be. Such a process requires a dynamic programming model, such as the within-the-year episodes model (Keeler et al., 1982, 1988). Because the work by Manning (forthcoming) agrees closely with price estimates based on the episodic model, we feel this assumption is relatively innocuous.

[7]There is no premium adjustment because HIE participants paid no premium.

Consistent estimates of δ, θ, β, and α are obtainable by the over-the-MDE approach or the Burtless and Hausman (1978) method using a parametric assumption (for example, assume θ is normally distributed), or a nonparametric approach (for more on the latter, see below).

Although the individual faces a nonlinear budget constraint, this approach allows us to avoid the inconsistent estimates that would result from looking at demand for health care directly as a function of ex ante, ex post, or average price. The price and income parameters α and δ in our model can be consistently estimated because the relevant explanatory variables—the price, coinsurance rate, income, and MDE—are exogenous and economic theory provides the direct link between exceeding the MDE and demand for health care.

Note that our method only needs to estimate the indirect utility function up to a monotonic transformation. Thus, it can use any specification that fits the over-the-MDE response without worrying about risk aversion (that is, curvature in the overall level of utility). This is a critical difference between using only ex post and using both ex ante and ex post data. With only ex post data, the appropriate monotonic transformation of Eq. 1 is underidentified.

Step 2. Estimating θ. Once these parameters are estimated, we can use the method described in App. A to derive the demand equation (Eq. 3), as well as estimates of θ. Thus, we have consistent estimates of each consumer's IU function and of the distribution of θ.

We use the responses about anticipated expenditures to provide us with a proxy for the systematic part of expenditures that the consumer knows. After controlling for anticipated expenditures and other covariates, the residual unexplained variation in use is arguably unexpected by the consumer.

Step 3. Estimating the Risk-Aversion Parameters. Once we know the indirect utility function, we can use the insurance hypotheticals to estimate the risk-aversion parameters—that is, the transformation IUTRUE = g(IU). For expositional simplicity, let us assume that there are two states of the world, $\theta 1$ and $\theta 2$, which correspond to being below (state 1) or above a hypothetical MDE (state 2). These states have probabilities $(1 - \gamma)$ and γ, respectively.[8]

The insurance hypotheticals involved choices between the experimental insurance plan and alternative upper limits on out-of-pocket expenses (MDEs), including full coverage (a plan with an out-of-pocket

[8]With a continuous distribution of θ rather than a two-state world, there is a probability density distribution associated with the θ, and the probability of being below the MDE is the cumulative distribution at a critical threshold $\theta 1$.

limit of zero). The example below is between an insurance plan with a catastrophic limit and full coverage.[9]

With an experimental catastrophic plan with coinsurance 1 up to the MDE and 0 afterwards,[10] the expected utility is

$$E(IU)_{BASE} = (1 - \gamma)g\{[\ -p^{\alpha}e^{\theta 1} + (I)^{\delta}]\}$$

$$+ \gamma\, g\{[(I - MDE)^{\delta}\}. \tag{4}$$

For full coverage with a given premium π, the expected indirect utility is

$$E(IU)_{FULL} = g[(I - \pi)^{\delta}]. \tag{5}$$

From the first two steps, we have consistent estimates of α, δ, $\theta 1$, $\theta 2$, and hence of γ. The consumer will choose the hypothetical insurance policy over the experimental insurance plan for a given π if

$$E[g(IU)]_{FULL} - E[g(IU)]_{BASE} > 0. \tag{6}$$

For specific functional forms, we use

$$g(IU) = (IU)^{\psi}. \tag{7}$$

To estimate ψ from the responses to the hypothetical plan offers, we first take repeated drawings of θ for each family to generate the distribution of risks the family faces. The θs come from a standard normal distribution with mean zero and with standard deviation given by the negative of the inverse of the coefficient on MDE/I from the health services demand model (see App. A). For each realization of θ, we calculate the indirect utility associated with the risk if the family does not purchase the offered hypothetical supplement. Similarly, we calculate the indirect utility associated with each risk outcome if the hypothetical offer to lower the MDE is purchased at the quoted premium. Let h be the family's response to the hypothetical offer, where h is one if the family responds that it would purchase the plan and h is zero if not. Then, we estimate the transformation parameter ψ by fitting the model:

$$P(h = 1) = G\{\Omega[E(IU^{\psi}_{FULL}) - E(IU^{\psi}_{BASE})]\}, \tag{8}$$

[9]The example is simpler than the choice in the hypotheticals, but there is no loss of generality from using the simpler example.

[10]The experimental plans did not have a family-paid premium.

where E denotes the expectation over the risks, G is a specified link function that we discuss below, and Ω is a scaling constant to be estimated.

Step 4. Estimating the Risk Premium. The premium π that makes the consumer indifferent between the experimental insurance plan and any alternative or base plan is the value for which

$$E(IU^{\psi}_{FULL}) = E(IU^{\psi}_{BASE}). \tag{9}$$

The results for the transformation function g in Eq. 7 and the demand results now allow us to calculate this premium. To calculate the premium, we again use simulation methods, taking 25 draws of θ to determine the distribution of risks facing the family. Given this distribution, we calculate the expected indirect utility for a base insurance plan and the premium that equates this expected utility with expected indirect utility for a full coverage plan.

The difference between this premium and the expected reduction in the family's out-of-pocket expenditure is the risk premium—the amount a family is willing to pay to eliminate the out-of-pocket cost it faces under the base plan. Given the distribution of θ for the family, we calculated the expected out-of-pocket expenditure given the base plan by using the demand equation in Eq. 3.

Once we have estimates of the parameters, we can evaluate the trade-off between the gains from risk sharing and losses from moral hazard. Assuming that the premiums are set on an actuarially fair basis, we can use the expected indirect utility function to evaluate various insurance alternatives. These include the net gains from a policy with various catastrophic caps on out-of-pocket expenditures, the net gains from lowering coinsurance rates, and the net gains from imposing deductibles.

Each of these alternatives can be set up as a standard optimization problem. Steps 3 and 4 (above) provide a prototype, except that we would now use the parameter estimates that answer the yes/no decision in Eq. 6 to rank the alternatives.

ESTIMATION TECHNIQUES

We use two estimation approaches: nonparametric, to check the sensitivity of the results to distributional assumptions; and parametric, to avoid the precision loss common to nonparametric approaches. We use a normal assumption on the distribution of θ, which yields estimates of health care demand through a probit regression for exceeding

the MDE. That approach yields estimates quite similar to the results for the price response using the Keeler et al. (1982, 1988) episodic approach. Following Marquis and Holmer (1986), we estimate Eq. 8 assuming that G is the standard normal cumulative distribution function.

Specifying the distribution in a maximum likelihood estimator (MLE) incorrectly can cause inconsistent estimates. To check the robustness of our estimates, we could use either Cosslett's (1983) nonparametric approach or Duan and Li's (in press) slicing regression as alternatives for both the over-the-MDE decision and the response to the hypotheticals. We use the latter approach because it collapses to the case of discriminant analysis in the dichotomous case, which has less restrictive assumptions and less expensive software than does Cosslett's.

We use limited information maximum likelihood (LIML) and other single-equation techniques rather than full information maximum likelihood (FIML) on the whole system of equations for the demand for health insurance and for health care. If we treat the decision to exceed the MDE as occurring after the patient knows the state of the world, Manning (forthcoming) shows that we can estimate α, δ, and θ simply by observing whether the family exceeds the MDE, without observing how much family health care it uses. If θ is normally distributed, a probit regression for exceeding the MDE yields the necessary parameter estimates.

ALTERNATIVE APPROACHES

In principle, we could use the information about how much families consume above or below the MDE to obtain more precise estimates if we knew the distribution for θ; this is the Burtless and Hausman (1978) FIML approach. However, the additional precision would come at the cost of a much more costly, complicated, and possibly inconsistent method. Consistency requires knowledge of the joint error distribution. Incorrect specification of the distribution function can cause inconsistent parameter estimates. From the work of Manning et al. (1981, 1987) and Duan et al. (1983, 1984), we know that certain normal theory methods are inappropriate for the demand for medical care. We know of no other alternative parametric distributions that are appropriate for health care demand.

Our sequential LIML approach allows us to relax the distributional assumptions to the point of nonparametric estimation, if need be.[11] In particular, we can avoid the inconsistency in FIML that results from having the wrong assumption about tail probabilities. Given the lack of robustness of normal theory MLEs and the lack of normality for medical expenditures, we would have little faith in the results of methods such as Burtless and Hausman's (1978) for this application.

We correct the inference statistics for intrafamily and intertemporal correlation. For parametric approaches, we can use available software for the probit based on Huber's (1967) approach for the nonparametric estimates. In either case, the estimates are inefficient, but the inference statistics are correct.

[11]However, using a sequential approach raises the problem that the inference statistics in the final steps will be incorrect.

IV. RESULTS

DEMAND FOR HEALTH CARE

Estimates

We estimated the demand for health care by determining which characteristics influence the probability of exceeding the MDE. Table 4.1 contains the parameter estimates for the major economic variables in health care demand; for the full set of parameter estimates, see App. B. The "coefficient" column is the probit regression estimate for exceeding the MDE.[1] Dividing the probit coefficients by the coefficient of ℓn (MDE/INC) yields the demand for health care parameters.

The estimated coefficients for exceeding the MDE are of the expected sign, once we allow for the implicit reversal of signs (that is, the price parameter for exceeding the MDE is positive and the corresponding demand parameter is negative).

Demand is significantly related to both price and income. The demand is both price and income inelastic, with elasticities of −0.18 and +0.22, respectively. The price elasticity estimate is consistent with those found by Keeler et al. (1988) using episodes to model decisions about purchasing health care as the price varies within the year; those estimates are also based on the HIE data.

We checked the model for goodness of fit—whether the predicted probability of exceeding the MDE closely tracks the average probability as price, income, family size, or health status change. If the model had been specified incorrectly, we could reach the wrong conclusion about demand elasticities and cause misestimates in the risk aversion parameter. As the results in App. B indicate, the specification of the indirect utility function used here fits the data quite well.

Nonparametric Results

The parameter estimates above assume that the unobserved shift parameter in the indirect utility function follows a normal distribution. To check the sensitivity of our results to this assumption, we used

[1]Unless the variance of the error term or some other parameter is known a priori, a probit regression is underidentified. One can only estimate the ratio of the coefficients to σ. In this case, however, the coefficient of ℓn (MDE/INC) is known to be one, to a first order approximation. Hence, all the parameters are identified. (See App. A for details.)

