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Altruism and Environmental Risks to Health of Parents and their Children*

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ABSTRACT

This paper tests an equilibrium condition from a model that incorporates: (1) altruism of parents toward their young children and (2) household production of latent health risks. The model demonstrates that an altruistic parent's marginal rate of substitution between an environmental health risk to herself and to her child is equal to the ratio of marginal risk reduction costs. Econometric estimates support this prediction based on data from a stated preference study involving 488 parents of children aged 3-12 years. This outcome implies that parents reallocate family resources to at least partly offset the effectiveness of public programs that aim to reduce their children's environmental risks.

Key words: Altruism, household production, environmental risk, child health.

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1. Introduction

Special protection of young children from environmental hazards has become a worldwide priority in government policies to improve human health.[1] Effectiveness of these measures depends on what steps parents voluntarily take to keep children out of harm's way. If parents are naive about hazards, do not care about their children, or lack the resources to protect their health, implementation of well-designed public policies to increase protection of children may have the intended effect. On the other hand, if parents are informed, altruistic, and sufficiently well off financially, measures aimed at increasing protection of their children from particular hazards will be offset to some extent as parents redistribute family resources. In any case, the fundamental tension between altruism and self-interest in family exchange looms as a crucial behavioral factor determining the effectiveness of government policies to protect children's health.

What is known about altruism in families? Several prominent empirical studies (e.g., Cox and Rank 1992, Altonji, Hayashi, and Kotlikoff 1992, 1997, Laitner and Juster 1996) do not support the implication of altruism for transfer-income derivatives in examining inter-household financial transfers between parents and adult children. Other papers (e.g., Liu *et al*. 2000, Jenkins, Owens, and Wiggins 2001, Nastis and Crocker 2003, Agee and Crocker 2004, Dickie and Messman 2004) look at how parents protect themselves and their pre-teenage children from

[1] For example, Executive Order 13045 (Federal Register, 1997) directs U.S. federal executive branch agencies to assign a high priority to addressing health and safety risks to children, coordinate research priorities on children's health, and ensure that their standards take into account special risks to children. The U.S. Environmental Protection Agency has formulated a seven-step strategy to protect children's health (U.S. EPA 1996). Some of the more visible federal decisions in which protection of children's health figured prominently include tightening of air quality standards for ozone and particulate matter and implementation of the 1996 Safe Drinking Water Act Amendments and the 1996 Food Quality Protection Act. Scapecchi (2006) summarizes similar efforts undertaken in other countries.

environmental and other hazards. In this branch of the literature, altruism is sometimes mentioned as a possible parental motivation, but equilibrium conditions implied by altruism are not tested.

This paper tests a model of altruistic family behavior (Becker 1974, 1981 and Barro 1974) that incorporates household production of latent health risks. The model demonstrates that the parent's marginal rate of substitution between risks faced by herself and her child is equal to the ratio of marginal risk reduction costs. This prediction is tested using survey data on skin cancer risks faced by 488 parents in Hattiesburg, MS and their biological children between the ages of 3 and 12 years. Marginal rates of substitution are obtained from stated preference values for a hypothetical sun lotion. While stated preference valuation remains a controversial method of obtaining willingness to pay for reduced environmental risk, its application here supports consistent estimation of the desired marginal rates of substitution because of the way the survey (described more fully later on) is designed. Test outcomes support the model and imply that parents are altruistic toward their young children.

2. Conceptual Framework

2.1 Model

This subsection presents an extension of Becker's (1981) model of altruism that incorporates household production of latent health risks. The model envisions a "family" composed of one altruistic parent and one child. Because only one child is included in the model, the analysis focuses on how parents allocate resources between themselves and their children, rather than on how parents make tradeoffs among different children. By including only one parent in the model, a unitary perspective is adopted in which possible divergent interests between parents in a family are not considered. Although the unitary model has been rejected in several empirical tests (e.g., Lundberg et al. 1997), tests presented in Section 4 reveal no significant differences in valuation of latent health risks between fathers and mothers. Blundell, Chiappori and Meghir (2005) and others analyze alternative intra-household decision making frameworks.

To facilitate treatment of latent health risks, assume that the parent has two periods of life remaining while the child has three. During the present period ($t = 0$), the parent receives all family income, purchases market goods for her family, and behaves as a paternalistic altruist in that she derives utility from her own consumption as well as from the combination of goods that she provides to her child.[2] Thus, the parent allocates goods to the child according to her own views as to what is best and disregards the child's preferences (if any) except in situations in which they are congruent with her own. In period $t = 1$, the child will be an adult with his own income, which the parent may supplement with transfers, and will make his own consumption decisions. In this period, the parent will derive utility from her own consumption and may also derive satisfaction from the level of utility achieved by the child. The model therefore envisions that after the child is mature enough to exhibit well-defined preferences and the parent can no longer dictate the combination of goods that the child will consume the parent's altruism may switch from paternalistic altruism to the more all-encompassing concern for the child's well-being considered by Altonji, Hayashi, and Kotlikoff (1997).[3] In the third and final period ($t = 2$), the child continues to receive income and purchase market goods while the parent is deceased.

