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FORMATION OF RISK BELIEFS, JOINT PRODUCTION AND WILLINGNESS TO PAY TO AVOID SKIN CANCER

Mark Dickie and Shelby Gerking*

Abstract—This paper uses a survey of risk beliefs about skin cancer to provide new evidence on how people view risky situations. Empirical results presented are based on a measure of risk beliefs held at the time of the survey. Key findings are that risk beliefs about skin cancer account for factors including skin type, complexion, and sunlight exposure history. Also, the connection between risk beliefs and willingness to pay is explored by using reservation prices for a sun protection product. A new method for treating joint production in a household production framework is developed to support this analysis.

I. Introduction

APPROPRIATE regulation of health risks depends on whether individuals clearly perceive hazards, how perceptions influence protective actions, and on the benefits of potential risk reductions. Numerous results in experimental economics and psychology show that risk beliefs often are inconsistent with objective risk measures and lead to apparently irrational behavior (e.g., Kunreuther et al. (1976), Lichtenstein et al. (1978), Grether and Plott (1979), Kahneman and Tversky (1982), Arrow (1982), Slovic, Fischhoff, and Lichtenstein (1985), and Tversky, Slovic, and Kahneman (1990)). These results cast doubt both on the ability of individuals to wisely choose protective actions and on the assumption that those choices reveal underlying valuations of risk. Recent evidence from surveys and labelling studies challenge this view by demonstrating that individual assessments of and responses to risk information are broadly consistent with rationality (e.g., Viscusi and O'Connor (1984), Viscusi, Magat, and Huber (1986, 1987), Smith and Johnson (1988), Smith, Desvousges, Fisher, and Johnson (1988), Viscusi (1990, 1991), and Magat and Viscusi (1992)). These latter findings are important because they support the analytical approach traditionally used by economists and suggest that it can be successfully applied in the policy arena.

This paper uses a survey of beliefs about skin cancer to provide new evidence on how people view risky situations. Three contributions are envisioned. First, data are collected that measure risk beliefs held at the time of the survey. In certain other studies, people are asked to recall risk beliefs held months or even years earlier (Smith and Johnson (1988), Smith, Desvousges, Fisher, and Johnson (1988), and Bernknopf, Brookshire, and Thayer (1990)) or are told what to believe about risk in a specific hypothetical situation (Viscusi, Magat, and Huber (1987)). Assessing current risk beliefs about a widely known hazard means that respondents in this study are likely to be more confident of their answers and that determinants of these beliefs can be more clearly identified.

Second, results presented yield insights into how risk beliefs are formed. For example, this study apparently is the first to investigate the role of genetic risk factors. According to the Skin Cancer Foundation (1989), approximately 90% of all skin cancers result from exposure to solar radiation and for a given level of exposure, risks of contracting this disease partly depend on easily measurable personal characteristics such as skin type and complexion. Consequently, the extent to which determinants of risk beliefs coincide with objective risk factors identified in epidemiological studies can be examined. This opportunity contrasts, for example, with recent studies of cigarette smoking and radon exposure in which people's genetic propensities to contract lung cancer are difficult to measure. Additionally, the relationship between respondents' age and risk beliefs identified in this study differs from the interpretation proposed by Viscusi (1991) and analysis of how skin cancer risk beliefs are revised permits examination of interactions between information provided and respondents' ability and/or incentives to process it.

Third, reservation prices for a sunscreen product are used to estimate willingness to pay for reduced skin cancer risk. These estimates are based on respondents' indifference maps together with a new method of treating certain joint production problems (see, for example, Pollack and Wachter (1975)) that arise in a household production framework. Specifically, it is difficult to infer willingness to pay from defensive actions such as use of sun protection products because these actions provide a bundle of services jointly with reduced skin cancer risk. The approach taken here to avoid complications posed by joint production: (1) builds on results from labelling studies, (2) is easier to implement in a survey context than alternative methods proposed by Hori (1975) and Bockstael and McConnell (1983), and (3) can be used to test empirically whether accounting for joint production "matters" when making willingness-to-pay estimates.

The remainder of this paper is divided into five sections. Section II outlines necessary theoretical background. Section III describes unique data concerning beliefs about skin cancer risk that were collected by surveys conducted in two U.S. cities. Sections IV and V present empirical results on determinants of risk beliefs, and on the connection between risk beliefs and willingness to pay to avoid skin cancer in a joint production framework. Section VI summarizes implications and conclusions.

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II. Theoretical Background

This section uses a household production model to: (1) derive an estimable risk perception function as an outcome of utility maximizing choices and (2) address complications that hinder attempts to value reduced risk when joint production is present. Because the model is familiar, discussion is kept to a minimum and focuses only on aspects directly relevant to empirical work presented in subsequent sections.

An individual maximizes the lifetime utility (U) function

$$U = U(X, R^*, A^*, S^*) \tag{1}$$

where X denotes a composite good and remaining arguments denote perceptions about consequences of exposure to sunlight; R^* denotes perceived lifetime risk of skin cancer, A^* denotes perceived risk of premature aging or wrinkling of skin, and S^* denotes perceptions of more immediate effects of sunlight such as suntanning and/or sunburning.[1] Specifying U in lifetime terms abstracts from dynamic issues such as the timing of occurrence or recurrence of skin cancer, but conforms with how risk is measured in the data at hand (see section III).

Perceived consequences of sunlight exposure differ from, but are functionally related to, actual consequences:

$$\begin{aligned} R^* &= R^*(R, \alpha, \beta) \\ A^* &= A^*(A, \alpha, \beta) \\ S^* &= S^*(S, \alpha, \beta) \end{aligned} \tag{2}$$

where R denotes actual risk of skin cancer, A denotes actual risk of premature skin aging, S denotes actual suntanning/sunburning, and α and β denote attitudes toward and awareness of effects of sunlight exposure, respectively. The commodities R, A, S, in turn, are determined by

$$\begin{aligned} R &= R(T, G, \Omega) \\ A &= A(T, G, \Omega) \\ S &= S(T, G, \Omega) \end{aligned} \tag{3}$$

where T denotes total time spent in direct sunlight whether at work or at leisure, G denotes a good that can be purchased to reduce harmful effects of sunlight, such as a sun protection product, and Ω denotes aspects of the individual's genetic endowment.[2] Choices of goods and time allocations are made subject to the full income budget constraint

$$V = q_x X + q_G G + WT \tag{4}$$

where full income, $V = \pi W$, reflects total time available (π) valued at the individual's wage rate (W) and q_i ($i = X, G$) denote full, time inclusive prices (see Becker (1965) for details).[3]

This model supports two main features of the empirical analysis presented later. First, using solutions for G and T, it yields:

$$R^* = f(W, q_x, q_G, \alpha, \beta, \Omega, \pi) \tag{5}$$

which expresses skin cancer risk perceptions as the outcome of utility maximizing choices of goods and time allocations. This equation focuses on total effects of risk factors in determining risk perceptions, rather than on partial effects holding X, G, and T constant. While both types of effects are of interest, estimation of total effects is helpful to understanding the overall role of prior information, genetic susceptibility to skin cancer, and other personal characteristics in determining risk perceptions.