Table 4.1

ESTIMATES OF EXCEEDING THE MDE AND CORRESPONDING DEMAND FOR HEALTH CARE

	Probit for Exceeding MDE			
Variable	Coefficient	Standard Error	t	Log Demand Parameter
LN(FAM)	.53750	.09949	5.40	0.7426
LN(PRICE)	.59454	.06738	8.82	−0.1786
LN(INCOME)	−.56795	.05342	−10.63	0.2153
LN(MDE/INC)	−.72380	.1035	−6.99	(a)
LN(ANT. EXP.)	.18893	.03696	5.11	0.2610

NOTES: MDE = maximum dollar expenditure; LN = log; FAM = family size; INC = family income; ANT. EXP. = anticipated expenditures (net of other factors). The coefficient for LN(PRICE) in the probit equation is the estimate of α/σ where σ is the standard deviation of θ in Eq. 2. In the demand equation, it is the estimate of α in Eq. 3.

[a]Not applicable.

discriminant analysis as a nonparametric alternative to the probit.[2] Although the discriminant estimates were similar to the probit ones, the nonparametric results are slightly more price-elastic demand estimates. The value for the price elasticity obtained from the discriminant function is −0.23, in contrast to the −0.18 estimate from the probit. The estimated income elasticities were also quite similar. The estimate is 0.22 using the probit results and 0.19 using the discriminant function.

DEMAND FOR HEALTH INSURANCE

Expected Utility Model Estimates

Using the estimated parameters of the indirect utility function and the responses to the hypothetical questions, we can estimate how risk-averse the HIE participants were. Specifically, we estimate a power transformation of the indirect utility function that maximizes the likelihood for accepting the hypothetical offer for supplementation. If the error term in Eq. 8 is normally distributed, then the model becomes a standard probit model for a known power transformation, ψ. We obtained estimates of Ω and ψ by repeated estimation of the probit

[2]See App. B for both the probit and discriminant estimates.

model using a grid search over ψ. The estimate of ψ is 0.425 ($\chi^2 = 14.0$) and of Ω is 6.583 ($t = -10.84$).[3]

We can use the expected (transformed) indirect utility function to estimate the price and income elasticities of the demand for health insurance. The implied price elasticity is –0.54.[4] This estimate is comparable to recent estimates in the literature that range from –0.16 to –0.41 (Holmer, 1984; Taylor and Wilensky, 1983; Farley and Wilensky, 1986).[5] Our estimate of the income elasticity is 0.07, which indicates that families exhibit constant absolute risk aversion in income. In contrast, the recent literature has yielded estimates of income elasticity of about 0.01 to 0.04, also showing constant absolute risk aversion.

The Pratt risk-aversion measure obtained from the transformed indirect utility function is .00052 in 1982 dollars.[6] In contrast, Marquis and Holmer (1986), using these same hypothetical insurance data, and Friedman (1974), using health plan choices by federal employees, estimated risk aversion in 1982 dollars to be .00113 and .00094, respectively. However, our method improves over these earlier studies by including the value of medical care purchases in the consumer's utility; part of what families are willing to pay for the insurance is attributable to the value of the additional medical care they will consume with insurance, and part is attributable to the financial risk avoided. In the earlier work, however, the value of the insurance is entirely attributed to the risk avoided. Thus, that our estimate of risk aversion is smaller than estimates from the earlier studies is not surprising.

Two Alternatives to the Expected Utility Model

A Modified Expected Utility Model. In comparing the estimated expected utility model predictions with the actual responses to the hypothetical offers, we observed a bias in our average prediction. This bias comes about because we suppress the intercept term in estimating

[3]For the power, the test is against $\psi = 1$. With this transform, the risk-aversion parameter is close to zero and so is essentially a risk-neutral estimate (in September 1988 dollars, the risk-aversion measure is .00002 if $\psi = 1$).

[4]The elasticity is for the change in the probability of purchasing insurance evaluated assuming a plan with 100 percent coinsurance up to a maximum out-of-pocket expenditure of $1250 (in September 1988 dollars), a premium of $615, and the average value of family demographic characteristics.

[5]However, earlier cross-section data (Phelps, 1973; Goldstein and Pauly, 1976) and time-series data (Long and Scott, 1982; Woodbury, 1983) have produced larger (in absolute values) estimates of the price elasticity of insurance demand. See Marquis, Kanouse, and Brodsley (1985) and Pauly (1986) for a summary of the available estimates.

[6]The degree of risk aversion is measured by $-u_{yy}/u_y$, where u_y is the marginal utility of income.

the probit model, as shown in Eq. 8. We do this because we would theoretically expect that as the baseline coverage approached full coverage, the premium families would pay to eliminate the remaining risk would approach zero (that is, the premium that would yield a purchase probability of 50 percent [indifference] would approach zero as the baseline coverage approaches full coverage).

However, families' responses to the hypothetical offers showed a tendency to purchase any insurance coverage whenever the premium was low, irrespective of whether the purchase is a "good buy," perhaps because some information cost is associated with evaluating the options. Or perhaps families want full coverage to avoid the psychic costs associated with having to make trade-offs between health care and money (Thaler, 1980). We can estimate the magnitude of this transaction cost by including an intercept term in fitting the probit model. In this model, the estimate of ψ is 0.75 (chi-square is 4.8); of Ω, 0.445 ($t = 11.12$); and of the intercept, 0.334 ($t = 8.77$).[7] The transaction cost implied by the model is $215 on average (September 1988 dollars).[8] This model yields a price elasticity of –0.43 and an income elasticity of 0.10—again, estimates comparable to other estimates in the literature. The implied risk aversion is .0003 (about half as large as our earlier estimate).

An Empirical Model. Our estimation of the risk-parameter in the expected utility model draws on the theoretically close link between the choice about health care consumption and demand for health insurance. The former choice is made to maximize utility once the illness level is known, while the latter is made before the illness level is known. In selecting health insurance coverage, the consumer is assumed to maximize expected utility, taking into account the uncertain distribution of possible illness levels that might occur. In each case, however, the consumer is dealing with the same utility function.

As one test of whether families behave in the way economic theory suggests, we have also fitted a probit model of the demand for health insurance services using the demographic and economic characteristics included in the estimation of the demand for health services model, but without imposing the form of the indirect utility function. The coefficient estimates for the empirical model can be found in App. B.

We compare the two variants of the "theoretical" model and the "empirical" model using the Akaike Information Criterion (AIC).[9] For

[7]The chi-square tests ψ versus 1.

[8]Calculated as the risk premium families are willing to pay to eliminate a $10 MDE.

[9]The AIC is given by $-l + K$, where l is the log likelihood and K is the number of estimated parameters (Akaike, 1973). One chooses the model with the lower AIC.

the first—or "pure" variant of the expected utility model, the AIC is 1978.7; the second—or "modified" model, which incorporates an intercept, has an AIC of 1880.6.[10] For the empirical model, the AIC is 1724.7, which is a significant improvement over either of the expected utility models given the form of the IU function our estimation uses.

Figures 4.1–4.4 illustrate the differences among the models. Figure 4.1 shows how the probability of purchasing a full supplementary insurance plan changes as the premium that the family will incur by buying the plan varies.[11] In the modified version of the expected utility model costs, purchase probabilities are slightly less responsive to changes in the premium because of the fixed cost of acquiring information. The empirical model shows that families' responses to the hypothetical offers are even more responsive to changes in premiums than the theoretical models predict. In contrast, the empirical model suggests that demand is less responsive to changes in the expected

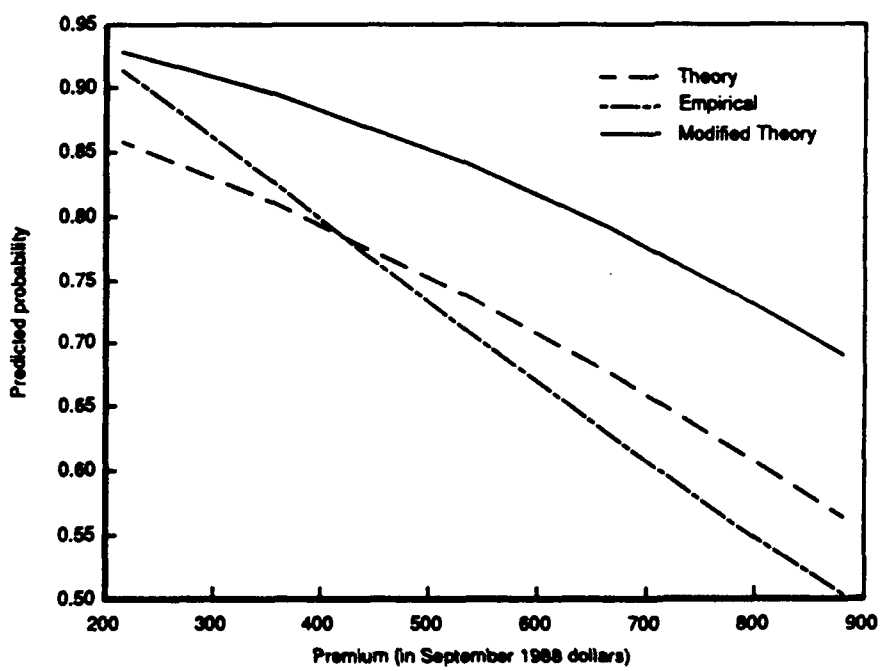

Fig. 4.1—Predicted purchase probabilities as premiums vary

[10]Thus, the modified expected utility model provides a significantly superior fit to the data. However, the elasticities are quite similar to those implied in the pure variant.

[11]The predictions assume a base plan with a 100 percent coinsurance to an MDE of $500 and a family with average values on the other characteristics.