The survey, described more fully in Section 3, elicits willingness to pay to reduce two latent environmental health risks facing both the parent and the child. In the model, these two

[2] Paternalistic altruism is more fully discussed by Jones-Lee (1991, 1992)
[3] Both types of altruism are incorporated into the model to assist in clarifying the interpretation of statistical tests presented in Section 4. All-encompassing concern for another's well-being has also been termed "benevolence" (Bergstrom 2006) or "pure" altruism (Jones-Lee 1991, 1992).

risks are denoted *a* and *b*. To consider a latency period that is longer for the child than for the parent, assume that the events at risk may occur in the last period of either individual's life. Constraining the lifetime risk to lie in a single period simplifies the task of communicating changes in risk to survey respondents (see Section 3). Perceptions of the *j*th latent risk to the *i*th person are denoted R_i^j, where superscript *j* distinguishes between the two risks (*a* and *b*) while subscript *i* distinguishes the parent (*p*) from the child (*k*). Perceived lifetime risks are influenced by the use of market goods that otherwise have no utility:

$$\begin{aligned} R_p^j &= R_p^j(G_{p0}^j, G_{p1}^j), \\ R_k^j &= R_k^j(G_{k0}^j, G_{k1}^j, G_{k2}^j), \qquad j = a, b. \end{aligned} \tag{1}$$

where G_{it}^j denotes individual *i*'s use in period *t* of a market good affecting the *j*th risk. Simplifying assumptions here are that: (1) the risk production functions do not shift over time, (2) the child when grown is assumed to share his parent's assessment of both risks, and (3) marginal products of the G_{it}^j are strictly negative in both production functions.

When the child begins to make his own consumption decisions as an adult in period $t=1$, he will maximize his lifetime utility given by $U_k(C_{k0}, C_{k1}, C_{k2}, R_k^a, R_k^b)$ subject to his perceived risk production functions given in equation (1), the choice of $(C_{k0}, G_{k0}^a, G_{k0}^b)$ that already will have been made by the parent, and his lifetime budget constraint, $T + y_{k1} + (1+r)^{-1} y_{k2} = C_{k1} + P^a G_{k1}^a + P^b G_{k1}^b + (1+r)^{-1}[C_{k2} + P^a G_{k2}^a + P^b G_{k2}^b]$. Here and in equations (2) and (3), variables y_{it} and C_{it} respectively denote individual i's income and consumption of an aggregate market good in period *t*, *T* denotes the income transfer from parent to child in period $t=1$ ($T \geq 0$), *r* denotes the market interest rate and P^j denotes the market price of the protective good affecting the *j*th risk.

In period $t = 0$ the parent maximizes the utility function

$$U_p(C_{p0}, C_{p1}, C_{k0}, R_p^a, R_p^b, R_k^a, R_k^b) + \eta U_k^*(C_{k0}, G_{k0}^a, G_{k0}^b, T, y_{k1}, y_{k2}, r, P^a, P^b) \quad (2)$$

subject to the four perceived risk production functions in equation (1), the restriction $T \geq 0$ and her lifetime budget constraint

$$\begin{aligned} y_{p0} + (1+r)^{-1} y_{p1} &= C_{p0} + C_{k0} + P^a(G_{p0}^a + G_{k0}^a) + P^b(G_{p0}^b + G_{k0}^b) \\ &+ (1+r)^{-1}[C_{p1} + T + P^a G_{p1}^a + P^b G_{p1}^b], \end{aligned} \quad (3)$$

where $\eta \geq 0$ is the weight the parent places on the child's lifetime utility and $U_k^*(\bullet)$ denotes the indirect utility function from the child's maximization problem. When $t = 0$, the parent chooses quantities of all market goods that she and her young child use and when $t = 1$, the parent makes these choices only for herself while deciding how much income to transfer to her child.

The parent's paternalistic altruism in period $t = 0$ is reflected in her concern for her child's present consumption and his risk . If $\eta = 0$, the parent has no further concern for the child in future periods and will not care how his future choices may affect the lifetime risk he ultimately faces. If $\eta > 0$, the parent continues to care about the child in the future, but she exhibits benevolence or all-encompassing altruism in that she respects the child's adult preferences and cares about his overall level of well-being rather than the specific bundle of goods he consumes.