Second, the ex ante marginal willingness to pay or option price of a reduction in perceived risk of skin cancer can be examined by solving for the change in expenditures on G that holds utility constant as shown in equation (6)

$$\begin{aligned} d(q_G G) = {} & (q_x U_{R^*}/U_x)dR^* + (q_x U_{A^*}/U_x)dA^* \\ & + (q_x U_{S^*}/U_x)dS^* - WdT. \end{aligned} \tag{6}$$

The desired option price is the coefficient of dR^*, the monetized marginal rate of substitution between perceived risk and the composite good. In the joint production model under consideration, however, this option price cannot be inferred from the relationship between expenditures on G and risk alone because R^* does not change independently of A^* and S^*. Hori (1975) and Bockstael and McConnell (1983) have proposed methods of estimating values of nonmarket commodities when joint production is present; but both are difficult to implement empirically. On the one hand, Hori's approach requires knowledge of all joint production functions as well as a technological independence condition which ensures that the number of inputs available to an individual is no smaller than the number of joint products. The approach of Bockstael and McConnell, on the other hand, involves the challenge of identifying a necessary input to the joint production process.

This paper develops an alternative approach to estimating option prices for nonmarket goods, which is simpler to implement when survey data are collected. In the context of the model at hand, it involves: (1) defining a hypothetical

[1] These consequences of solar radiation exposure span the main dermatological effects discussed more fully in U.S. Environmental Protection Agency (1987). Solar radiation exposure also has been linked to immune system suppression; however, this aspect is not modeled or treated explicitly in subsequent empirical analyses. Also, perceived, rather than actual, consequences are relevant to ex ante decisions of the type examined in this paper, such as purchases of protective goods and willingness to pay to reduce risk.

[2] Joint production arising because G and T are direct sources of utility is ignored in the present context but is considered at length in Dickie and Gerking (1991).

[3] The budget constraint is based on simplifying assumptions that (1) time spent to consume one unit of X and G is fixed, and (2) the individual cannot undertake more than one activity at a time. In this case, the full price equals the dollar price plus the product of the wage rate and the time required to consume one unit.

sun protection product as a bundle of characteristics ($G = G(Z_R, Z_A, Z_S)$), where Z_R denotes protection against R, Z_A denotes protection against A, and Z_S denotes protection against S, and (2) varying these characteristics independently. With this refinement, the model permits independent variation in R^*, A^*, and S^* and allows the option price of a reduction in perceived skin cancer risk to be calculated as q_x times the marginal rate of substitution between R^* and X (i.e., the coefficient of dR^*). Data used to implement this approach, which center around estimation of skin cancer risk perceptions together with reservation prices for the hypothetical good, are described in section III.

III. Data and Survey Methodology

Data on risk beliefs and related variables were collected through in-person interviews with 291 individuals in Laramie, Wyoming and San Diego, California.[4] Although these communities differ substantially in average annual temperature, both have a large number of sunny days each year, and residents have experience dealing with immediate consequences of exposure to sunlight, such as suntanning and sunburning. To facilitate testing for age and gender related differences in skin cancer risk beliefs, the sampling plan for each location called for surveying 12 males and 12 females in each of six age groups (21–30 years, 31–40 years, 41–50 years, 51–60 years, 61–70 years, and 71 years and older).[5] Thus, older cohorts were intentionally oversampled; the sample median age of 50 years exceeds that of the U.S. population by 18 years. Respondents were selected by dialing telephone numbers at random at various times during daytime and evening hours both on weekdays and weekends. After a brief introduction, in which age and gender were ascertained and the general purpose of the survey was stated, prospective respondents were added to the sample if they agreed to participate and if their age–gender cell was not already filled.[6] Prospective respondents were told that they would receive $15 at the end of a 45 minute interview and were allowed to choose a convenient time and location for the questioning.

The interview began by asking a brief sequence of questions to focus the respondent's attention on the general topic of skin damage from solar radiation exposure. For example, respondents were asked whether they ever had heard or read about skin cancer, whether they ever had been diagnosed by a physician as having this disease, and whether they knew of public figures, acquaintances, or relatives who had been treated for skin cancer. Respondents then were asked to make an initial assessment of the risk of contracting skin cancer. Risk assessments were measured using an illustration of a ladder with steps numbered from 0 to 20.[7] Respondents were asked to choose the step that best reflected their own chance (in 20) of contracting skin cancer during the remainder of their lives (or contracting it again if they had already had it). Additionally, they were told to ignore the issue of how severe their case might be. As discussed by Slovic, Fischhoff, and Lichtenstein (1985), people more easily understand lifetime rather than annual risks of relatively low-probability events.[8]

A frequency distribution of initial risk responses (*RISK*0) is shown in table 1. All steps were chosen at least three times, except the seventeenth which was never selected. The modal step chosen was the tenth. Table 1 reflects three possible and interrelated concerns with the initial risk data. First, because of the disproportionately large number of responses that occurred at steps 0, 5, 10, 15, and 20, some people appear to have been unable or unwilling to precisely estimate their risk of getting skin cancer in terms of chances in 20. Second, some respondents apparently were unsure of their answers. Immediately after providing their estimate of *RISK*0, respondents rated their degree of certainty in making this selection on a scale from 1 to 7 with larger values reflecting greater certainty. The mean of this variable was 4.4 with 67% of respondents choosing values of 4, 5, 6, or 7. Relatively greater uncertainty among respondents who chose lower values could arise for several reasons including a feeling of inadequate knowledge of skin cancer and/or inadequate understanding of probabilities (interviewers did explain the concept of chances in 20, however). Also, respondents who rated their degree of certainty at 1 or 2

[4] The survey instrument, available from the authors on request, was pretested on 21 volunteers in Laramie. Ages of these volunteers ranged from 23 to 71; 9 were females. Pretesting, which led to extensive revisions in the wording and order of questions, was conducted using the same interviewers who conducted the actual survey.

[5] Ideally, enough observations would be available to support separate statistical analyses (of determinants of skin cancer risk beliefs, for example) in each age/gender cell. Budget constraints, however, limited the number of respondents in the study. In consequence, the sampling plan was aimed at collecting sufficient numbers of observations to allow for regression analysis of the entire data set with age and gender intercept shifts. Also, the sampling plan called for a total sample of 288; however, interviewers unintentionally oversampled by three. These extra observations are used in the empirical analysis.

[6] Approximately 36% of prospective respondents declined to participate in the study. These individuals were disproportionately concentrated in the oldest two age groups. Comparing sample statistics with results of the 1990 census reveals that individuals who had not graduated from high school, were nonwhites or had household incomes exceeding $50,000 were underrepresented in the San Diego sample relative to their size in the population. The representation of these demographic groups in the Laramie sample, however, closely approximates their population frequencies, except that household incomes exceeding $50,000 are oversampled in Laramie while incomes less than $10,000 are undersampled.

[7] Gerking, de Haan, and Schulze (1988) used a similar approach in a mail survey designed to collect risk belief information about chances of accidental death in the workplace. That paper contains a diagram of the 10-step risk ladder shown to respondents. Seven example occupations were shown beside the ladder to provide reference points. In the present study, the ladder had 20 numbered steps and was professionally drawn on a large sheet of posterboard. After the initial risk question was asked, the interviewer unfolded the posterboard to reveal the ladder, explained the concept of "chances in 20," and attempted to make sure that the respondent understood. The respondent then was handed a token (from a common board game) and asked to place it on the ladder. Respondents made subsequent risk estimates by moving the token to another step on the ladder. The ladder did not show risks of other hazards, and there was no experimentation with other risk intervals (i.e., other than twentieths).

[8] The procedure of treating risks in the context of total outcomes within a base population has been successfully applied by, for example, Viscusi (1990, 1991) and Viscusi, Magat, and Huber (1987).