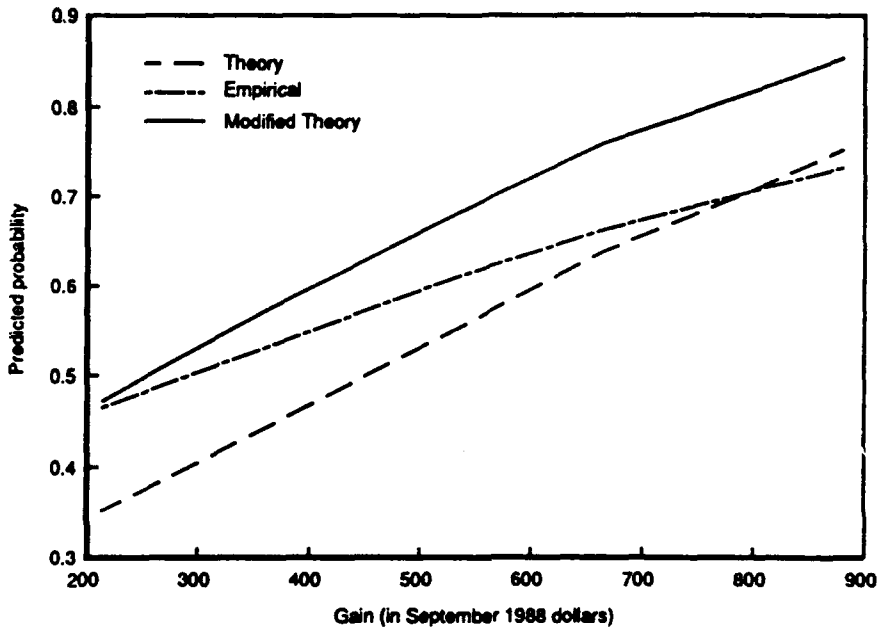

Fig. 4.2—Predicted purchase probabilities as gains vary

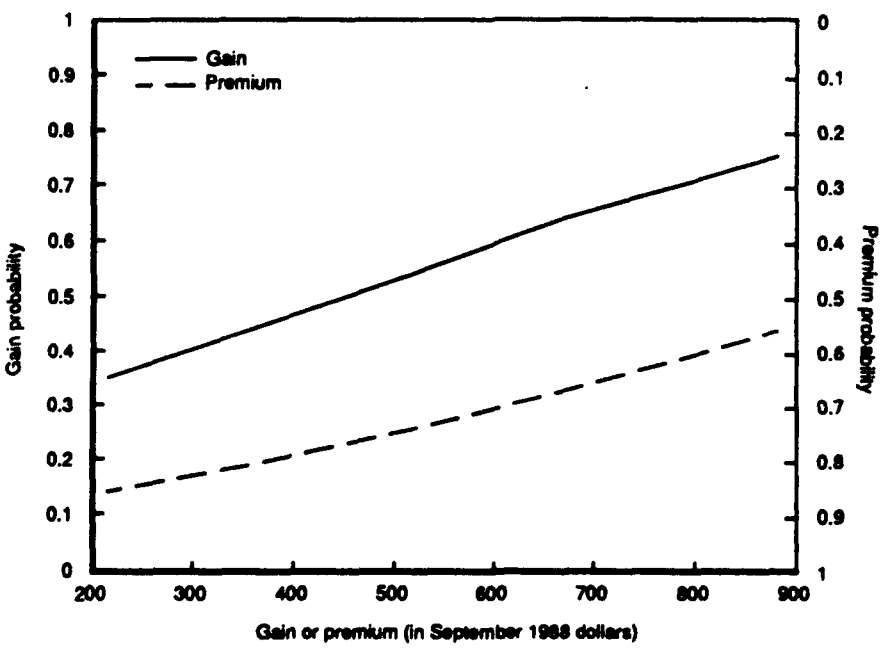

Fig. 4.3—Predicted probabilities: theory model

supplementary purchase than in response to the gain. This latter finding is particularly interesting in that it supports a hypothesis advanced by Kahneman and Tversky (1979) in presenting their "prospect" theory of decision making under uncertainty—namely, that losses loom larger than gains, and so increases in the size of losses (in our case the premium) have a bigger effect on behavior than does an equivalent size gain.

This result is also consistent with prospect theory's hypothesis that certain outcomes weigh more heavily in decision making than do equivalent outcomes that are uncertain. In our data, the losses or premiums are the certain outcomes, whereas the gains or expected reductions in out-of-pocket expenditures are the uncertain outcomes. With these data, we cannot determine whether the result stems from the certainty effect or from the overweighting of losses.

We also explored these differences in the response to changes in the gains and losses in a probit model to explain the responses to the hypothetical offers. The model included the expected utility index, log of the quoted premium, and log of the offered reduction in the MDE. The coefficient on the quoted premium in this regression was negative and statistically significant ($t = -5.3$), indicating that the expected utility index does not fully capture the effect of premium changes on the reported likelihood of purchasing the supplementary plan. The coefficient of the change in MDE was positive but not statistically significant ($t = 1.2$).

Robustness

We used discriminant analysis as a nonparametric alternative to test our results' sensitivity to the assumption of a normal error in both the theoretical and empirical models of the demand for health insurance. In both versions of the model, the discriminant function estimates produced results that were very similar to the probit results.

In the "pure" expected utility theory version of the insurance demand, the discriminant function estimate of ψ was 0.5, versus 0.425 using the probit. The transformations, however, yield estimates of the premiums families would pay that are almost identical.[13]

For the empirical version of the insurance demand, the discriminant function resulted in a slightly more elastic estimate of the response to

[13]The risk premiums are somewhat larger when we specify a fully nonparametric alternative using the discriminant estimates of the utility function from the analysis of exceeding the MDE. In the nonparametric case, the estimate of ψ is 0.65. Offsetting this increase in the risk premium is an increase in the estimates of the deadweight losses from moral hazard. The net effect is that the estimated nonparametric optimal coinsurance rate is negligibly different from the parametric estimate.

changes in the premium and policy characteristics than did the probit version of the empirical model. For example, the discriminant function produced a premium elasticity of –1.0, versus –0.76 in the probit. The MDE and coinsurance elasticities in the two were the same.

EVALUATING ALTERNATIVE INSURANCE PLANS

Using the estimated demand function for health care (Eq. 3) based on the probit, we can calculate the expenditures for health care and the associated deadweight loss. Using the probit estimates of the demand function for health insurance based on the expected utility theory model, we can calculate the pure risk premium (the amount families would pay in excess of an actuarially fair insurance premium) for each alternative. We make these calculations for all families still present at the end of their period of participation in the experiment. We refer to this group as the reference population, and we shall use the same population to make predictions based on the health insurance demand results. The loss calculations are exact, using the compensating variation (Hausman, 1981) rather than the more commonly used measures based on consumer's surplus or Harberger's triangle rule. Table 4.2 gives the deadweight loss, risk gain, and net gain for the average family (not the average person) in September 1988 dollars for pure coinsurance plans of 1 percent, 25 percent, 50 percent, and 100 percent. Table 4.3 gives the corresponding numbers for plans with first-dollar coverage (that is, with coinsurance rates) of 0, 25, 50, or 100 percent, followed by a stop-loss of $1250, $2500, or $5000 per year on out-of-pocket expenses.[14]

Table 4.2

DEADWEIGHT LOSS AND RISK GAINS FOR ALTERNATIVE COINSURANCE PLANS

Coinsurance (Percent)	Waste	Risk Premium	Risk Gain	Net Gain
100	0	706	0	0
75	13	541	165	152
50	65	223	483	418
25	220	134	572	352
1	1596	0	706	–890

NOTES: Risk gain is relative to no insurance. Amounts in September 1988 dollars.

[14]For each family-year in the estimation sample for the demand for health care, we drew a random normal number with mean zero and standard deviation corresponding to the LN(MDE/INC) term in Table 4.1. Unlike the HIE, whose out-of-pocket costs are

In each table, we show the waste (deadweight loss) from moral hazard, the risk premium the consumers would be willing to pay to reduce their financial risk to this coverage from no insurance, and the risk gain over no insurance (= risk premium under full coverage - risk premium at this coverage).

The results for pure coinsurance plans—plans with no stop-loss—indicate that increases in insurance generosity through lower coinsurance rates have a modest effect on total demand. Gross expenditures are 28 percent higher with a 25 percent plan than with no insurance, and the deadweight loss is 12 percent of total expenditures. If we were to extrapolate beyond the range of the estimation sample to

Table 4.3

WASTE AND RISK FOR ALTERNATIVE COINSURANCE: STOP-LOSS PLANS

Coinsurance Rate (Percent)	Stop-Loss	Deadweight Loss	Risk Premium	Risk Gain	Net Gain
100	0	1596	0	706	-890
	1250	1346	67	639	-707
	2500	1096	137	569	-527
	5000	778	242	464	-314
	infinite	0	706	0	0
50	0	1596	0	706	-890
	1250	1180	57	649	-531
	2500	860	100	606	-254
	5000	555	144	562	7
	infinite	65	223	483	418
25	0	1596	0	706	-890
	1250	975	55	651	-324
	2500	709	79	627	- 82
	5000	487	101	605	118
	infinite	220	134	572	352
0	0	1596	0	706	-890

NOTE: Amounts are in September 1988 dollars.

limited to at most 15 percent of income, the predicted out-of-pocket costs on the prototype pure coinsurance and stop-loss plans could exceed family income. We assume that if the out-of-pocket costs with no insurance exceeds family income, the family is fully covered by a public insurance plan such as Medicaid. Such families were deleted from both Tables 4.2 and 4.3. Given the price elasticity of demand, such families were also excluded from the partial-pay plans. A total of 40 family-years out of 2131 were deleted.

a 1 percent coinsurance plan,[15] the total expenditures would be 2.3 times as high as with no insurance; the deadweight loss would be 48 percent of total expenses.

As Table 4.3 indicates, introducing only a stop-loss[16] of as much as $5000 (in September 1988 dollars) can generate substantial increases in both expenditures and deadweight losses. For a $5000 stop-loss, expenditures increase by 68 percent over expenditures with no insurance, the deadweight loss is 36 percent of total expenditure. Reductions in the stop-loss generate further losses.

The magnitude of the deadweight loss may seem surprising at first. On the HIE, individuals with the 10 percent highest expenses accounted for half of total expenditures. For a $5000 stop-loss, we predict that approximately 9 percent of the families will exceed their stop-loss and face no out-of-pocket cost at the margin.

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[15]Our functional form for the demand curve yields an infinite demand at free care. With data only on pay plans, we cannot discriminate among alternative specifications that have finite demands when the out-of-pocket price is zero. Instead, we approximate such a free care plan by the demand under a 1 percent coinsurance rate. Note that our forecast at 1 percent is very close to the one Keeler et al. (1988) obtained for free care using an episodes model.

[16]With no first dollar coverage (that is, the coinsurance rate = 100 percent).

a 1 percent coinsurance plan,[15] the total expenditures would be 2.3 times as high as with no insurance; the deadweight loss would be 48 percent of total expenses.