First order conditions[4] for period $t = 0$ quantities imply that for $j = a, b$

$$\begin{aligned} &\partial U_p / \partial C_{p0} = \partial U_p / \partial C_{k0} + \eta(\partial U_k / \partial C_{k0}) \\ &(\partial U_p / \partial R_p^j)(\partial R_p^j / \partial G_{p0}^j) = (\partial U_p / \partial R_k^j)(\partial R_k^j / \partial G_{k0}^j) + \eta(\partial U_k / \partial R_k^j)(\partial R_k^j / \partial G_{k0}^j). \end{aligned} \quad (4)$$

[4] These equations make use of the relationships $\partial U_k^* / \partial G_{k0}^j = (\partial U_k / \partial R_k^j)(\partial R_k^j / \partial G_{k0}^j)$. Equations (4) and (5) also make use of the assumption that the parent exhibits paternalistic altruism only in period $t=0$. Thus her paternalistic altruissm encompasses concern for how her present choices affect her child's risk but does not extend to concern for how his future choices may alter his risk. Any concern for the child in future periods is reflected by $\eta > 0$, not by

Thus, in period $t = 0$, the model predicts the familiar result that if both individuals consume C and G in positive quantities, the parent's marginal rate of substitution between the child's consumption of C (G) and her own consumption of C (G) is equal to unity.[5] This outcome holds independently of the magnitude of η, the weight that the child's utility receives in the parent's utility function, and also holds if the parent exhibits either type of altruism. If instead the parent exhibits neither type of altruism (i.e., is not an altruist toward the child), then these marginal rates of substitution equal zero. If the parent exhibits either or both types of altruism toward the child but does not care about her own consumption or about the level of risks that she faces, then these marginal rates of substitution are arbitrarily large.

In periods $t = 1$ and $t = 2$, first order conditions imply that

$$\begin{aligned}
&\partial U_p / \partial C_{p1} = \lambda_p (1+r)^{-1} && \\
&\partial U_k / \partial C_{kt} = \lambda_k (1+r)^{1-t} && t = 1,2 \\
&(\partial U_p / \partial R_p^j)(\partial R_p^j / \partial G_{p1}^j) = \lambda_p P^j (1+r)^{-1} && j = a,b \\
&(\partial U_k / \partial R_k^j)(\partial R_k^j / \partial G_{kt}^j) = \lambda_k P^j (1+r)^{1-t} && j = a,b \quad t = 1,2 \\
&\eta \lambda_k = \lambda_p (1+r)^{-1} && \text{if } T > 0.
\end{aligned} \tag{5}$$

Equation (5) shows that if $\eta > 0$ and if $T > 0$, then in period $t = 1$ the parent's marginal rate of substitution between the child's consumption of C (G) and her own consumption of C (G) also is equal to unity. In the case in which $\eta > 0$, therefore, transfers from the parent to child ensure that the parent's marginal rate of substitution between the child's consumption of market goods and her own consumption of market goods is equal to unity in all periods in which both individuals are alive. If $\eta > 0$, but $T = 0$ (as may occur in period $t = 1$ if the child is rich and the

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$\partial U_p / \partial R_k^j$. This assumption means that the parent does not have to consider the dependence of her child's future choices on her decisions today. A more formal analysis of this point is available on request.

[5] Throughout the paper, the convention adopted for calculating marginal rates of substitution is that the parent's marginal utility of the child's consumption is in the numerator and the parent's marginal utility of her own consumption is in the denominator.

parent is poor) then the parent's marginal rates of substitution between her child's consumption and her own consumption are positive, but in general are not equal to unity because $\eta\lambda_k \neq \lambda_p(1+r)$. On the other hand, if the parent is a paternalistic altruist only and has no concern for the child's well-being after period $t = 0$ has ended ($\eta = 0$), then in period $t = 1$ the parent's marginal rates of substitution between her child's consumption and her own consumption are equal to zero. Finally, just as in period $t = 0$, if the parent cares about her child's well-being but not about her own consumption of market goods, then her marginal rates of substitution between the child's consumption and her own consumption become arbitrarily large.[6]

The empirical analysis presented in Section 4 looks at risk reduction, not consumption of G^j. So, in period $t = 0$, the first order equation for G^j in (4) is rewritten as equation (6) to show that when corner solutions are set aside, the parent's marginal rate of substitution between risk to her child and risk to herself is equal to the ratio of marginal products of a risk-reducing market good that both individuals consume.

$$\frac{(\partial U_p / \partial R_k^j) + \eta(\partial U_k / \partial R_k^j)}{(\partial U_p / \partial R_p^j)} = \frac{(\partial R_p^j / \partial G_{p0}^j)}{(\partial R_k^j / \partial G_{k0}^j)} = \frac{MC_{k0}^j}{MC_{p0}^j} \qquad j = a,b. \tag{6}$$

The ratio of marginal products, in turn, equates to the ratio of present value marginal costs because the price per unit of G^j is the same no matter who uses it.

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[6] Equation (5) also implies that when the parent and child consume positive quantities of all goods in all periods, the inter-temporal marginal rate of substitution between consumption of *C* (*G*) in period $t + 1$ and consumption of *C* (*G*) in period *t* equals the discount factor $(1+r)^{-1}$ for both the parent and the child. The inter-temporal marginal rate of technical substitution between risk-reducing goods in different periods likewise equals the discount factor for both individuals. If $\eta > 0$ and if $T > 0$, then the parent's marginal rate of substitution between her child's consumption of *C* (*G*) in period $t + 1$ and her own consumption of *C* (*G*) in period *t* is equal to the discount factor as well.