TABLE 1.—FREQUENCY DISTRIBUTION OF RISK RESPONSES

Step		Number of Responses		
		Initial (*RISK*0)	Revised (*RISK*1)	Final (*RISK*2)
0		21	19	71
1		22	19	45
2		20	29	34
3		17	38	35
4		12	23	17
5		39	25	23
6		9	15	15
7		18	14	8
8		15	12	5
9		3	4	2
10		51	42	10
11		3	3	3
12		8	5	1
13		3	4	1
14		5	1	2
15		17	14	6
16		4	4	4
17		0	1	1
18		5	2	1
19		4	3	2
20		15	14	5
	Total Responses	291	291	291
	Mean Step Chosen	7.6	6.8	3.8

were more likely than members of the whole sample (22% vs. 18%) to choose step 10 on the ladder; but were less likely than members of the whole sample (21% vs. 31%) to choose steps 0, 5, 15, and 20. Interestingly, all respondents at step 20 rated their certainty level at 6 or 7, and 11 of these had a previous diagnosis of skin cancer. Further analysis indicates that degree of certainty rises with *RISK*0 and is lower for college graduates than for those with less schooling.

Third, people appear to have overestimated the risk of contracting skin cancer. Although Mintzis (1986) estimates that people, on average, have a 1 in 7 chance of contracting skin cancer during their lifetime (step 3 on the ladder), table 1 indicates that 73% of respondents assessed their own risk at a higher level. Moreover, the mean of *RISK*0 (7.6) suggests that perceived risks are more than twice as high as Mintzis' estimate. This apparent overestimate is consistent with findings in related studies (for example, Viscusi (1991)). However, this comparison requires further explanation for at least two reasons. First, respondents who never have had skin cancer, particularly those in the older cohorts, may now have less than a 1 in 7 chance of contracting this disease in the remainder of their lifetimes. Second, Mintzis' estimate appears to refer to the number of people who will contract skin cancer, while the initial risk question, and thus the ladder, introduces the possibility that people can contract this disease more than once. In any case, because 15% of the sample already had been diagnosed with skin cancer and because this disease frequently is recurrent, a mean of *RISK*0 above step 3 on the ladder would not be unexpected.

After collecting initial risk assessments, interviewers provided respondents with Mintzis' estimate for the general population by saying that "In recent studies, medical researchers have estimated that the average person has about a 3 in 20 chance of getting some type of skin cancer during his or her lifetime (Step 3 on the risk ladder)." Interviewers also explained that according to available medical information, an individual's risk can vary from this average depending on: (1) amount of time spent in direct sunlight, (2) sensitivity of skin to sunlight, (3) extent of previous skin damage, such as severe sunburns or a prior diagnosis of skin cancer, and (4) defensive actions taken to avoid skin damage such as wearing protective clothing and using sun protection products. These risk factors were stated in order to introduce a series of questions, comprising over one-half of the survey, that allowed respondents to consider their own behavior and personal characteristics affecting the chances of getting skin cancer. Quantitative effects of these factors on actual risks were not presented; in fact, available data do not permit breakdowns of skin cancer risk by trait or behavioral characteristic. Data also were collected on respondents' socioeconomic and demographic characteristics including age, gender, marital status, income, schooling, and employment. Respondents then were given an opportunity to provide a revised risk estimate (*RISK*1) by choosing an alternative step on the risk ladder. A frequency distribution for this variable is shown in the third column of table 1. The mean of *RISK*1 is 6.8. When compared to the mean of *RISK*0 of 7.6, this outcome may reflect less revision in risk beliefs than occurred in related studies (Viscusi and O'Connor (1984) and Smith and Johnson (1988)), a point discussed more fully in section IV.

The final portion of the survey obtained data for valuing skin cancer risk reductions. The approach taken was to unbundle characteristics of a hypothetical sun protection product that offered protection against skin cancer for one year after use. Eight labels (see appendix A for an example) were prepared to describe all possible combinations of three product characteristics: (1) skin cancer protection in regular strength or extra strength, (2) presence or absence of protection against premature aging of skin, and (3) sunblock formula, to prevent all burning and tanning, or tanning formula to allow tanning but not protect against burning. Care was taken to design labels to look like those found on over-the-counter sunscreen products and to make the purchase scenario believable.[9] In particular, respondents were told (and labels also stated) that the sunscreen would be FDA approved and is guaranteed not to wash off, feel greasy, or stain clothing. Also, interviewers said that very long-lasting sunscreens may be marketed in future using results from current research on vitamin A derivative products. Two labels were randomly assigned to each respondent and of the 12 respondents in each age/gender cell in each of the two communities, six were given two extra strength labels and

[9] Also, much of the terminology on the labels was chosen to resemble language found on labels of over-the-counter products, which often describe "protection" of skin and reduced "chances of skin cancer" as benefits of use. However, use of the word "protect" may have encouraged some respondents to believe that use of the sunscreen would eliminate all skin cancer risk.

six were given two regular strength labels. There are six ways to form pairs of the four labels of a given strength, and each of the six pairs was given to two respondents in each cell. Thus, the labels together with the sample design allow product characteristics to vary independently and facilitate estimation of option prices for reduced skin cancer risk.

After making sure that respondents had read the first label shown, interviewers asked whether they would buy the product. Those answering "yes" (64% of the sample) then were asked: "What would be the maximum amount you would be willing to pay for the first bottle (remember that one bottle lasts an entire year)?"[10] Then all respondents, whether or not they would purchase the sunscreen, were asked to think about applying it at one year intervals for the rest of their lives, and asked whether their lifetime skin cancer risk would change if they did so. Those answering "yes" (74% of the sample) were asked to select a new step on the risk ladder to represent their lifetime risk of skin cancer assuming use of the new sunscreen. Those answering "no" were assigned their previously selected value of *RISK*1. This outcome resulted in the frequency distribution for *RISK*2 shown in the fourth column of table 1. Finally, interviewers gave respondents the second label in their assigned pair, allowed time to read it, and repeated the questions about purchase intentions for the first bottle and willingness to pay. The risk assessment question was not repeated because cancer protection strength was the same for each respondent.

Perceived risks conditional on lifetime use of the new sunscreen have a mean of 3.8, reflecting an average risk reduction of 2.9 ladder steps. Although 26% of respondents believed the sunscreen would not reduce their risk at all, others associated substantial risk reduction with use of the product. Expressed as a percentage of *RISK*1, the risk reduction has a mean of 48% and a median of 50%. Also, 18% of respondents felt that lifetime use would reduce risk to zero suggesting that possible certainty premiums in reservation prices should be investigated (see section V).[11]

Frequency distributions of sunscreen reservation prices, tabulated by first and second label offered, are shown in table 2. Reservation prices range from $0, the value assigned to those who would not purchase, to $1,000; prices are disproportionately concentrated at lower values. In total, 8% of observations are above $50 per bottle and the mean price computed over both labels offered was $24.66.[12] The mean bid was 45.5% higher for the second label than for the first, although the median bid was $10 for each. Because presentation of labels was randomized, as described above, reasons why respondents tended to bid more for the second label are a matter of speculation.