As Table 4.3 indicates, introducing only a stop-loss[16] of as much as $5000 (in September 1988 dollars) can generate substantial increases in both expenditures and deadweight losses. For a $5000 stop-loss, expenditures increase by 68 percent over expenditures with no insurance. the deadweight loss is 36 percent of total expenditure. Reductions in the stop-loss generate further losses.

The magnitude of the deadweight loss may seem surprising at first. On the HIE, individuals with the 10 percent highest expenses accounted for half of total expenditures. For a $5000 stop-loss, we predict that approximately 9 percent of the families will exceed their stop-loss and face no out-of-pocket cost at the margin.

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V. DISCUSSION

The choice of an economically optimal health insurance plan involves a trade-off between the utility gains from a reduction in the risks born by individuals and the deadweight losses from the purchase of too much health care (Arrow, 1963, 1971, 1973, 1976; Zeckhauser, 1970). In this paper, we have used data from the HIE to address this trade-off empirically. This study obtains estimates of both the demand for health insurance and the demand for health services—estimates that allow us to assess the trade-off between risksharing and incentives for excessive use of health care.

PURE COINSURANCE PLANS

The results for pure coinsurance plans—plans with no stop-loss[1] — indicate that a coinsurance rate on the order of 55 percent would be optimal. That is the rate at which the marginal gain from increased risk pooling equals the marginal loss from increased moral hazard. However, the net gain is extremely flat over the range from 40 to 65 percent. There is only a small loss—on the order of $10 per family (in September 1988 dollars)—from not being at the optimum. At a coinsurance rate of 25 to 30 percent—approximately the current average coinsurance rate—the loss relative to the optimum is on the order of $30 per family per year.

If we rely on either the nonparametric estimates of the demand for health care and health insurance or the modified expected utility model (which adds an intercept), the estimates of the net gains from insurance—the risk gains from insurance less the deadweight loss from moral hazard—are essentially the same, but the estimates of the components differ. Thus, we are confident that our results are driven by neither an inappropriate distributional assumption nor an overadherence to the functional form dictated by expected utility theory.

However, our estimates of the gains from insurance are sensitive to the estimated risk aversion, which depends on the estimate of α, β, σ, and ψ. Our estimates correspond to an absolute risk-aversion parameter of approximately 0.0005 (in 1982 dollars), but the corresponding

[1]Note that our analysis is limited to cases in which the out-of-pocket expense under no coverage and the insurance plan considered are less than family income (that is, each plan has a catastrophic cap imbedded in it—a cap equal to family income).

estimate from Marquis and Holmer (1986) is 0.001. Although ours is half theirs, we can barely reject their value for our model; the likelihood of our model is fairly flat in terms of ψ.[2] Although the two estimates are not statistically different, they are quite different in their implications. As a sensitivity analysis, consider what would happen if their estimate of the risk-aversion parameter were correct. Doubling the estimate of the risk-aversion parameter is equivalent to multiplying the risk-gain column in Table 4.2 by two. The higher risk gain causes the estimate of the optimal pure coinsurance rate to change from 55 percent to 35 percent.

PLANS WITH A STOP-LOSS

The prospects for insurance plans with a stop-loss, or with a stop-loss and first-dollar cost sharing, are less clear. The literature (Arrow, 1971, 1973) suggests that an optimal insurance plan should have a stop-loss of some sort. Yet our results indicate that such a plan, if it exists, would have a very high stop-loss—in excess of $15,000 (in September 1988 dollars). Thus, we were unable to find a plausible estimate of the optimal stop-loss within the range of our data. The maximum MDE in the HIE was $1000 in current dollars (or approximately $2000 in 1988 dollars). At most, the MDE was either 5, 10, or 15 percent of income. This range of MDEs may be insufficient to obtain a precise estimate of the critical risk-aversion parameter ψ. As we saw above, estimates for the coinsurance rate are sensitive to this value, which is imprecisely estimated. In this case, the conclusions are triply sensitive. First, extrapolating beyond the range of our data becomes necessary—always a very dangerous step. Second, we are making that extrapolation based on an imprecise estimate of ψ. And finally, we are relying on a functional form that may fit the observed range reasonably well but miss important nonlinearities because of the lack of precision in our probit-based methods.

Conceivably the stated answers to the hypothetical questions about supplementation could exhibit less risk aversion than they should. However, the predictive validity of the work by Marquis and Holmer (1986) suggests otherwise.

Alternatively, the inability to detect a stop-loss may result from our forecast methods. In our calculations, our methods do not allow an individual to have expenses (under no insurance) that exceed his

[2]A ψ of 0.21 would yield a risk-aversion parameter similar to the Marquis and Holmer estimate. A chi-square test against ψ of 0.21 is 4.4; thus, we reject the alternative at the 0.05 level but not at the 0.025 level.

income. If such were the case, we assumed that the state would pay the bill. If our model had been richer, in that an individual could spend his assets or borrow, we could have avoided this truncation. Aversion to precisely these very rare, but very large, losses may be what makes the stop-loss desirable.

Nevertheless, our estimates suggest that some form of stop-loss can result in a net welfare gain over no insurance. If we use the value of $\psi = 0.425$, then 25 or 50 percent coinsurance plans with stop-losses of $3000 and above have risk gains larger than losses from moral hazard. For $\psi = 0.21$, which corresponds roughly to the Marquis and Holmer (1986) value of risk aversion, there is a net gain at stop-losses of $1500 and above. Thus, our empirical problem is not whether stop-losses improve the welfare of consumers, but which stop-loss is optimal.

In addition, plans with first dollar cost sharing and a stop-loss appear to perform appreciably better than do pure stop-loss plans. Compare the 25 percent/$5000 stop-loss and 50 percent coinsurance/$5000 stop-loss plans with a pure $5000 stop-loss plan in Table 4.3. This seemingly paradoxical result comes largely from the deadweight loss from moral hazard. With a coinsurance rate of 100 percent and a $5000 limit, a family exceeds its limit when it accumulates $5000 in gross expenditures. When the coinsurance rate falls to 25 percent, the family needs $20,000 to exceed the limit. Thus, more families exceed the limit for the higher coinsurance rate plan and then face free care. The deadweight loss past the MDE is larger than the deadweight loss from a lower coinsurance rate before the limit is reached because the high-spending families spend a disproportionate share of all dollars. In the HIE, the top 10 percent of individuals accounted for 60 percent of total expenses.

POLICY IMPLICATIONS

Our expected utility results suggests that the present *average* insurance coverage, with insurance and government programs paying nearly 70 percent of the health bill, is not far from optimal. The losses from more generous coverage than is optimal for the average family are not very large.

However, what is true on *average* may be misleading. Estimates suggest that nearly 40 million Americans currently have no health insurance. Those who are insured have more generous coverage than the 30 percent paid out of pocket would suggest. Thus, the losses in the current arrangement are substantially larger than would occur if every family faced a coinsurance rate of 30 percent. Instead, the

current loss is probably on the order of $300 per family in September 1988 dollars—an average loss of some $430 per uninsured family and $250 per insured family relative to our estimated optimal pure coinsurance plan.

LIMITATIONS

Our method relies very heavily on the following economic assumptions. First, consumers are assumed to have well-behaved utility functions—that is, the utility functions satisfy the usual assumptions, including the integrability condition and risk aversion. Second, the ex post demand functions for health care (and hence, all other goods as a composite) can be estimated consistently as a function of price, income, and other factors. As a result, a consistent estimate of the error term can be obtained for a world with constant marginal prices and can be used as an empirically derived estimate of the unobserved stochastic element for both ex ante and ex post choices. Third, consumers maximize expected utility with objectively correct assessments of risk (that is, there is no divergence between objective and subjective risk assessments).

Of these assumptions, the last is both critical and untestable. If prospect theory (Kahneman and Tversky, 1979) is correct or if there is some divergence between objective and subjective risks, then our method based on expected utility theory will produce inconsistent estimates. Because our method uses only ex post data on use to infer the probability of events, there is no way to test the model with the data at hand. However, to the extent that the estimates agree with others, our estimates will be robust to the maintained hypothesis. If our estimates disagree with others, the divergence could result either from limitations in this approach or in the other.

Our estimates of the price elasticity of demand for health care do yield estimates that are very close to those found by Keeler et al. (1988) using episodes to model health care demand decisions. The estimates of the price and income elasticity of demand for insurance are quite similar to estimates in the recent literature. The major divergence is in the risk-aversion parameter estimate; we obtain estimates that are approximately half those of earlier empirical studies. In part, this divergence may exist because earlier studies ignored the direct contribution of health care to utility.

The main unresolved statistical problem is how to test the maintained hypotheses of expected utility maximization and objective, rather than subjective, risk assessment. Nevertheless, we believe our estimates are instructive. As far as we know, this attempt is the first

to integrate the demand for health care and the demand for health insurance. Previous work has assumed values for one component or another (for example, the risk-aversion parameter in the work of Keeler et al., 1988) and then worked out the implications. Our integrated approach yields:

- Estimates of the price elasticity of health care demand and the welfare losses from moral hazard—estimates that are consistent with other unbiased estimates;
- Estimates of the price and income elasticity of insurance demand that are consistent with other estimates;
- Estimates of risk aversion that account for the direct contribution of medical care purchases to utility.

These estimates suggest that current average coinsurance rates are not very far from ideal.

Appendix A

EXCEEDING THE MAXIMUM DOLLAR EXPENDITURE

This appendix is a condensed version of the theory section of Manning (forthcoming).

ECONOMIC MODEL OF CHOICE

Consider a consumer facing a simple insurance policy for medical care (x) that pays p_1 per unit for the first q_0 units and p_2 ($< p_1$) for each succeeding unit of the medical care good x.[1] The consumer has income I, which is spent on medical care (x) and a composite of all other goods (y). Because demand is homogeneous of degree zero in prices and income, we normalize the price of the other good y to one. Then we state the price (p) of medical care (x) as a ratio of its nominal price to the price of y and income as a ratio of nominal income to the price of y. The consumer maximizes his utility, which has all the usual properties (subject to the budget constraint imposed by his income and the two block insurance policy).

We will use the indirect utility function to examine the consumer's choice:

$$IU = f(p, I; z, \theta), \tag{1}$$

where θ is an unobserved shift parameter and z is a vector of observed shift variables. The argument for the price of y is suppressed because it is normalized to one.