Equation (5) also implies that each individual equates the present-value marginal costs of risk reduction over time, provided that risk production functions are constant over time. Thus, in period $t = 1$, the present-value marginal cost of risk reduction for the parent will be the same as in period $t = 0$, and the present-value marginal cost of risk reduction will be the same for the child in periods $t = 1$ and $t = 2$. In addition, if $\eta > 0$ and $T > 0$, then the marginal costs of risk reduction for the child are the same in all three periods.[7] Evidently, the parent's all-encompassing concern for the child's well-being together with her monetary transfers enables her to choose marginal cost of risk reduction values that the child will use for the rest of his life. In consequence, if $\eta > 0$ and $T > 0$

$$\frac{\eta(\partial U_k / \partial R_k^j)}{(\partial U_p / \partial R_p^j)} = \frac{(\partial R_p^j / \partial G_{p1}^j)}{(\partial R_k^j / \partial G_{kt}^j)} = \frac{MC_k^j}{MC_p^j} \qquad j = a,b \qquad t = 1,2. \tag{7}$$

On the other hand, this marginal rate of substitution equates to zero if $\eta = 0$ and will not equate to the marginal cost ratio if either $T = 0$ or if the parent does not care about risk to herself.

Together, equations (6) and (7) imply that if $\eta > 0$ and $T > 0$, and both the child and parent consume positive quantities of all market goods in all periods when they are alive, then the parent's marginal rate of substitution between her child's and her own latent risk equals the ratio of present-value marginal costs of reducing risk in any period. Three further implications of equations (6) and (7) are that even if the parent is a paternalistic altruist in period t=0 and if $\eta > 0$ and $T > 0$: (1) the ratio of marginal risk reduction costs for the child and the parent is not expected to equal unity because the technologies used to produce perceived risk reduction may differ and, even if the technologies are the same, levels of perceived risk faced by the two people may not be the same, (2) for either individual, the ratio of marginal costs for reducing the first

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[7] $MC_p^j = (1+r)^{-t} P^j / (\partial R_p^j / \partial G_{pt}^j), t = 0,1,$ and $MC_k^j = (1+r)^{-t} P^j / (\partial R_k^j / \partial G_{kt}^j), t = 0,1,2.$

risk need not equal the ratio of marginal costs for reducing the second risk, and thus (3) for either individual, the marginal rate of substitution between the two types of risks equals the corresponding ratio of marginal costs in reducing the two risks.

Empirical estimates described in Section 4 test the null hypothesis that the equilibrium conditions stated in equations (6) and (7) hold. This test is facilitated by considering percentage risk changes rather than absolute changes in risk. For instance, when the parent and child experience the same percentage reduction in a risk, the ratio of marginal products in equation (6) equals the ratio of initial risk levels, as illustrated below for period $t = 0$.[8]

$$\frac{(\partial R_p^j / \partial G_{p0}^j)}{(\partial R_k^j / \partial G_{k0}^j)} = \frac{R_p^j}{R_k^j} \qquad j = a, b$$

Thus, in this case, as shown in equation (8), the parent's marginal rate of substitution between equal percentage risk changes for herself and for the child equates to unity.

$$\frac{[(\partial U_p / \partial R_k^j) + \eta(\partial U_k / \partial R_k^j)]R_k^j}{(\partial U_p / \partial R_p^j)R_p^j} = \frac{(\partial R_p^j / \partial G_{p0}^j) / R_p^j}{(\partial R_k^j / \partial G_{k0}^j) / R_k^j} = 1 \qquad j = a, b \qquad (8)$$

If $\eta > 0$ and $T > 0$, then the corresponding condition will hold for periods $t = 1$ and $t = 2$, as shown in equation (9).

$$\frac{\eta(\partial U_k / \partial R_k^j)R_k^j}{(\partial U_p / \partial R_p^j)R_p^j} = \frac{(\partial R_p^j / \partial G_{p1}^j) / R_p^j}{(\partial R_k^j / \partial G_{kt}^j) / R_k^j} = 1 \qquad j = a, b \quad t = 1,2 \qquad (9)$$

Evidence that equation (8) holds supports the notion that parents are altruistic toward their children, but does not indicate whether parents are paternalistic altruists only, whether

[8] This outcome also yields a useful corollary for transferring adult morbidity estimates to children when equal proportionate changes in risk to both groups are considered. If the parent and child experience the same percentage reduction in risk, the ratio of marginal products in equation (4) equals the ratio of initial risk levels. This means that the ratio of the parent's willingness to pay to reduce risk to the child to the parent's willingness to pay to protect herself equates to this ratio of risks. The ratio of actual risks faced might be estimated in some cases using existing health science and biomedical information. The ratio of perceived risks might be established by studies of parents' perceived risks to children and to themselves.