TABLE 2.—FREQUENCY DISTRIBUTION OF SUNSCREEN RESERVATION PRICES BY LABELS

	Number of Responses		
Reservation Price	First Label	Second Label	Total
$0 (Would not purchase)	107	103	210
$1.00–$5.00	22	22	44
$5.01–$10.00	43	29	72
$10.01–$15.00	18	25	43
$15.01–$20.00	31	26	57
$20.01–$25.00	20	22	42
$25.01–$50.00	31	36	67
$50.01–$75.00	2	9	11
$75.01–$100.00	10	10	20
$100.01–$200.00	5	4	9
$200.01–$300.00	1	0	1
$300.01–$500.00	1	4	5
$1000	0	1	1
Total Responses	291	291	582
Median Reservation Price	$10	$10	$10
Mean Reservation Price (including $0 amounts)	$20.12	$29.29	$24.66

IV. Determinants of Risk Beliefs

Table 3 reports estimates of a risk perception function (equation (5)) and sample means of variables used in the analysis. Explanatory variables measure respondents' attitudes toward and awareness of skin disorders, genetic attributes, prior information, and economic circumstances that may determine risk beliefs about skin cancer and related effects of exposure to sunlight. Prices of market goods and total time available per day are assumed to be the same for all respondents and, therefore, do not appear as explanatory variables in the equations estimated. Age variables serve to proxy remaining years of life. Column 4 of table 3 presents fully-censored regression (see Stewart (1983)) estimates of an equation for *RISK*0. This estimation method was chosen because, as shown in table 1, 7% of observations on *RISK*0 occur at the lower limit of zero and 5% occur at the upper limit of twenty. Also, this method captures the idea that respondents have a continuous, latent "true" subjective risk assessment and choose the step on the ladder that most closely reflects the value of the latent variable. Estimates presented show how respondents formed their initial risk

[10] This open-ended format for valuation questions often yields high nonresponse rates and/or a large number of protest zeros and implausibly high or low stated values (Freeman (1993), p. 171; Mitchell and Carson (1989)). As noted by Mitchell and Carson (p. 97), however, the format works smoothly in some cases, particularly if respondents are familiar with paying for similar goods. In the present study, there is a 100% response rate to the valuation question among those who indicated they would purchase the sunscreen lotion.

[11] Those who believe the sunscreen can eliminate all risk evidently attach a large (and perhaps implausible) weight to future incremental exposure relative to past exposure. Indeed, further analysis indicates that those with less past exposure perceive significantly larger risk reductions, including younger individuals and those who report they have not previously spent a lot of time outdoors in direct sunlight. In any event, neither the product labels nor the interviewers offered specific instructions on distinguishing past from future exposure.

[12] A possible concern about the sunscreen reservation price data relates to the $15 payment to respondents for participating in the survey. However, because all respondents received the payment, this potential source of bias cannot be investigated.

TABLE 3.—DETERMINANTS OF *RISK*0 AND *RISK*1

Explanatory Variable	Definition	Sample Mean	Dependent Variables[a]	
			*RISK*0	*RISK*1
*RISK*0	= Initial lifetime skin cancer risk assessment	—	—	0.920[c] (0.03)
SCDIAG	= 1 if have been diagnosed with skin cancer	0.15	6.295[c] (1.00)	1.503[c] (0.42)
KNOWANY	= 1 if know acquaintance or relative or know of a public figure who has had skin cancer	0.87	1.806[c] (0.94)	0.942[c] (0.38)
FAIR	= 1 if natural skin color is fair	0.20	—[b]	—[b]
MODFAIR	= 1 if natural skin color without suntan is moderately fair	0.39	−2.545[c] (0.88)	0.132[c] (0.35)
MEDIUM	= 1 if natural skin color without suntan is medium	0.29	−2.903[c] (0.96)	−0.109 (0.39)
DARK	= 1 if natural skin color without suntan is dark/olive	0.12	−2.119[c] (1.19)	−0.121 (0.48)
*NOT TYPE*1	= 1 if skin response to 2 hrs direct sunlight without special protection is not "always burns"	0.62	−0.496 (0.72)	−0.694[c] (0.29)
BADBURN	= 1 if have ever had a sunburn with blisters	0.56	1.106 (0.66)	−0.629[c] (0.27)
ALOTSUN	= 1 if have spent a lot of time in sun in lifetime	0.77	2.038[c] (0.76)	−0.027 (0.31)
TWENTY	= 1 if age 21–30	0.16	—[b]	—[b]
THIRTY	= 1 if age 31–40	0.17	−2.135[c] (1.07)	−0.205 (0.43)
FORTY	= 1 if age 41–50	0.17	−1.107 (1.15)	−0.064 (0.46)
FIFTY	= 1 if age 51–60	0.17	−3.119[c] (1.18)	−0.342 (0.48)
SIXTY	= 1 if age 61–70	0.16	−2.448[c] (1.26)	−0.325 (0.50)
SEVENTY	= 1 if age 71 or older	0.17	−3.102[c] (1.29)	−0.776 (0.52)
MALE	= 1 if male	0.50	−0.415 (0.66)	0.723[c] (0.26)
IMPSKCAN	= 1 if avoiding skin cancer not unimportant	0.71	0.074 (0.95)	−0.806[c] (0.38)
IMPAGING	= 1 if avoiding premature aging of skin not unimportant	0.73	0.663 (0.86)	0.083 (0.34)
IMPBURN	= 1 if avoiding sunburn not unimportant	0.73	0.694 (0.86)	0.542 (0.35)
LARAMIE	= 1 if live in Laramie, 0 if San Diego	0.50	−0.107 (0.65)	−0.526[c] (0.26)
MARRIED	= 1 if currently married	0.56	1.082 (0.71)	0.177 (0.28)
INCOME	= household annual income, ten thousand dollars	3.39	0.091 (0.19)	−0.101 (0.08)
COLLGRAD	= 1 if college graduate	0.39	0.552 (0.69)	0.070 (0.28)
EMPLOYED	= 1 if employed full- or part-time	0.55	0.735 (0.81)	−0.279 (0.32)
BLUE	= 1 if blue-collar occupation	0.25	1.556[c] (0.77)	0.131 (0.31)
CONSTANT		—	4.752[c] (1.77)	−0.756 (0.72)
σ		—	5.081[c] (0.23)	1.993[c] (0.09)
Log-Likelihood			−811.82	−568.19
Chi-Square			103.90	589.72
p-value for likelihood ratio test that coefficients of all explanatory variables are jointly zero			<.001	<.001

[a] Asymptotic standard errors are in parentheses beneath coefficient estimates.
[b] Denotes omitted dummy variable.
[c] Denotes significance at 5% level using one-tail test.

beliefs. Data on initial risk beliefs were collected *prior* to obtaining information on all variables except whether respondents knew of anyone who ever had contracted skin cancer or whether they themselves ever had been diagnosed by a physician as having this disease.

The log-likelihood value for this equation suggests that initial skin cancer risk assessments are significantly related at the 1% level to measurable risk factors and related variables. Both variables measuring prior experience with skin cancer (*SCDIAG* and *KNOWANY*) positively and significantly affect *RISK*0. As reported by Greenberg et al. (1990), people who previously have had a nonmelanoma skin cancer face a higher risk for another. The coefficient of *SCDIAG* indicates that individuals previously diagnosed with skin cancer perceive lifetime risks approximately 30 percentage points higher than other individuals.