In the face of a two-block tariff, the individual chooses the block and consumption bundle (x, y) that gives him the higher indirect utility. With constant price p_1 and income I, the individual would have maximum indirect utility $IU_1 = f(p_1, I; z, \theta)$ and demand $x_1 = g(p_1, I; z, \theta)$. With constant price p_2 and net income

[1]In the case of a health insurance policy with a deductible followed by free care, $p_1 = 1$ and $p_2 = 0$. If the policy has a first-dollar coinsurance rate c, followed by free care after meeting a catastrophic cap on out-of-pocket expenditures, then $p_1 = cp$, where p is the price of medical treatment.

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$$I_2 = I - (p_1 - p_2)^{\bullet} q_0 < I, \tag{2}$$

the individual would have maximum indirect utility $IU_2 = f(p_2, I_2; z, \theta)$ and demand $x_2 = g(p_2, I_2; z, \theta)$.

If the individual is economically rational, then he chooses to consume on the block with the higher indirect utility—that is,

$$x > q_0 \text{ iff } IU_2 > IU_1. \tag{3}$$

For simplicity, we can ignore the fact that some combinations of p_1, p_2, I, z, and q_0 may exist such that the individual is indifferent between the two blocks of a declining-block tariff. As a practical matter, such an event should occur with probability zero if the distribution of unobserved characteristics θ has a continuous density function.[2]

AN ECONOMETRIC MODEL OF CHOICE

The economic model of choice in Eq. 3 can be converted into an econometric model by assuming that the indirect utility function has a specific form and that the unobserved shift parameter θ follows some specific distribution. To illustrate the methodology, we will assume that the indirect utility function is of the form

$$IU = -p^{\alpha} e^{z\beta + \theta} + I^{\delta}, \tag{4}$$

which is the indirect utility function for a constant elasticity demand for x (Burtless and Hausman, 1978; Hausman, 1981). We also assume that θ is normally distributed. Other functional forms and distributions can be used as the data dictate. Although this particular utility function is separable in prices and income, the method does not require such an assumption.

Thus, we can rewrite Eq. 3 as $x > q_0$ iff

$$\Delta(IU) = -e^{z\beta + \theta}(p_2^{\alpha} - p_1^{\alpha}) + (I_2^{\delta} - I_1^{\delta}) > 0. \tag{5}$$

The appealing aspect of Eq. 5 is that the choice depends on exogenous variables (p_1, p_2, z, I_1, and I_2) and on an unobserved error term, θ. Thus, by observing on which block the individual decides to consume, we can estimate the indirect utility function's parameters.

[2]In contrast, for an increasing block tariff (such as mental health insurance coverage, which has a limit on covered expenditures or visits), a nontrivial proportion of the cases may choose to consume at the break between two blocks (see Burtless and Hausman [1978]).

We could use Roy's Identity to glean additional information from the individual's choice of x and block. The demand curve for x is derivable from the indirect utility function. Under a regime of constant price p and income I, the demand is given by

$$x = \frac{-\partial IU/\partial p}{\partial IU/\partial I} . \tag{6}$$

The observed demand for this indirect utility function is given by

$$\ell nx = (\alpha - 1)\ell np_1 + (1 - \delta)\ell nI_1 + z\beta + \theta \tag{7a}$$

if $\Delta IU < 0$ and the individual consumes in the first block, and

$$\ell nx = (\alpha - 1)\ell np_2 + (1 - \delta)\ell nI_2 + z\beta + \theta \tag{7b}$$

if $\Delta IU > 0$ and the individual consumes in the second block.[3]

For the reasons given in Sec. III, we do not use the additional information from using Eqs. 5 and 7 together. See Burtless and Hausman (1978), Terza and Welch (1982), and Ellis (1986) for methods that use the additional information on how much is demanded. Instead, we focus on the estimates that are obtainable by using Eq. 5 alone. We will then use Eq. 7 to obtain an estimate of the demand function based on the choice of block alone.

HEALTH INSURANCE EXPERIMENT APPLICATION

In the case of the HIE, the insurance variables are the price for the first block, p_1 ($= c * p$, which is the coinsurance rate c times the price p of health care); the upper limit q_0 on out-of-pocket expenses, stated in quantity terms

$$q_0 = MDE/(c * p);$$

and the second block price p_2 ($= 0$, because health care is free after the MDE is reached). The measure of the price p reflects differences in the cost of living temporally and cross-sectionally. Substituting this information into Eq. 5, the family will choose block 2 (that is, will exceed the MDE) if and only if

[3]Again, we ignore the case in which the consumer is indifferent about the two blocks ($\Delta IU = 0$), because it occurs with probability zero with a declining block tariff.

$$\Delta\,(IU) = IU_2 - IU_1$$

$$= [-e^{z\beta+\theta}\,(0)^{\alpha} + (I - MDE)^{\delta}]$$

$$- [-e^{z\beta+\theta}\,(cp)^{\alpha} + I^{\delta}]$$

$$= e^{z\beta+\theta}\,(cp)^{\alpha} + (I - MDE)^{\delta} - I^{\delta} > 0. \qquad (8)$$

Rearranging Eq. 8 yields

$$\Delta\,(IU) > 0 \text{ iff}$$

$$e^{z\beta+\theta}\,(cp)^{\alpha} > I^{\delta}\,[1 - (1 - MDE/I)^{\delta}]. \qquad (9)$$

Taking the natural logarithm of both sides preserves the inequality

$$\Delta\,(IU) > 0 \text{ iff}$$

$$Z\beta + \theta + \alpha\,\ell n\,(cp) - \delta\,\ell n\ I - \ell n[1 - (1 - MDE/I)^{\delta}] > 0.$$

The term in brackets can be approximated by $\ell n(\delta\ MDE/I)$ because the MDE is a small percentage of income (0 to 15 percent, with an average of 7 percent).[4] Thus, the consumer chooses to operate in block 2 ($\Delta\,(IU) > 0$) if and only if

$$\alpha\,\ell n(cp) + z\beta - \delta\,\ell nI - \ell n\delta - \ell n(MDE/I) + \theta > 0. \qquad (10)$$

Because θ is normally distributed, Eq. 10 is a probit regression specification for exceeding the MDE and consuming in the second block. Unless the $var(\theta) = \sigma^2$ or some other parameter is known a priori, a probit regression is underidentified. One can only estimate the ratio of the coefficients to σ. In this case, however, the coefficient of $\ell n(MDE/I)$ is known to be one (to a first order approximation). Hence, all the parameters are identified. Eq. 10 can be rewritten

$$(\alpha/\sigma)\,\ell n(cp) + z(\beta/\sigma) - (\delta/\sigma)\,\ell n\ I - (\ell n\delta)/\sigma$$

$$- (1/\sigma)\,\ell n\,(MDE/I) + \theta/\sigma \qquad (11)$$

[4]Note that from a Taylor's series expansion $(1 - a)^m \approx 1 - ma$ for small a. This approximation should also work wt . for other cases in which the inframarginal amount is small relative to income. However, if the amount is large relative to income, then a highly nonlinear variant of Eqs. 5 or 9 needs to be estimated.

Appendix B

ADDITIONAL RESULTS

This appendix provides some additional detail to Sec. 3. Specifically, we provide the underlying parameter estimates for the health care and health insurance demands, tests of goodness of fit, and contrasts between parametric and nonparametric results.

DEMAND FOR HEALTH CARE

Estimates

Table B.1 lists the independent variables in the demand for health care. Table B.2 contains the probit coefficients for exceeding the MDE and the corresponding demand parameters for the indirect utility function in Eq. 4 of App. A. The "probit coefficient" column is from the probit regression for exceeding the MDE.

Based on HIE analyses that indicate no effect of insurance plan on health status, we decided to use an individual's average health status over as many as six measurements to obtain a more reliable assessment of health status. Using this approach, we found that demand is not only influenced by the average health status in a family, but also depends on worst value among the members ($p < 0.10$).

Increases in family size increase family consumption. However, because the demand is inelastic, per capita demand for health care is decreasing in family size.

Demand is not significantly related to education, to site (once we control for income and the cost-of-living differences among the sites), or to family composition (once we control for family size). There are no significant interactions between the price and other variables (not shown).

Anticipated expenditures predict actual expenses quite well. The measure of anticipations we use in the demand model is the residual from a regression of the log of anticipations on all other measures in the demand model. Thus, the measure reflects what is known to the family about its health care needs that we cannot predict based on observable demographic and other characteristics. The elasticity is on the order of 0.2. The results are insensitive to the choice of measure of anticipated expenditures: entry, exit, or the average value of this variable.

Table B.1

INDEPENDENT VARIABLES

Variable	Definition
SEATTLE	Dummy variable = 1 if Seattle site
FITCHBURG COUNTY	Dummy variable = 1 if Fitchburg site
FRANKLIN	Dummy variable = 1 if Franklin site
CHARLESTON	Dummy variable = 1 if Charleston site
GEORGETOWN COUNTY	Dummy variable = 1 if Georgetown site
LN(FAM)	Log of family size
LN(PRICE)	Log of coinsurance percentage
LN(INCOME)	Log of family income in prior year
EDLTHS	Dummy variable = 1 if education < 12 years
SOMCOL	Dummy variable = 1 if some college education
COLL	Dummy variable = 1 if at least 4 years of college
LN(MDE/INC)	Log(MDE/family income)
MMLGHI	Family mean of log general health index
MMLMHI	Family mean of log mental health index
MPHYSLM	Family mean of dummy for physical/role limitation
AVGBLACK	Family mean of dummy for black
DELLGHI	Difference between worst and family average for log general health index
DELLMHI	Difference between worst and family average for log mental health index
DELPHYS	Difference between worst and family average for physical/role limitation
LN(ANT. EXP.)	Residual of log anticipated expenditures regressed on variables above

NOTE: MDE = maximum dollar expenditure. The omitted categories are the Dayton site, nonblacks, a high school education, and people without a role or physical limitation.

Goodness of Fit

We have also checked the model for goodness of fit—whether the predicted probability of exceeding the MDE closely tracks the average probability as price, income, family size, or health status change. If the model is specified incorrectly, we may reach the wrong conclusion about demand elasticities *and* cause misestimates in the risk-aversion parameter. If the estimates from the first stage (exceeding the MDE) are incorrect, then the second-stage (hypothetical demand for insurance) estimates will be some mixture of the true response and the first-stage mistake.