parents only exhibit the broader type of altruism associated with $\eta > 0$ and $T > 0$, or whether parents exhibit both types of altruism. Evidence that equation (9) holds, on the other hand, says nothing about paternalistic altruism, but supports the notion that $\eta > 0$ and $T > 0$. Evidence supporting equations (8) and/or (9) does not indicate whether η or the provisions the parent makes for the child (C_{k0}, G_{k0}^{j}, T) are large or small. As discussed more fully in Section 4, tests applied do not distinguish between paternal and all-encompassing altruism and do not identify the value of η.[9]

2.2 Policy implications

The model developed in the previous subsection suggests that effectiveness of government programs aimed at reducing risk through behavior modification will be compromised to some extent because they motivate parents to reallocate family resources, as illustrated by the following three examples.[10] First, suppose that in a country composed of M identical families[11], the government initiates an administratively costless program in time period $t = 0$ to provide special protection of children from risk, as envisioned by Executive Order #13045 (Federal Register 1997) in the United States and by similar policies pursued by other countries (Scapecchi 2006). Assume that: (1) the government has access only to the "family

[9] The model presented can be modified or extended in a variety of ways without altering the basic result that the altruistic parent's marginal rate of substitution between her child's and her own risk equals the ratio of marginal costs of risk reduction. For example, a discounted expected utility model in which individuals produce risk but probabilities condition expectations rather than utility itself also implies equality between the parent's marginal rate of substitution and the ratio of risk-reduction costs.

[10] Although the model does not address issues related to government risk information provision or how parents might respond to such information, it is at least plausible that such programs might be more effective than behavior modification programs. Also, along these lines, note that if in addition to paternalistic altruism, $\eta > 0$ and $T > 0$, parental learning about risks will be retained by the child through adulthood in the sense that his marginal costs of avoiding a risk are equated through all periods of his life. In this situation, parental learning may be passed to future generations as well, but a formal investigation of this matter would require reformulating the model to allow the child to have children of his own as, for example, in Becker (1974).

[11] Further examples based on heterogeneity of parent incomes, two-parent families, and families with multiple children easily can be constructed based on those presented below. Similar examples also can be developed for models where government policy operates by determining the level of an environmental hazard that affects child and/or parent risk rather than by providing G, although in that case the rate of substitution between G and the environmental hazard in the risk production functions must be considered.

technology" for risk reduction described by equation (1), (2) the program provides the parent with an extra unit of G earmarked for the child's use, (3) the program is financed by levying a tax on each parent in the amount of $\$P$, the price per unit of G,[12] and (4) parents exhibit one or both types of altruism. As long as prices of market goods and the parent's income remain unchanged, parents and children in each family end up consuming the same quantities of all goods as before. In consequence, the program does not alter behavior and has no effect on the level of risk faced by either person.

Second, suppose instead that the government program sets out to protect everyone (i.e., both adults and children) from risk by giving each family one unit of G for either person to use, rather than earmarking it for the child's use. In this situation, each family simply "purchases" one unit of G for $\$P$ from the government rather than from the private market. Again, if incomes and market prices remain unchanged and parents behave altruistically, each family member consumes the same quantities of C and G as before so that the program has no effect on behavior or on risk levels faced by either parents or children.

Third, suppose that the government is more efficient than families in lowering risk, perhaps because of economies of scale in providing risk reduction. In this case, each family might receive more than one unit of G in return for the tax payment of $\$P$, thereby experiencing the equivalent of an increase in income. Pure paternalistic altruists would then divide the income increase between their own consumption of C and G in periods $t = 0$ and $t = 1$ and their child's consumption of these goods in period $t = 0$, with the increment in G allocated between the parent and the child so that the parent's marginal rate of substitution between risk to the child and risk to herself remained equal to the ratio of marginal costs of risk reduction. If in

[12] Becker (1981, Chapter 8) presents a closely related example with extended discussion in the context of an income transfer between an altruistic person and his/her spouse.

addition to or instead of paternalistic altruism, parents also exhibit all-encompassing altruism with $\eta > 0$ and $T > 0$, more substitution possibilities arise because a portion of the income increase could be transferred to the child for use later in his life. Thus, while the program could succeed in lowering risk, the efficiency gain is diffused because both family members now consume more of all goods in the present period and possibly in future periods.

3. Data and Experimental Design

3.1 Background

Field data were collected from parents of pre-teenage children during summer of 2002 using a self-paced, interactive, computerized instrument.[13] An early version of this instrument was used in a pilot study of parents' willingness to pay to reduce perceived skin cancer risks (Dickie and Gerking 2003). Two subsequent versions of the instrument were pre-tested and de-briefing sessions with pre-test participants guided development of the final version. Parents who participated in this study were residents of the Hattiesburg, MS metropolitan statistical area and were initially identified by random digit dialing. When calls reached adults, interviewers asked whether they had at least one biological child between the ages of 3-12 living at home, and whether they were willing come to the University of Southern Mississippi to participate in a federally funded study of health risks to parents and their children. Biological children were singled out for inclusion in the study because skin cancer risk is partly determined by genetic characteristics inherited from parents (e.g., fairness of skin and sensitivity of skin to sunlight). Parents were offered a $25 payment for participating in the study.[14]

[13] A more complete description of these data is provided in Dickie and Gerking (2006).