Additionally, individuals with moderately fair, medium, or dark complexions perceive lower levels of skin cancer risk as compared with those having a fair complexion. Personal experience with solar radiation exposure, such as a judgment that a lot of time previously had been spent in the sun, elevate *RISK*0. These results are of interest because they suggest that people account for important objective risk factors and exposure history when forming risk beliefs. Comparison of predicted *RISK*0 values with actual risks would be a logical next step; however, medical data on nonmelanoma skin cancers (the overwhelmingly predominant type) are weak and, as indicated previously, breakdowns by skin type and solar radiation exposure history are not possible. Thus, the issue of accuracy and rationality of perceived risk assessments is not pursued beyond testing whether beliefs are predictably related to objective risk factors.

Results also show that the youngest respondents (those in the age group 21–30) perceive significantly higher lifetime skin cancer risk than older respondents, although coefficients of dummy variables for age do not show a systematic pattern of decline. This outcome has at least two competing interpretations. First, as more fully discussed by Viscusi (1991), it is consistent with a Bayesian learning model in which younger people weight recent publicity about risk more heavily than would older people and older people weight experience with risky activities more heavily than would younger people. Further analysis, however, does not support this interpretation. Viscusi's conjecture suggests that effects of experience with solar radiation (measured by *BADBURN*, *ALOTSUN*, *SCDIAG*, and *KNOWANY*) should intensify with age. Interactions between age and experience variables, when added to the table 3 equation for *RISK*0, had coefficients that were not jointly, significantly different from zero at conventional levels ($p = 0.34$).[13]

Second, the effect of age on initial risk assessments instead may suggest that respondents distinguished between marginal and cumulative hazards. As people age, they face a greater chance of experiencing skin cancer in a given year. However, members of younger cohorts appear to face larger cumulative lifetime risks, both because they would expect to live longer (and, thus, have more time available to contract skin cancer) and because lifetime skin cancer risks have been increasing. Glass and Hoover (1989) report that skin cancer risks now have grown to "epidemic proportions" and that incidence rates of squamous cell skin cancer and melanoma have increased by a factor of three or four since the 1960s. In any case, this speculation is not conclusive and the role of age or life expectancy in subjective risk assessments will be an important topic to consider in future studies.[14]

Remaining explanatory variables do not significantly affect *RISK*0, except that blue collar workers report higher values of *RISK*0 than do others.[15] This result presumably occurs because they spend more time in sunlight while on the job.[16] Men and women evidently perceive similar levels of initial risk.[17]

Column 5 of table 3 presents fully-censored regression estimates of the determinants of *RISK*1, the revised estimate of lifetime skin cancer risks made by respondents after receiving information. This equation includes *RISK*0 as an explanatory variable, and can be interpreted in the Bayesian learning framework used by Viscusi and O'Connor (1984) and Smith and Johnson (1988). Because only 28.2% of respondents in the present study revised their original risk assessment, *RISK*0 is highly significant in explaining variation in *RISK*1, and because 88% of revisions were downward, the coefficient of *RISK*0 is significantly lower than unity. Remaining coefficient estimates measure effects of variables on revised risk assessments after controlling for initial assessments.

As shown in table 3, individuals who had a previous diagnosis and/or who knew of others having skin cancer still perceive higher risk (net of effects of *RISK*0) than individuals having less direct experience with the disease, while those who view avoiding skin cancer as important perceive lower risk. These results reflect the greater propensity of less knowledgeable or more concerned individuals to use information provided and then decrease their risk assessments. In an unreported probit equation to explain the probability of revision based on the same explanatory variables used in the *RISK*1 equation, coefficients of *SCDIAG* and *KNOWANY* are negative and significant (at 5%). The higher probability of revision among less knowledgeable individuals, coupled with the previously noted tendency to revise downward, results in the less informed group making significantly lower revised risk assessments, net of effects of initial assessments. Similarly, importance of avoiding skin cancer

[13] Results from this and other supplementary regressions referred to later in the text are available from the authors on request.

[14] A referee suggested that effects of solar radiation experience may not intensify with age because tanning was not a way to show a healthy and attractive appearance until relatively recently. Earlier in life, older people may have avoided the sun to maintain a youthful look and to avoid leaving the impression that they had to work outdoors.

[15] The "importance" variables (*IMPSKCAN*, *IMPAGING*, *IMPBURN*) are included as measures of attitudes towards effects of sunlight exposure (denoted as α in equation (5)). These variables are jointly insignificant in the *RISK*0 equation, however, and removing them does not substantially alter other coefficients.

[16] A supplementary regression (available on request) to explain time currently spent outdoors between 10:00 a.m. and 3:00 p.m. suggests that blue collar workers spend significantly more work time but no more leisure time in direct sunlight than other individuals. Also, current exposure is not as closely related to historical exposure as might be expected; the Pearson correlation between *BLUE* and *ALOTSUN* is 0.11.

[17] Men and women appear to weight the various determinants of risk differently, however. When the *RISK*0 equation is re-estimated including interactions between all explanatory variables and *MALE*, the hypothesis that coefficients of interaction variables are jointly zero is rejected at less than 1%.

is positively associated with the probability of revision, leading to lower revised risk assessments among more concerned individuals.

A few other variables are significantly related to *RISK*1 at the 5% level in a two tail test after removing effects of *RISK*0. People with some sensitive skin types perceive lower levels of risk, as do males and those who recall a sunburn with blisters. The insignificant effects of age categories suggest that the effect of age on skin cancer risk beliefs operates mainly through initial assessments rather than through responses to information.

The table 3 estimates reflect smaller revisions in risk beliefs as compared with findings of Viscusi and O'Connor (1984) and Smith and Johnson (1988). These two studies compute a ratio measuring how information received by respondents is weighted relative to information already possessed. The denominator is the weight respondents attached to their original estimate when making their revised estimate. The numerator is the weight implicitly attached to information received, calculated using the ex post restriction that the two weights sum to unity. Ratios reported by Viscusi and O'Connor exceed unity in 7 of 8 cases considered and exceed 30 when the risk revision is largest, suggesting that information respondents received dominated prior beliefs in revised risk assessments. Smith and Johnson report a substantially smaller ratio of approximately one-third.

A similar calculation was performed by re-estimating the *RISK*1 equation with the constraint that the weights sum to unity, yielding a ratio of 0.16. Possible explanations for the more limited revision of risk estimates found here include: (1) when people provide their own current estimate of a risk, they may be more reluctant to alter it than in situations where they are asked to make a retrospective judgment as was necessary in the Smith and Johnson study; (2) there is a greater difference between the risk information provided and respondents' priors in the Viscusi and O'Connor study than between Mintzis' estimate and the mean of *RISK*0, or more generally, people may be more knowledgeable about skin cancer risk than other hazards, so that information provided by the interviewers may already have been known; (3) information provided verbally may have less impact than it would if provided in a pamphlet or label, as was done in the cited studies; and (4) the nature of the risks may differ in several important respects. Specifically, skin cancer is rarely fatal, while exposure to radon gas and certain chemicals may be associated with less easily treated diseases; many people have more direct experience with skin cancer or other consequences of sunlight exposure than they would with other diseases, as evidenced by means of *SCDIAG*, *KNOWANY*, *ALOTSUN* and *BADBURN*; and skin cancer risks are large relative to risks often considered in other studies.