We include two tables comparing actual and predicted probabilities. In Table B.3, we first sort the data by the predicted probability, split the sample into ten groups of equal size, and tabulate the actual and average probability by group. The residuals have no apparent pattern.

Table B.2

ESTIMATES OF EXCEEDING THE MDE AND CORRESPONDING DEMAND FOR HEALTH CARE

Variable	Exceeding the MDE: Probit Coefficient	Probit t	Discriminant Coefficient	Log Demand Parameter
INTERCEPT	4.6663	3.06	5.1731	6.4469
SEATTLE	.020873	0.19	.033984	0.0288
FITCHBURG	.085544	0.59	.050091	0.1182
FRANKLIN COUNTY	-.0010996	-0.01	-.0024806	-0.0015
CHARLESTON	-.12480	-0.89	-.15414	-0.1724
GEORGETOWN COUNTY	-.17052	-1.23	-.16646	-0.2359
LN(FAM)	.53750	5.40	.48676	0.7426
LN(PRICE)	.59454	8.82	.58143	-0.1786
LN(INCOME)	-.56795	-10.63	-.61290	0.2153
EDLTHS	.079889	0.68	.050967	0.1104
SOMCOL	-.069141	-0.53	-.082824	-0.0955
COLL	-.018421	-0.14	-.050315	-0.0254
LN(MDE/INC)	-.72380	-6.99	-.75677	(a)
MMLGHI	-.90883	-3.09	-.87791	-1.2556
MMLMHI	-.40266	-1.16	-.46905	-0.5563
MPHYSLM	.0036487	0.02	-.013316	0.0050
AVGBLACK	-.34422	-2.53	-.30850	-0.4756
DELLGHI	.57893	1.60	.78149	0.7998
DELLMHI	-.70923	-1.36	-.71387	-0.9799
DELPHYS	-.27601	-1.57	-.33367	-0.3813
LN(ANT. EXP.)	.18893	5.11	.18785	0.2610

NOTE: MDE = maximum dollar expenditure; see Table B.1 for key to other abbreviations. Log demand estimates are based on the probit results.

[a]Not applicable.

A parametric test of linearity based on Pregibon's thesis indicates no statistically significant misfit. In Table B.4, we sort by the price variable and compare actual and predicted probabilities for high and low price values. The table shows that our results tend to underpredict (actual greater than predicted) at extremes of the price range, but the amount of misfit is quite small and statistically insignificant (t = 0.32). For the other major variables, we found no systematic or apparent misfit in the model. We obtained fits as good as these for the other major variables.

Table B.3

PREDICTED AND ACTUAL PROBABILITIES OF EXCEEDING THE MDE BY PREDICTION

Group	Predicted Probability	Actual Probability	Residual
Low 0	0.0302	0.0282	−0.0021
1	0.0688	0.0657	−0.0030
2	0.1005	0.0563	−0.0441
3	0.1373	0.1408	0.0036
4	0.1778	0.1831	0.0053
5	0.2224	0.2009	−0.0215
6	0.2722	0.3662	0.0940
7	0.3368	0.3615	0.0247
8	0.4261	0.3991	−0.0270
High 9	0.6750	0.6526	−0.0224

NOTE: MDE = maximum dollar expenditure. Observations are grouped in prediction order from low to high. Residual = actual probability − predicted probability.

Table B.4

PREDICTIONS AND RESIDUALS BY LOG PRICE

Group	Predicted Probability	Actual Probability	Residual
Low 0	0.1319	0.1455	0.0137
1	0.1194	0.1221	0.0027
2	0.1568	0.1549	−0.0018
3	0.1747	0.1643	−0.0104
4	0.2072	0.2066	−0.0007
5	0.3282	0.3178	−0.0104
6	0.3187	0.3146	−0.0042
7	0.3371	0.3286	−0.0085
8	0.3293	0.3474	0.0181
High 9	0.3433	0.3521	0.0088

NOTES: Observations are grouped in log (price) order from low to high. Residual = actual probability − predicted probability.

DEMAND FOR HEALTH INSURANCE

Risk Premium Estimates

The results on the families' aversion to risk in their responses to the hypothetical equations can be used to estimate the premium families would pay to eliminate all risk they remain exposed to under any base insurance policy—namely, the premium that equates expected utility with full insurance to expected utility given the base coverage. The results for 21 different base plans are given in Tables B.5 and B.6. The results presented are for the "pure" expected utility model and the modified version, which includes an intercept to allow for information costs. The different plans vary the cost sharing (100, 50, and 25 percent) and the maximum out-of-pocket expenditure from $500 to no maximum (our analysis is in September 1988 dollars).

The results are obtained by simulating the values for every family for all plans and averaging the estimates for each family.[1] Table B.5 gives the results for families of two or more; Table B.6 gives the results for single-person families.

In the "modified model," we obtain the surprising result that the premiums families are willing to pay to reduce a $500 MDE exceed the actual MDE. This is because of the "transaction" cost discussed in the text. Families are willing to pay the $215 transaction cost in addition to the expected reduction in out-of-pocket expenses. The total premium is above $500 because most families have expenses exceeding the $500 MDE, and out-of-pocket expenses are close to $500.

Empirical Model

As a test of whether families behave as economic theory suggests, we also fitted a probit model of the demand for health insurance services using the demographic and economic characteristics included in the estimation of the demand for health services model, but without imposing the form of the IU function obtained in that estimation. Thus, this empirical model is data-analytic rather than theoretical in its derivation. Table B.7 gives the coefficient estimates for the empirical model. We use this model to simulate the premium families would pay to eliminate risk under various assumptions about the base plan. Table B.8 gives a comparison of the

[1]In simulating expected utility, we assume that families anticipate that Medicaid or some public insurance plan will provide some protection if they incur catastrophic expenditures (namely, those in excess of income), so we limit the maximum out-of-pocket risk the family faces to be equal to its income. This is a slightly different treatment than the ex post assumption in which families with out-of-pocket expenses in excess of income were deleted from the analysis.

Table B.5

EXPECTED BASE PLAN OUT-OF-POCKET EXPENDITURE AND ADDITIONAL PREMIUMS WILLING TO PAY FOR FULL COVERAGE: ESTIMATES FOR FAMILIES OF TWO OR MORE

Base Plan	Base Plan Expected Out-of-Pocket	"Pure" Model		"Modified" Model	
		Total Premium	Pure Premium	Total Premium	Pure Premium
Coinsurance 100 percent, MDE of:					
Infinite	2033.35	2960.30	926.95	2913.55	880.20
10,000	1739.65	2194.65	455.00	2346.10	606.45
5000	1437.60	1711.35	273.75	1906.15	468.55
2500	1085.45	1228.95	143.50	1444.95	359.50
1250	743.75	809.30	65.55	1033.55	289.80
500	392.55	410.90	18.35	639.30	246.75
Coinsurance of 50 percent, MDE of:					
Infinite	1220.95	1496.65	275.70	1720.70	499.25
10,000	1084.40	1305.45	221.05	1530.65	446.25
5000	960.50	1132.70	172.20	1358.55	398.05
2500	785.00	900.65	115.65	1127.50	342.50
1250	583.55	645.25	61.70	873.15	289.60
500	336.85	359.75	22.90	588.90	252.05
Coinsurance of 25 percent, MDE of:					
Infinite	708.30	879.15	170.85	1106.05	397.76
10,000	667.70	811.90	144.10	1039.30	371.60
5000	602.75	727.50	124.75	955.25	352.50
2500	526.70	620.45	93.75	848.55	321.85
1250	423.35	484.80	61.45	713.45	290.12
500	273.85	298.00	24.15	527.50	253.65

NOTE: MDE = maximum dollar expenditure. Amounts are in September 1988 dollars.

results based on the empirical and the "pure" expected utility theory model. We restrict the range of MDEs in the base plan under consideration to the range that was predominant in our observed data—namely, $500 to $2500 in September 1988 dollars (some 90 percent of our observations were actually in the range of $300 to $2500).

For the empirical version of the insurance demand, the discriminant function resulted in slightly more elastic demand with respect to changes in the premium and policy characteristics than did the probit

Table B.6

EXPECTED BASE PLAN OUT-OF-POCKET EXPENDITURE AND ADDITIONAL PREMIUMS WILLING TO PAY FOR FULL COVERAGE: ESTIMATES FOR SINGLE-PERSON FAMILY

Base Plan	Base Plan Expected Out-of-Pocket	"Pure" Model		"Modified" Model	
		Total Premium	Pure Premium	Total Premium	Pure Premium
Coinsurance of 100 percent, MDE of:					
Infinite	734.25	1040.85	306.60	1144.59	410.34
10,000	707.05	946.05	239.00	1081.12	374.07
5000	656.90	840.40	183.50	992.50	335.60
2500	571.95	695.86	123.91	860.74	288.79
1250	453.45	523.55	70.10	698.15	244.70
500	287.25	313.90	26.65	493.90	206.65
Coinsurance of 50 percent, MDE of:					
Infinite	471.75	585.05	113.30	764.25	292.50
10,000	453.20	554.90	101.70	734.25	281.05
5000	429.30	521.05	91.75	700.45	271.15
2500	383.00	454.45	71.45	634.35	251.35
1250	321.85	372.40	50.55	552.80	230.95
500	225.55	251.45	25.90	432.65	207.10
Coinsurance of 25 percent, MDE of:					
Infinite	268.90	337.05	68.15	517.90	249.00
10,000	268.65	331.50	62.85	512.40	243.75
5000	257.10	316.05	58.95	497.00	239.90
2500	239.70	291.60	51.90	472.70	233.00
1250	210.45	255.50	45.05	431.85	221.40
500	161.25	184.95	23.70	366.70	205.45

NOTE: MDE = maximum dollar expenditure. Amounts are in September 1988 dollars.

version of the empirical result; in fact, the discriminant function estimates of these elasticities is quite similar to the theoretical model estimates. For example, the discriminant function produced a premium elasticity of –1.0 versus –0.76 in the probit. The MDE and coinsurance elasticities in the two were the same. However, as with the probit estimate of the empirical model, we find no effect of income using the discriminant estimates; this result contrasts with the income-elastic result from the utility theory-based estimates.