[14] Approximately 30% of calls to presumed working residential numbers yielded no contact with an adult after three attempts at different times of day and days of the week. In 64% of cases in which a call reached an adult, the adult declared that the household did not meet eligibility requirements (had no biological children aged 3-12 living at home). Parents agreeing to participate in the study constituted 3.5% of working residential numbers, 5% of contacts

The sample consisted of 610 parents; children did not participate.[15] Of the parents, 75% were white, 20% were African-American, and 5% were members of other races. Data from the 122 African-American parents are not considered further in this paper (but are analyzed in Dickie and Gerking 2006) because blacks face low levels of risk and therefore have fewer incentives than whites to think about precautions against solar radiation exposure and how their own risk might differ from that of their children. Of the 488 non-black parents, 25% were male, 75% were under the age of 40, mean household income was $60,000 per year, 83% were married, and 60% worked full time. Parents generally were aware of skin cancer: 83% knew someone personally who had been diagnosed with this disease, 18% knew of someone (public figures, friends, or relatives) who had died from skin cancer, and 82% had considered the possibility that one of their children might get skin cancer. At an early stage in the interview, one biological child aged 3-12 of each parent was randomly selected (if there was more than one in this age range) and designated as the sample child. Questions asked mainly focused on the parent and the sample child. Half (50.4%) of the sample children were male and the average age of sample children was 7 years.

3.2. *Elicitation of Risk Beliefs*

Two types of risk to both parents and children were elicited: (1) the unconditional risk of getting skin cancer during one's lifetime and (2) the conditional risk of dying from this disease given that it occurs.[16] Parents made preliminary assessments of lifetime skin cancer risk using an

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with adults, and 14.3% of contacts with adults who did not declare the household ineligible. Finally, 68% of persons agreeing to participate completed the instrument.

[15] Responses from 25 parents were disregarded either because they did not answer all questions (21 parents) or because they did not follow instructions given by the survey administrator (4 parents).

[16] The ability of respondents to understand the risk concepts presented and to clearly distinguish between these two types of risk was a concern from the beginning of the study because of difficulties people have thinking about probabilities (Slovic, Fischhoff and Lichtenstein 1985). This concern was amplified for the present study because few previous surveys have dealt with compound risks. In de-briefing sessions conducted after the pre-tests, the meaning of the morbidity risk and conditional death risk questions were extensively discussed with participants.

interactive scale similar to that used by Krupnick *et al.* (2002) and Corso, Hammitt, and Graham (2001). The scale, which underwent a number of design changes based on the pre-tests, depicted 400 squares in 20 rows and 20 columns and all 400 squares were initially colored green. Parents changed green squares to red ones to represent amounts of risk. Before using the scale to estimate skin cancer risk, parents practiced using the risk scale for an unrelated event (a possible auto accident) and were told about the meaning of "chances in 400". Also, they were told to consider only the chances of getting skin cancer (or of getting it again if they had already had it), rather than how serious the case might be. Parents then used the risk scale to estimate lifetime chances of getting skin cancer, for themselves and then for their sample child. Frequency distributions of these responses presented in Table 1 indicate considerable variation in risk estimates with some parents believing that skin cancer is highly unlikely and a smaller number of parents believing that skin cancer is inevitable. Risk estimates tended to pile up at the 5, 10, 15, etc. percent marks.

As shown in Table 2, parents estimated that their own lifetime risk of getting skin cancer exceeded that of their sample child (26.9% vs. 22.5%). The null hypothesis that mean perceived skin cancer risks are equal for parents and children is rejected at the 1% level in a matched-samples test. This outcome may reflect a number of factors possibly including parents' beliefs that they take greater precautions to protect their children from skin cancer risk than their parents did in an earlier period when less was known about the hazards of solar radiation exposure. Parents also appear to have overestimated skin cancer risk. Ries *et al.* (1999) found that whites have a lifetime chance of 21% of getting either melanoma or non-melanoma skin cancer. The fact that the survey introduced the possibility of getting skin cancer again if the parent had

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Participants suggested a number of wording changes in the questions, but through this discussion and through their direct statements, they demonstrated facility with the risk concepts involved.

already had it does not appear to be an important complicating factor in this regard. Sample parents are relatively young and 4.3% reported having been previously diagnosed with this disease.

Parents were given an opportunity to revise their beliefs about the chances of getting skin cancer after receiving information about this disease. They were told that: (1) according to the National Cancer Institute, the average person in the United States has a lifetime risk of getting skin cancer of 18% and (2) a person's risk may differ from this average because of skin color and sensitivity to sunlight, family history of skin cancer, amount of time spent in direct sunlight, experience with sunburns, and use of sun protection products. Parents were questioned about observable skin characteristics, sun exposure history, and use of sun protection products both for themselves and their sample children. Over 90% of parents and 97% of children use sun protection products such as sun lotion. Children use sun protection products a greater fraction of the time that they are outside and use products with a higher sun protection factor than do their parents (Table 3). About 40% of parents revised their own lifetime risk estimates, but upward and downward revisions balanced to yield zero mean revision. Revised risk estimates for children were on average 2 percentage points lower than initial risk estimates.