V. Option Price of Reducing Skin Cancer Risk

Option price estimates for reducing skin cancer risk are based on equation (6) in section II and make use of the risk data analyzed in section IV. In this section, attention is primarily directed to treatment of joint production and related conceptual issues. Option price estimates presented are intended to illustrate methods developed, although they also may be of possible policy relevance. Results presented in table 4 use respondents' intended expenditures (bids) on the sunscreen described in section III as the dependent variable. Bids are assumed to be generated by

$$RPRICE_{ij} = \begin{cases} RPRICE^*_{ij} & \text{if} \quad RPRICE^*_{ij} \geq M \\ 0 & \text{if} \quad RPRICE^*_{ij} < M \end{cases} \qquad (7)$$

where $RPRICE^*_{ij}$ is a latent variable measuring respondent i's ($i = 1, \ldots, 291$) reservation price for one bottle of sunscreen on the j^{th} opportunity to purchase it ($j = 1, 2$). Positive bids are observed when $RPRICE^*_{ij}$ is greater than or equal to M, the expected market price, which is assumed to be constant for all respondents. Also, as previously discussed, $RPRICE_{ij}$ pertains to a one year's supply of sunscreen, rather than to a lifetime supply as envisioned by the model. This discrepancy is treated as an errors-in-variables problem in which the always non-negative error imparts a downward bias to the estimate of the constant term, but does not affect estimates of other coefficients. Calculation of the option price hinges on the relationship between the reservation price and *DRISK* which measures the reduction in perceived lifetime risk of skin cancer when other sunscreen characteristics are held constant.

Estimates presented in table 4 were obtained using maximum likelihood methods adapted from Smith and Blundell (1986). This joint estimation procedure takes account of probable simultaneity between *RPRICE* and *DRISK*, and includes a tobit component in the likelihood function for *RPRICE* as well as a linear regression component for *DRISK*. Also, because each respondent had the opportunity to report two reservation prices, estimates are obtained in a random effects framework where the error term in the *RPRICE* equation is the sum of permanent and transitory components.[18] Computations used the quadrature routine of Butler and Moffitt (1982). Joint maximum likelihood estimation was pursued after application of Smith and Blundell's exogeneity test which resulted in rejecting the null hypothesis of exogeneity of *DRISK* at 1% significance in preliminary regressions. Estimates of the *DRISK* equation are reported in appendix B. Coefficient estimates in both of the table 4 equations are jointly, statistically significant at conventional

[18] A three step procedure was used to obtain the estimates presented. First, a least squares regression of *RPRICE* on its determinants was estimated with no account taken of repeated observations to obtain initial coefficient values. Second, these initial values were used in joint maximum likelihood estimation of *RPRICE* and *DRISK* equations with no account taken of repeated observations. Third, joint maximum likelihood estimates incorporating the variance components structure were obtained using the step two estimates as start-up values. Note that the variance components framework incorporated here was not treated by Smith and Blundell (1986).

TABLE 4.—DETERMINANTS OF THE SUNSCREEN RESERVATION PRICE[a]

Explanatory Variable	Definition	Sample Mean	Coefficient Estimates[b] (1)	(2)
DRISK	= −(*RISK*2 − *RISK*1)	2.93	54.703[e]	43.718[e]
			(7.73)	(6.87)
*R*1	= 0 ≤ *RISK*1 ≤ 1	0.13	—[c]	—[c]
*R*2	= 2 ≤ *RISK*1 ≤ 4	0.31	45.028[e]	27.880[e]
			(7.92)	(9.17)
*R*3	= 5 ≤ *RISK*1 ≤ 9	0.24	−29.325[e]	−60.248[e]
			(10.99)	(12.83)
*R*4	= 10 ≤ *RISK*1 ≤ 14	0.19	−69.641[e]	−95.562[e]
			(15.90)	(15.65)
*R*5	= 15 ≤ *RISK*1 ≤ 20	0.13	−147.72[e]	−157.61[e]
			(21.77)	(22.98)
LOWINC	= 1 if household annual income <$20,000	0.30	—[c]	—[c]
MEDINC	= 1 if $20,000 ≤ household annual income <$40,000	0.38	−15.532	−9.012
			(24.03)	(22.88)
HIGHINC	= 1 if household annual income ≥ $40,000	0.32	−0.683	−4.971
			(26.32)	(23.85)
*R2*DRISK*	= Interaction of *R*2 and *DRISK*	0.49	−17.905[e]	−4.117
			(4.85)	(4.92)
*R3*DRISK*	= Interaction of *R*3 and *DRISK*	0.78	−4.383	6.966
			(4.08)	(4.35)
*R4*DRISK*	= Interaction of *R*4 and *DRISK*	0.98	−2.833	9.296[e]
			(4.07)	(3.97)
*R5*DRISK*	= Interaction of *R*5 and *DRISK*	0.63	−4.883	6.532
			(3.87)	(4.08)
*MED*DRISK*	= Interaction of *MEDINC* and *DRISK*	1.17	0.675	−1.972
			(1.43)	(1.45)
*HIGH*DRISK*	= Interaction of *HIGHINC* and *DRISK*	0.95	6.045[e]	5.938[e]
			(1.47)	(1.65)
DT	= 1 if respondent uses sun protection products to remain in sunlight for a longer time	0.34	−14.744	−13.343
			(21.95)	(20.11)
AGEFRM	= 1 if label indicated protection against aging	0.50	2.922	—[c]
			(4.59)	
TANFRM	= 1 if label indicated no protection against sunburn	0.50	6.361	—[c]
			(5.86)	
*IMPAGING*AGEFRM*	= Interaction of *IMPAGING* and *AGEFRM*	0.32	9.400	—[c]
			(7.52)	
*IMPBURN*TANFRM*	= Interaction of *IMPBURN* and *TANFRM*	0.37	−11.430[e]	—[c]
			(7.02)	
*TANTRY*TANFRM*	= Interaction of *TANTRY*[d] and *TANFRM*	0.11	19.118[e]	—[c]
			(8.53)	
CONSTANT		—	−112.59[e]	−92.540[e]
			(32.02)	(29.65)
σ_v	Standard deviation of transitory error component	—	24.874[e]	24.865[e]
			(0.81)	(0.71)
σ_u	Standard deviation of individual specific error component	—	38.654[e]	37.979[e]
			(1.80)	(1.98)
Log-Likelihood			−2822.3	−2854.5

[a] The reservation price equation is estimated jointly with the *DRISK* equation.
[b] Asymptotic standard errors are in parentheses beneath coefficient estimates.
[c] Excluded variable.
[d] *TANTRY* = 1 if respondent reports spending time in sunlight mainly for the purpose of getting a tan.
[e] Denotes significance at 5% level using one-tail test.

levels. Also, estimates of the standard errors of the error components are statistically significant and indicate the relative importance of unmeasured individual effects in determining intended sunscreen expenditures.

In column (1) of table 4, joint production is controlled by including variables measuring the contribution to value of the sunscreen arising from its perceived effects on aging and/or wrinkling of skin and suntanning/sunburning. These controls are excluded from column (2). In contrast to treatment of changes in skin cancer risk perceptions measured by *DRISK*, effects on aging/wrinkling and suntanning/sunburning were not directly measured in the survey. Instead, they are accounted for by including dummy variables reflecting the type of sunscreen offered (tanning, sunblock, and/or aging formulae) interacted with measures of attitudes toward the condition(s) against which protection is provided. These attitudinal effects are important because an individual's intended expenditure on sunscreen is determined jointly through interaction of product characteristics and preferences (note the presence of utility terms in equation (6)).