Table B.7

PROBIT ESTIMATES FROM EMPIRICAL VERSION OF DEMAND FOR HEALTH INSURANCE

	Probit for Accepting Supplemental Insurance Plan		
Variable	Coefficient	Standard Error	t
INTERCEPT	4.811	1.573	3.06
SEATTLE	−.075	.111	−0.68
FITCHBURG	.043	.143	0.30
FRANKLIN COUNTY	−.021	.124	−0.01
CHARLESTON	.104	.146	0.71
GEORGETOWN COUNTY	−.232	.151	−1.54
LN(FAM)	−.066	.196	−0.34
LN(PRICE)	.233	.074	3.14
LN(INCOME)	.048	.081	0.60
EDLTHS	−.231	.134	−1.72
SOMCOL	−.271	.142	−1.92
COLL	−.396	.140	−2.83
MMLGHI	−.882	.293	−3.01
MMLMHI	.102	.345	0.30
MPHYSLM	−.285	.226	−1.26
AVGBLACK	−.345	.139	−2.49
DELLGHI	−.682	.420	−1.62
DELLMHI	−.367	.602	−0.61
DELPHYS	−.265	.195	−1.36
LN(ANT. EXP.)	.196	.041	4.72
$MDE^{0.3}$	−.335	.091	−3.68
$PREMIUM^{0.3}$	−.906	.009	−9.42
$(CHANGE\ IN\ MDE)^{0.3}$	.555	.105	5.30
$LN(FAM)*PREMIUM^{0.3}$	.100	.048	2.09

NOTE: MDE = maximum dollar expenditure; see Table B.1 for key to other abbreviations.

Goodness of Fit

We have also checked the model for goodness of fit (whether the predicted probability of accepting the supplemental insurance plan tracks the average probability as price, income, family size, or health status change). If the model was specified incorrectly, we could reach the wrong conclusion about the nature of risk aversion.

Table B.8

COMPARISON OF UTILITY THEORY AND EMPIRICAL MODEL RESULTS

Base Plan	Estimated Premium Participants Are Willing to Pay to Eliminate Risk under Base Plan: "Pure Theory" Model	Empirical Model
Families of two or more		
Coinsurance 100 percent, MDE of:		
2500	1288.95	1016.65
1250	809.30	803.00
500	410.90	616.70
Coinsurance of 50 percent, MDE of:		
2500	900.65	882.65
1250	645.25	689.95
500	359.75	523.25
Coinsurance of 25 percent, MDE of:		
2500	620.45	761.65
1250	484.80	588.65
500	298.00	440.35
Single-person family		
Coinsurance of 100 percent, MDE of:		
2500	695.80	733.80
1250	523.55	586.15
500	313.90	456.30
Coinsurance of 50 percent, MDE of:		
2500	454.45	641.35
1250	372.40	807.55
500	251.45	390.70
Coinsurance of 25 percent, MDE of:		
2500	291.60	557.45
1250	255.50	436.65
500	184.90	332.00

NOTE: MDE = maximum dollar expenditure.

We include two tables comparing actual and predicted probabilities. In Table B.9, we first sort the data by the predicted probability, split the sample into ten groups of equal size, and tabulate the actual and

average probability by group based on the pure expected utility model. The residuals are systematically positive and show some evidence of curvature. The positive residual is attributable to the absence of an intercept term and disappears once one is introduced (not shown). The curvature does not result from an incorrect specification of the utility function's monotonic transform. If we use a second-order expansion around the 0.425 power transform, we find a statistically insignificant (t = 0.90) second-order term. Instead, the restricted form of the expected utility model appears not to reflect properly consumers' response to the price, premium, and MDE variables. Table B.10 displays the actual versus the predicted probabilities for the empirical model.

Table B.9

ACTUAL VERSUS PREDICTED PROBABILITY OF ACCEPTING SUPPLEMENTAL INSURANCE: EXPECTED UTILITY MODEL

Decile	Actual Probability	Predicted Probability	Residual
0	0.2606	0.2154	0.0452
1	0.4026	0.3700	0.0326
2	0.5032	0.4330	0.0702
3	0.6623	0.4714	0.1909
4	0.7305	0.4997	0.2308
5	0.7338	0.5251	0.2086
6	0.7143	0.5529	0.1614
7	0.7208	0.5864	0.1344
8	0.7435	0.6416	0.1019
9	0.7785	0.7734	0.0051

NOTE: Deciles based on predicted probability.

Table B.10

ACTUAL VERSUS PREDICTED PROBABILITY OF ACCEPTING SUPPLEMENTAL INSURANCE: EMPIRICAL MODEL

Decile	Actual Probability	Predicted Probability	Residual
0	0.1987	0.2283	−0.0296
1	0.3994	0.3863	0.0131
2	0.4805	0.4882	−0.0077
3	0.5617	0.5624	−0.0007
4	0.6461	0.6266	0.0195
5	0.6851	0.6857	−0.0006
6	0.7662	0.7335	0.0327
7	0.8247	0.7813	0.0434
8	0.7890	0.8353	−0.0463
9	0.8990	0.9143	−0.0153

NOTE: Deciles based on predicted probability.

REFERENCES

Akaike, H., "Information Theory and an Extension of the Maximum Likelihood Principle," in B. N. Petrov and F. Csaski (eds.), *Second International Symposium on Information Theory,* Akademiai Kiado, Budapest, 1973.

Arrow, K. J., "Uncertainty and the Welfare Economics of Medical Care," *American Economic Review,* Vol. 53, 1963, pp. 941–973.

Arrow, K. J., *Essays in the Theory of Risk-Bearing,* Markham Publishing Company, Chicago, 1971.

Arrow, K. J., *Optimal Insurance and Generalized Deductibles,* The RAND Corporation, R-1108-OEO, 1973.

Arrow, K. J., "Welfare Analysis of Changes in Health Coinsurance Rates," in Richard Rosett (ed.), *The Role of Health Insurance in the Health Services Sector,* National Bureau of Economic Research, New York, 1976.

Baumol, W. J., and D. F. Bradford, "Optimal Departures from Marginal Cost Pricing," *American Economic Review,* Vol. 60, June 1970, pp. 265–283.

Belk, R. W., "Issues in the Intention-Behavior Discrepancy," in J. N. Sheth (ed.), *Research in Consumer Behavior,* Vol. 1, JAI Press, Greenwich, Conn., 1985, pp. 1–34.

Brook, R. H., et al., "Overview of Adult Health Status Measures Fielded in Rand's Health Insurance Study," *Medical Care* (supplement), Vol. 17, 1979, pp. 1–131.

Brook, R. H., et al., "Does Free Care Improve Adults' Health? Results from a Randomized Controlled Trial," *New England Journal of Medicine,* Vol. 309, 1983, pp. 1426–1434.

Brook, R. H., J. E. Ware, Jr., W. H. Rogers, E. B. Keeler, A. R. Davies, C. D. Sherbourne, G. A. Goldberg, K. N. Lohr, P. Camp, and J. P. Newhouse, *The Effect of Coinsurance on the Health of Adults,* The RAND Corporation, R-3055-HHS, 1984.

Burtless, G., and J. A. Hausman, "The Effect of Taxation on Labor Supply," *Journal of Political Economy,* Vol. 86, 1978, pp. 1103–1130.

Cattin, P., and D. R. Wittink, "Commercial Use of Conjoint Analysis: A Survey," *Journal of Marketing,* Vol. 46, 1982, pp. 44–53.

Clasquin, L. A., *Mental Health, Dental Services, and Other Coverage in the Health Insurance Study,* The RAND Corporation, R-1216-OEO, 1973.

Clasquin, L. A., and M. E. Brown, *Rules of Operation for the Rand Health Insurance Study,* The RAND Corporation, R-1602-HEW, 1977.

Cosslett, S. R., "Distribution-Free Maximum Likelihood Estimator of the Binary Choice Model," *Econometrica,* Vol. 51, No. 3, May 1983.

Davies, A. R., and J. E. Ware, Jr., *Measuring Health Perceptions in the Health Insurance Experiment,* The RAND Corporation, R-2711-HHS, October 1981.

Duan, N., W. G. Manning, C. N. Morris, and J. P. Newhouse, "A Comparison of Alternative Models for the Demand for Medical Care," *Journal of Economic and Business Statistics,* Vol. 1, April 1983, pp. 115–226; also, The RAND Corporation, R-2754-HHS, 1982.

Duan, N., et al., "Choosing Between the Sample-Selection Model and the Multi-Part Model," *Journal of Business and Economic Statistics,* Vol. 2, July 1984, pp. 283–289.

Duan, N., and K. Li, "Slicing Regression: A Link-Free Estimation Method," *Annals of Statistics,* forthcoming.

Duan, N., "Comments on Selectivity Bias," in R. M. Schleffler and L. F. Rossiter (eds.), *Advances in Health Economics and Health Services Research,* Vol. 6, JAI Press, Greenwich, Conn., 1985, pp. 19–24.

Eisen, M. B., C. A. Donald, J. E. Ware, Jr., and R. H. Brook, *Conceptualization and Measurement of Health for Children in the Health Insurance Study,* The RAND Corporation, R-2313-HEW, 1980.

Ellis, Randall P., "Rational Behavior in the Presence of Coverage Ceilings and Deductibles," *The RAND Journal of Economics,* Vol. 17, Summer 1986, pp. 158–175.

Farley, P., and G. R. Wilensky, "Household Wealth and Health Insurance Protection against Medical Risks," in M. David and T. Smeeding (eds.), *Horizontal Equity, Uncertainty, and Economic Well-being,* University of Chicago Press, Chicago, 1986.

Feldstein, M., "The Welfare Loss of Excess Health Insurance," *Journal of Political Economics,* Vol. 81, No. 2, March–April 1973, pp. 251–280.

Feldstein, M., and B. Friedman, "Tax Subsidies, the Rational Demand for Health Insurance, and the Health Care Crisis," *Journal of Public Economics,* Vol. 7, April 1977, pp. 155–178.

Friedman, B., "Risk Aversion and the Consumer Choice of Health Insurance Option," *Review of Economics and Statistics,* Vol. 56, May 1974, pp. 209–214.

Goldstein, Gerald S., and Mark V. Pauly, "Group Health Insurance as a Local Public Good," Richard Rosett (ed.), *The Role of Health Insurance in the Health Service Sector,* National Bureau of Economic Research, New York, 1976, pp. 73–110.

Granbois, D. H., and J. O. Summers, "Primary and Secondary Validity of Consumer Purchase Probabilities," *Journal of Consumer Research,* Vol. 1, March 1975, pp. 31–38.

Hausman, J. A., "Exact Consumer's Surplus and Deadweight Loss," *American Economic Review,* Vol. 71, 1981, pp. 662–676.