To obtain a rough indication of beliefs about latency of skin cancer risks, parents were asked, “Suppose you do get skin cancer sometime in the future. At what age do you think you would get it for the first time (or for the next time if you have already had it)?” Responses to this and a parallel question about the children are summarized in Table 4. About 65% of parents saw skin cancer as a disease that would strike them or their children at age 50 or later. Based on the midpoints of the age intervals listed in Table 4, parents on average expected that skin cancer, if it occurs, would strike them at age 53 or their children at age 55. Comparing expected age at onset to current age, the average implied latency period is 18 years for parents and 48 years for children, a difference that is significant at the 1% level. These rough measures of perceived latency suggest that parents see skin cancer as a disease that occurs later in life and see their children's risk as lying farther in the future than their own.

Parents also provided estimates of mortality risk from skin cancer both for themselves and for their sample children assuming a doctor had diagnosed this disease. Parents were unaware that they would be asked about the likelihood of dying from skin cancer when they answered the previously described questions about getting this disease.[17] Parents provided their perceptions of conditional mortality risk of skin cancer given a diagnosis of this disease using the previously described risk scale. Table 1 presents the frequency distribution of responses. About two-thirds of parents believed that their conditional risk of death given a diagnosis of skin cancer is 10% or less and about three-fourths of parents believed that if similarly diagnosed, their sample child's conditional risk of death is 10% or less. Many parents felt that the conditional risk of death is less than 5% both for themselves and for their children. This outcome suggests that parents were aware that skin cancer is seldom fatal. Parents reported higher mean conditional death risk estimates for themselves (12.1%) than for their sample children (9.4%), a significant difference at the 1% level.

3.3 Experimental Design and the Choice Experiment

Parents valued risk reductions by expressing willingness to pay for a hypothetical sun lotion.[18] The product was described using labels (see Figure 1 for an example) designed to look like those on bottles of over-the-counter sun lotions. Except for differences in the type and

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[17] Respondents were instructed not to look ahead or to go back to previous questions but rather to see the survey administrator if they needed to correct a mistaken answer. Data from 4 respondents who did not comply with this instruction were among the previously mentioned observations that were deleted.

[18] This approach also was used in a recent cross-country study of skin cancer risks (see Brouwer and Bateman 2005).

amount of skin cancer protection offered, the labels were identical in all respects to control for other possible motivations for purchasing sun lotion, such as to prevent sunburn or to get a suntan and to guard against aging or wrinkling of skin (see Dickie and Gerking 1996). Eight labels were used in the study: Four labels varied reductions in risk of getting skin cancer (10%/50% for parent/child) and four labels varied reductions in conditional death risk (10%/50% for parent/child).[19] As demonstrated in Section 2, use of percentage changes simplifies the econometric tests. Use of percentage changes in risk also has an advantage over presenting absolute risk reductions in that the post-treatment risk levels always are non-negative.[20]

Each parent was randomly assigned two of the eight labels and asked for willingness to pay for each.[21] One of the assigned labels offered reduced risk of getting skin cancer and the other offered reduced conditional death risk from skin cancer. Labels were presented one at a time in randomized order. After parents were given time to read a label as if considering buying the product for the first time, they were shown their previously marked risk scales both for themselves and their children showing the level of perceived risk the parent originally indicated,

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[19]The survey presents exogenous changes in risk to avoid issues that arose in a previous study (Dickie and Gerking 1996) in which risk changes were treated as endogenous. In the earlier work, labels were presented without the stated risk changes and respondents indicated the amount by which risk would be reduced if the product were used as directed. Survey participants, however, expressed little confidence in their response to this question and responses obtained were unavoidably correlated with unobserved participant characteristics. In the present context, telling parents what to believe about the magnitude of risk change is at least arguably better than asking a difficult question. Also, random assignment of labels means that risk changes are orthogonal to respondent characteristics. Nonetheless, because changes in risk actually are endogenous, interpretation of the econometric estimates presented in the next section must necessarily be guarded.

[20] Data on actual purchases of currently marketed sunscreen lotions would not support valuation of the two risks separately from other motivations for using sunscreen (Dickie and Gerking 1991, 1996) and would not reflect random assignment of exogenous risk changes. These two features of the field study are critical for estimating the marginal rate of substitution.

[21] Means of the four perceived risks, family income, number of children in the family, and age and gender of parent and children were compared across labels, separately for the four morbidity labels and four conditional mortality labels. Statistical tests fail to reject the null of a constant mean across labels at 10% for all characteristics except gender of parent across the four morbidity labels. With that one exception, the randomly assigned labels are orthogonal to important parent and child characteristics.

and the risk reduction the sun lotion would offer. In this way the magnitude of the risk change for the parent and the child was described in absolute as well as in percentage terms.