Comparison of the column (1) equation to the column (2) equation reveals that the controls for joint production are statistically significant at less than the 1% level using a likelihood ratio test.[19] Also, respondents who felt that avoiding sunburn was important, but who received the tanning formula label (which did not offer protection against sunburning), bid less for the new sunscreen. On the other hand, people who spend time in direct sunlight for the purpose of getting a tan bid larger amounts of money when offered a tanning formula label. In contrast to results for tanning/burning effects, labels offering protection against aging/wrinkling of skin did not inspire significantly larger reservation prices even among those who felt it important to avoid this problem. This outcome may imply that people truly are unwilling to pay for protection against aging/wrinkling of skin. It may also suggest, however, that the survey instrument did not adequately stress this factor relative to other consequences of exposure to sunlight. More generally, the contrasting results obtained for aging/wrinkling and suntanning/sunburning effects may indicate that methods adopted here to treat joint production are most effective when the consequences examined are familiar and/or immediate.

Results from table 4 can be used to compute option price estimates by income and risk category. In particular, as shown in equation (6), the coefficient of risk change (measured as *DRISK*) is interpreted as the option price of a one unit reduction in risk. Because this coefficient depends on the value of time (a component of the full price of the composite good) and initial levels of risk perceived at the time the sunscreen was described, *DRISK* was interacted with *RISK*1 and a measure of income in the table 4 regressions.[20] Estimates show that *DRISK* has a positive and significant effect on the sunscreen bid. This effect is significantly larger for respondents who have higher incomes and varies according to perceived skin cancer risk levels. Results of calculations are shown in table 5 and are interpreted as ex ante willingness to pay for a one-step movement down the risk ladder, which is equivalent to a 5 percentage point reduction in lifetime skin cancer risk. Estimates reported in panel A of table 5 are computed by adding the coefficient of *DRISK* to coefficients of relevant interaction variables from the regression in column (1) of table 4 and incorporate controls for joint products of sunscreen use; estimates reported in panel B are based on the column (2) regression, which does not include joint production controls.

Four features of table 5 are worth further discussion. First, comparison of panels A and B in table 5 is useful because the direction and magnitude of bias resulting from omitting controls for joint production is difficult to predict a priori. Estimated option prices presented in panel A range from $36 to $61 (1988 dollars). Omitting controls for joint products in panel B leads to option price estimates that are as much as 25% lower than corresponding estimates in panel A. The largest difference in option prices occur at the lowest values of *RISK*1 ($0 \leq RISK1 \leq 4$). Interestingly, panel A and panel B estimates are quite similar when $5 \leq RISK1 \leq 20$. This result may not be indicative of outcomes when joint production is analyzed in other settings; however, even comparatively small differences in option price estimates can mount into substantial sums when national benefit estimates are computed by aggregating over a population of hundreds of millions.

TABLE 5.—OPTION PRICES TO REDUCE SKIN CANCER RISK[a]

Risk Category	Low Income	Medium Income	High Income
	A. WITH JOINT PRODUCTS[b]		
$0 \leq RISK1 \leq 1$	$54.70	$55.38	$60.75
	(7.734)	(7.597)	(7.416)
$2 \leq RISK1 \leq 4$	$36.80	$37.47	$42.84
	(7.873)	(7.647)	(7.493)
$5 \leq RISK1 \leq 9$	$50.32	$51.00	$56.37
	(7.561)	(7.385)	(7.184)
$10 \leq RISK1 \leq 14$	$51.87	$52.55	$57.92
	(7.250)	(7.087)	(6.921)
$15 \leq RISK1 \leq 20$	$49.82	$50.50	$55.87
	(7.544)	(7.259)	(7.067)
	B. WITHOUT JOINT PRODUCTS[b]		
$0 \leq RISK1 \leq 1$	$43.72	$41.75	$49.66
	(6.865)	(6.940)	(6.631)
$2 \leq RISK1 \leq 4$	$39.60	$37.63	$45.54
	(7.661)	(7.747)	(7.255)
$5 \leq RISK1 \leq 9$	$50.68	$48.71	$56.62
	(7.273)	(7.372)	(6.898)
$10 \leq RISK1 \leq 14$	$53.01	$51.04	$58.95
	(6.887)	(7.01)	(6.613)
$15 \leq RISK1 \leq 20$	$50.25	$48.28	$56.19
	(7.409)	(7.50)	(6.899)

[a] Ex ante willingness to pay (1988 dollars) per one ladder step (5 percentage point) reduction in lifetime risk of contracting skin cancer. Computed based on equation (6) and results in table 4.
[b] Asymptotic standard errors are in parentheses.

Second, estimates presented may provide evidence of a certainty premium in skin cancer risk valuation, thus supporting findings of Viscusi, Magat and Huber (1987). Results indicate that the option price per unit of risk reduction is significantly higher when computed from step 1 on the risk ladder, than when computed from steps 2–4. Interpreting these results as evidence of a certainty premium, however, is weakened because respondents who reported $RISK1 = 1$ generally did not report $RISK2 = 0$, and thus did not envision making the one step change required to eliminate risk.[21] Also, the approach taken here to valuing risk reduc-

[19] Twice the difference in likelihood values in the table 4 equations is χ^2 distributed with 10 degrees of freedom. (When the five joint production controls were excluded in estimating the column (2) equation, they also were excluded from the corresponding equation for *DRISK*.) The value of this statistic is 64.40 whereas the 1% significance point is 23.209.

[20] Respondents are expected to interpret benefits of the product in light of their own estimates of initial risk and risk change. Regressors involving *DRISK* and initial risk levels control for variation in these perceptions.

[21] An alternative approach which avoids this problem (but introduces others) is to allow marginal valuation to differ for those who report zero final risk ($RISK2 = 0$), regardless of their initial risk level. This approach was implemented by replacing the baseline risk (*RISK*1) categories in table 4 with final risk categories (*RISK*2). Results indicate that the marginal value of risk reduction is significantly greater when final risk is zero than when final risk falls on steps 1 or 2 of the ladder. Marginal values then increase with further increases in final risk. These results offer additional support for existence of certainty premia but should be interpreted cautiously because: (1) *RISK*2 was treated as exogenous while for consistency with the model and exogeneity tests of table 4, *RISK*2 should be viewed as endogenous, and (2) the approach does not

tion is not directly comparable to that used by Viscusi, Magat, and Huber, although it is consistent with the section II model of protective behavior. In the present study, respondents may begin from any risk level and may choose any size of risk reduction; whereas in the earlier study, respondents were assigned initial risk levels and equal exogenous risk reductions.

Third, option price calculations show that (1) risk reduction and the composite good are substitutes and (2) for $RISK1 \geq 2$, those perceiving high initial levels of risk are willing to pay more per unit of risk reduction than those perceiving lower levels of risk.[22] The latter outcome indicates that, apart from certainty effects, the shape of indifference curves in the risk, composite good plane is consistent with theoretical analyses of Jones-Lee (1974) and Weinstein, Shepard, and Pliskin (1980) and empirical results of Jones-Lee, Hammerton, and Philips (1985) and Gerking, de Haan, and Schulze (1988) who examine traffic safety and job safety, respectively.