Hausman, J. A., "The Econometrics of Nonlinear Budget Sets," *Econometrica,* Vol. 53, 1985, pp. 1255–1282.

Hershey, J. C., et al., "Health Insurance Under Competition: Would People Choose What Is Expected?" *Inquiry,* Vol. 21, No. 4, Winter 1985, pp. 349–360.

Holmer, M., "Tax Policy and the Demand for Health Insurance," *Journal of Health Economics,* Vol. 3, No. 3, 1984, pp. 203–222.

Huber, P. J., "The Behavior of Maximum Likelihood Estimates Under Nonstandard Conditions," *Fifth Berkeley Symposium on Mathematical Statistics and Probability,* Vol. 1, 1967, pp. 221–233.

Kahneman, D., and A. Tversky, "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica,* Vol. 47, March 1979, pp. 263–291.

Keeler, E. B., J. L. Buchanan, J. E. Rolph, J. M. Hanley, and D. M. Reboussin, *Demand for Episodes of Medical Treatment in the Health Insurance Experiment,* The RAND Corporation, R-3454-HHS, March 1988.

Keeler, E. B., J. P. Newhouse, and C. E. Phelps, "Deductibles and the Demand for Medical Care Treatment: The Theory of a Consumer Facing a Variable Price Schedule Under Uncertainty," *Econometrica,* Vol. 45, April 1977, pp. 641–656.

Keeler, E. B., J. E. Rolph, N. Duan, J. M. Hanley, and W. G. Manning, *The Demand for Episodes of Medical Treatment: Interim Results from the Health Insurance Experiment,* The RAND Corporation, R-2829-HHS, December 1982.

LaTour, S. A., B. S. Friedman, and E. F. Hughes, "Medicare Beneficiary Decision Making About Health Insurance: Implications for a Voucher System," *Medical Care,* Vol. 24, No. 7, July 1986, pp. 601–614.

Long, James, and Frank Scott, "The Income Tax and Nonwage Compensation," *Review of Economics and Statistics,* Vol. 64, No. 2, May 1982, pp. 211–219.

Morris, C. N., "A Finite Selection Model for Experimental Design of the Health Insurance Study," *Journal of Econometrics,* Vol. 11, 1979, pp. 43–61.

Morris, C. N., *Sample Selection in the Health Insurance Experiment: Comparing the Enrolled and Nonenrolled Populations,* The RAND Corporation, N-2354-HHS, October 1985.

Morris, C. N., J. P. Newhouse, and R. W. Archibald, "On the Theory and Practice of Obtaining Unbiased and Efficient Samples in Social Surveys and Experiments," in V. L. Smith (ed.), *Experimental Economics,* Vol. 1, JAI Press, Greenwich, Conn., 1979; also in *Evaluation Studies Review Annual,* Vol. 5, Sage Publications, Beverly Hills, Calif., 1980.

Newhouse, J. P., "A Design for a Health Insurance Experiment," *Inquiry,* Vol. 11, 1974, pp. 5–27.

Newhouse, J. P., "The Demand for Medical Care Services: A Retrospect and Prospect," in J. van der Gaag and M. Perlman (eds.), *Health, Economics, and Health Economics,* North Holland, Amsterdam, 1981.

Newhouse, J. P., C. E. Phelps, and M. S. Marquis, "On Having Your Cake and Eating It Too: Econometric Problems in Estimating the Demand for Health Services," *Journal of Econometrics,* Vol. 13, 1980, pp. 365–390.

Newhouse, J. P., et al., "Measurement Issues in the Second Generation of Social Experiments: The Health Insurance Study," in D. J. Aigner and C. N. Morris (eds.), "Experimental Design in Econometrics," *Journal of Econometrics,* Vol. 11, 1979, pp. 117–130.

Newhouse, J. P., W. G. Manning, C. N. Morris, L. L. O[illegible] N. Duan, E. B. Keeler, A. Leibowitz, K. H. Marquis, M. S. Marquis, C. E. Phelps, and R. H. Brook, "Some Interim Results from a Controlled Trial of Cost Sharing in Health Insurance," *New England Journal of Medicine,* Vol. 305, December 17, 1981, pp. 1501–1507; see also The RAND Corporation, R-2847-HHS, January 1982.

Pauly, M. V., "The Economics of Moral Hazard," *American Economic Review,* Vol. 58, 1968, pp. 231–237.

Pauly, M. V., *Medical Care at Public Expense,* Prager, New York, 1971.

Pauly, M. V., "Taxation, Health Insurance, and Market Failure," *Journal of Economic Literature,* Vol. 24, June 1986, pp. 629–675.

Phelps, Charles E., *Demand for Health Insurance: A Theoretical and Empirical Investigation,* R-1054-OEO, The RAND Corporation, July 1973.

Phlips, L., *The Economics of Price Discrimination,* Cambridge University Press, Cambridge, 1985.

Ramsey, F., "A Contribution to the Theory of Taxation," *Economic Journal*, Vol. 37, March 1927, pp. 47–61.

Rogers, W. H., and J. P. Newhouse, "Measuring Unfiled Claims in the Health Insurance Experiment," in L. Burstein, H. E. Freeman, and P. H. Rossi (eds.), *Collecting Evaluation Data: Problems and Solutions*, Sage Publications, Beverly Hills, Calif., 1985, pp. 121–133.

Rothschild, M., and J. Stiglitz, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics*, Vol. 90, 1976, pp. 629–650.

Roy, R., "La distribution du revenue entre les divers biens," *Econometrica*, Vol. 15, 1947, pp. 205–225.

Searle, S. R., *Linear Models*, John Wiley and Sons, New York, 1971.

Stewart, A., J. E. Ware, Jr., and R. H. Brook, "The Meaning of Health: Understanding Functional Limitations," *Medical Care*, Vol. 15, No. 11, November 1977, pp. 939–952.

Stewart, A. L., J. E. Ware, Jr., and R. H. Brook, *Construction and Scoring of Aggregate Functional Status Indexes: Volume I*, The RAND Corporation, R-2551-HHS, January 1981a.

Stewart, A. L., J. E. Ware, Jr., and R. H. Brook, "Advances in the Measurement of Function Status: Construction of Aggregate Indexes," *Medical Care*, Vol. 19, No. 5, May 1981b, pp. 473–488.

Stewart, A. L., J. E. Ware, Jr., R. H. Brook, and A. Davies-Avery, *Conceptualization and Measurement of Health for Adults in the Health Insurance Study: Vol. II, Physical Health in Terms of Functioning*, The RAND Corporation, R-1987/2-HEW, July 1978.

Taylor, A. K., and G. R. Wilensky, "The Effect of Tax Policies on Expenditures for Private Health Insurance," in J. A. Meyer (ed.), *Market Reforms in Health Care*, American Enterprise Institute, Washington, D.C., 1983.

Taylor, L. D., "The Demand for Electricity: A Survey," *Bell Journal of Economics*, Vol. 6, No. 1, 1975, pp. 74–110.

Terza, J. V., and W. P. Welch, "Estimating Demand under Block Rates: Electricity and Water," *Land Economics*, Vol. 58, 1982, pp. 181–188.

Thaler, Richard, "Toward a Positive Theory of Consumer Choice," *Journal of Economic Behavior and Organization*, Vol. 1, No. 1, 1980, pp. 39–60.

Tversky, A., and D. Kahneman, "Rational Choices and the Framing of Decisions," in R. M. Hogarth and M. W. Reder (eds.), *Rational Choice: The Contrast Between Economics and Psychology*, University of Chicago Press, Chicago, 1986.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Planning and Evaluation, *A Study of Competitive Plans and Flexible Spending Accounts,* Washington, D.C., July 1985.

van de Ven, W. P., and B. M. van Praag, "The Demand for Deductibles in Private Health Insurance: A Probit Model with Sample Selection," *Journal of Econometrics,* Vol. 17, 1981, pp. 229–252.

van de Ven, W. P., and B. M. van Praag, "Risk Aversion of Deductibles in Private Health Insurance: Application of an Adjusted Tobit Model to Family Health Care Expenditures," in J. van der Gaag and M. Perlman (eds.), *Health, Economics, and Health Economics,* North Holland, Amsterdam, 1981.

Veit, C. T., and J. E. Ware, Jr., "The Structure of Psychological Distress and Well-Being in General Populations," *Journal of Consulting and Clinical Psychology,* Vol. 51, 1983, pp. 703–742.

Ware, J. E., Jr., "Scales for Measuring General Health Perceptions," *Health Services Research,* Vol. 11, 1976, pp. 596–615.

Ware, J. E., Jr., R. H. Brook, A. Davies-Avery, K. N. Williams, A. L. Stewart, W. H. Rogers, C. A. Donald, and S. A. Johnston, *Conceptualization and Measurement of Health for Adults in the Health Insurance Study: Vol. I, Model of Health and Methodology,* The RAND Corporation, R-1987/1-HEW, May 1980.

Ware, J. E., Jr., A. Davies-Avery, and R. H. Brook, *Conceptualization and Measurement of Health for Adults in the Health Insurance Study: Vol. VI, Analysis of Relationships among Health Status Measures,* The RAND Corporation, R-1987/6-HEW, November 1980.

Ware, J. E., Jr., S. A. Johnston, A. Davies-Avery, and R. H. Brook, *Conceptualization and Measurement of Health for Adults in the Health Insurance Study: Vol. III, Mental Health,* The RAND Corporation, R-1987/3-HEW, 1979.

Ware, W. P., M. K. Snyder, and W. P. Wright, *Development and Validation of Scales to Measure Patient Satisfaction with Health Care Services,* NTIS Pub. No. (PB)288–330, National Technical Information Service, Springfield, Va., 1976.

Williams, A. W., J. E. Ware, Jr., and C. A. Donald, "A Model of Mental Health, Life Events, and Social Supports Applicable to General Populations," *Journal of Health and Social Behavior,* Vol. 22, 1981, pp. 324–336.

Wolf, C., and L. Pohlman, "The Recovery of Risk Preferences from Actual Choices," *Econometrica,* Vol. 51, May 1983, pp. 843–850.

Woodbury, Steve, "Substitution Between Wage and Nonwage Benefits," *American Economic Review,* Vol. 73, March 1983, pp. 166–182.

Zeckhauser, R. J., "Medical Insurance: A Case Study of the Trade-Off between Risk Spreading and Appropriate Incentives," *Journal of Economic Theory,* Vol. 2, 1970, pp. 10–26.