Fourth, option price estimates in table 5 should be interpreted cautiously because they may be subject to sources of both upward and downward bias. On the one hand, respondents may not have fully internalized the value of risk reduction, perhaps because the sunscreen product was new to them or because they experienced difficulty in monetizing a change in risk. Also, some respondents may have implicitly made protest zero bids (recall from table 2 that about 36% would not buy the new sunscreen) and others may have used prices of currently marketed sunscreens as a ceiling or focal point when deciding how much to bid (note that in table 2, 116 of 362 nonzero bids for both labels were in the $1.00–$10.00 range and the median bid was $10). These concerns would result in option price estimates that are too low. On the other hand, because estimated joint production effects of skin aging/wrinkling are quite small, another possibility is that respondents did not fully adjust their sunscreen bids to account for this effect, which might make option price estimates too large. In any case, multiplying option price estimates in panel A of table 5 by 20 yields values per skin cancer case avoided ranging from about $720 to about $1,200. As expected, these figures are well below commonly cited value of life estimates because skin cancer seldom is fatal. Also, they overlap at the lower end of the range of values ($1,036–$2,538) surveyed by Viscusi (1993, table 7, pp. 1941–1942) for avoiding skin poisoning from insecticide and they are below the range of medical treatment cost estimates for nonmelanoma skin cancer ($4,000–$7,000) reported by the U.S. Environmental Protection Agency (1987). Willingness to pay estimates reported here, however, envision payment to avoid a future case of skin cancer, whereas the comparative studies appear to focus on payments to avoid more immediate disorders.

VI. Conclusions

This paper has presented empirical evidence on how individuals form beliefs about skin cancer risk and on links between risk beliefs and willingness to pay to reduce risk. A perceived risk equation is derived from a model in which risks are determined jointly with utility maximizing allocations of goods and time. Estimates of this equation indicate that people account for important risk factors including complexion and sunlight exposure history when assessing skin cancer risk. Perceived lifetime risks are lower among older than among younger individuals, suggesting that people are able to distinguish between marginal and cumulative hazards. The extent of revision of risk assessments in response to information is smaller than in related studies, but less knowledgeable and more concerned individuals demonstrated a greater propensity to use information provided to reduce their risk assessments. Caution should be exercised in generalizing these results to other risks, however, owing to unique features of skin cancer including the size of the risk and the amount of experience people have with skin cancer or other consequences of sunlight exposure.

The link between risk beliefs and willingness to pay to reduce risk was examined using individuals' reservation prices for a sun protection product. This product, which combined up to three types of protection from solar radiation (aging/wrinkling of skin, suntanning/sunburning, and risk of skin cancer), was described using labels. By independently varying the three types of protection across labels and obtaining reservation prices after randomly assigning labels to respondents, the value of skin cancer risk reduction could be separated from the value of other product characteristics. This approach appears to hold promise for obtaining values for other nonmarket commodities in surveys when joint production issues must be addressed. Estimates indicate that willingness to pay per unit risk reduction is positive and increases with income. Also, willingness to pay may include a certainty premium for people initially perceiving low levels of risk.

distinguish between those who move to $RISK2 = 0$ with use of the new sunscreen and those who already perceived $RISK1 = 0$.

[22] Although the option price of risk reduction at the highest initial risk levels ($15 \leq RISK1 \leq 20$) is smaller than the coefficient of $R4$ is lower at the next highest risk level ($10 \leq RISK \leq 14$), this difference is not significantly different from zero at 5%.

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APPENDIX

APPENDIX A.—EXAMPLE SUNSCREEN LABEL

Front of Bottle	Back of Bottle
	New SKINSAVER® sun protection lotion is dermatologist-tested to protect your skin from the harmful effects of the sun.
SKINSAVER®	* REGULAR STRENGTH helps protect your skin from the chance of getting skin cancer.
Sun Protection Lotion	* TANNING FORMULA allows your skin to tan as it would naturally, does not protect against burning.
"The skin protection with staying power." Lasts up to one full year.	* UVB PROTECTION blocks UVB light, helping protect against wrinkling and premature aging of your skin.
REGULAR STRENGTH TANNING FORMULA	* One application lasts up to one full year.
UVB PROTECTION	* FDA approved.
(UVB's are the harmful ultraviolet rays)	* Hypoallergenic.
	* Unscented.
4 fluid ounces	DIRECTIONS: For the most complete protection, apply entire contents of bottle to all areas of your skin not covered by a bikini swimsuit. Allow 15 minutes before bathing, swimming, or heavy exertion. FOR EXTERNAL USE ONLY.
	ACTIVE INGREDIENTS: Octyl Methoxycinnamate, Benzophene-3, titanium dioxide.

APPENDIX B.—DETERMINANTS OF *DRISK*

Explanatory Variable	Coefficient Estimates (1)	(2)
*RISK*1	0.213[a]	0.204[a]
	(0.027)	(0.024)
KNOWANY	−0.037	0.079
	(0.123)	(0.126)
FAIR	—[b]	—[b]
MODFAIR	−0.025	0.047
	(0.087)	(0.084)
MEDIUM	0.150	−0.023
	(0.098)	(0.102)
DARK	0.244[a]	−0.042
	(0.119)	(0.131)
*NOTTYPE*1	0.015	0.042
	(0.084)	(0.085)
BADBURN	0.433[a]	0.162[a]
	(0.096)	(0.077)
ALOTSUN	−0.074	0.020
	(0.081)	(0.083)
EMPLOYED	0.169[a]	0.091
	(0.102)	(0.104)
BLUE	0.052	−0.038
	(0.084)	(0.085)
SCDIAG	0.239[a]	0.875[a]
	(0.113)	(0.162)
TWENTY	—[b]	—[b]
THIRTY	−0.753[a]	−0.784[a]
	(0.155)	(0.177)
FORTY	−0.993[a]	−1.226[a]
	(0.194)	(0.212)
FIFTY	−0.761[a]	−1.090[a]
	(0.169)	(0.218)
SIXTY	−0.839[a]	−0.904[a]
	(0.193)	(0.218)
SEVENTY	−0.956[a]	−1.069[a]
	(0.212)	(0.227)
HSGRAD	−0.294	−0.288[a]
	(0.179)	(0.166)
COLLGRAD	0.248	0.276
	(0.185)	(0.176)
ADVGRAD	−0.167	−0.160
	(0.203)	(0.192)
LARAMIE	−0.316[a]	−0.069
	(0.084)	(0.075)
MALE	−0.342[a]	0.184[a]
	(0.091)	(0.073)
IMPSKCAN	0.500[a]	0.070
	(0.167)	(0.120)
IMPAGING	−0.428[a]	−0.153[a]
	(0.136)	(0.093)
IMPBURN	0.426[a]	0.419[a]
	(0.153)	(0.119)
NOTTRY	0.906[a]	0.069
	(0.184)	(0.100)
LOWINC	—[b]	—[b]
MEDINC	0.323	0.418
	(0.486)	(0.473)
HIGHINC	−0.076	−0.022
	(0.515)	(0.493)
DT	0.038	0.123
	(0.436)	(0.422)
AGEFRM	−0.528[a]	—[b]
	(0.129)	
TANFRM	−0.164	—[b]
	(0.142)	
*IMPAGING*AGEFRM*	0.656[a]	—[b]
	(0.183)	
*IMPBURN*TANFRM*	−0.630[a]	—[b]
	(0.182)	
*TANTRY*TANFRM*	0.538[a]	—[b]
	(0.214)	
CONSTANT	1.390[a]	1.567[a]
	(0.571)	(0.570)
σ[c]	2.537[a]	2.540[a]
	(0.083)	(0.092)
(σ_{12}/σ^2)[d]	−49.622[a]	−47.569[a]
	(7.062)	(6.834)

Note: For variable means and definitions, see tables 3 and 4. Estimated standard errors are in parentheses.
[a] Denotes significance at 5% using one-tail test.
[b] Denotes omitted variable.
[c] Standard deviation of residual.
[d] Cross-equation error correlation (between *DRISK* residual and transitory error component) divided by *DRISK* residual variance.