For the first of the two labels, parents were asked, "Now please think about whether you would buy the new sun protection lotion for yourself or your child. Please do not consider buying it for anyone else. Suppose that buying enough of the lotion to last you and your child for one year would cost $X. Of course, if you did buy it, you would have less money for all of the other things that your family needs. Would you be willing to pay $X for enough of the sunscreen to last you and your child for one year?" The value of X was randomly selected from among nine values ranging between $20 and $125. The narrative also reminded parents that lifetime use of the sun lotion is necessary to obtain the stated skin cancer protection benefits. For the second label, parents were told, "Suppose that instead of the previous label, we showed you the following label." Willingness to pay then was elicited as before.

4. Empirical Estimates

4.1. Methods and Interpretation

Following Cameron (1988), the null hypothesis that parents' stated purchase intentions for the hypothetical sun lotion are consistent with equations (8) and (9) is tested based on a specification of the willingness-to-pay function rather than on an explicit specification of a difference in random utility functions. The approach taken uses the model developed in Section 2 to derive present period ($t = 0$) willingness to pay (WTP^j) for the hypothetical sun lotions to reduce the unconditional risk of getting skin cancer ($j = a$) and the conditional risk of dying from this disease if it is contracted ($j = b$).

Each new sun lotion is treated as a newly available private good that if purchased would provide an increment, S_{it}^j, in the planned amount of protective goods that was optimal in the absence of the new sun lotion. If individual *i* uses sunscreen *j* during period *t* then $dG_{it}^{j} = S_{it}^{j} = 1$; otherwise $dG_{it}^{j} = S_{it}^{j} = 0$. The resulting changes in lifetime risk are $dR_{i}^{j} = \sum_{t} (\partial R_{i}^{j} / \partial G_{it}^{j}) S_{it}^{j}$.[22]

Parents participating in the field study were told the lifetime risk reductions that would result from use of the new sun lotion and that achieving these risk reductions would require lifetime use of the product. Therefore assume that the parent would prefer not to purchase the sun lotion for herself now, unless she envisioned continuing to use it in the future. Likewise, she would prefer not to purchase the sun lotion for her child now, unless she believed that he would find it in his interest to use it in the future. Also, the first period's supply of the sun lotion is offered as a single purchase decision for the parent and child together, rather than as a separate purchase decision for each. In consequence, the parent decides that neither she nor her child will use the sun lotion at all ($S_{it}^{j} = S = 0$), or that both will use it now and in the future ($S_{it}^{j} = S = 1$). The possibility that only one of the two individuals would use the sun lotion is addressed below.

Suppose that the required expenditure for the lotion for the parent and child together during $t = 0$ is denoted X^{j}, and that in subsequent periods, when the child makes his own allocation decisions, each individual may purchase the sun lotion in an amount for one person at half of this expenditure, $X^{j}/2$. Then the parent's maximal lifetime utility assuming continuing use of the sun lotion is $U_{p}^{*}(y_{p0} - X^{j}, y_{p1} - X^{j}/2, y_{k1} - X^{j}/2, y_{k2} - X^{j}/2, r, P^{a}, P^{b}; S = 1)$, where

[22] This specification assumes that users of the new sun lotions would not neutralize the risk reductions by making other substitutions, for example by spending more time outdoors in sunlight. In two previous skin cancer surveys, attempts were made to account for possible substitutions that might influence endogenously perceived risk changes associated with hypothetical sun lotions. In Dickie and Gerking (1996), an indicator for whether respondents used current sunscreen in order to stay outdoors longer was not significantly related to the perceived risk reduction associated with a hypothetical sun lotion. In Dickie and Gerking (2003), respondents were asked whether using a hypothetical sun lotion would lead them or their children to spend more time outdoors in sunlight. Fewer than 10% of parents responded affirmatively, and indicators for this type of substitution were not significantly related to perceived risk changes associated with the hypothetical sun lotion, or with willingness to pay for it. These results suggested that the possibility of offsetting substitutions would not be a major factor considered by parents when they initially evaluated the new sun lotions and consequently no questions concerning this type of behavior were included in the present study.

$U_p^*(\bullet)$ denotes the indirect utility function and where $\partial U_p^* / \partial y_{kt} = 0$ if $\eta = 0.$ Derivatives of this function include

$$
\begin{aligned}
(\partial U_p^* / \partial S) &= (\partial U_p / \partial R_p^j) dR_p^j + (\partial U_p / \partial R_k^j) dR_k^j + \eta (\partial U_k / \partial R_k^j) dR_k^j \\
(\partial U_p^* / \partial X^j) &= -\left[\lambda_p + (1/2)(1+r)^{-1}(\lambda_p + \eta\lambda_k) + (1/2)(1+r)^{-2}\eta\lambda_k \right] \\
&= -\lambda_p \sum_{t=0}^{2} \left({n_t}/{2} \right)(1+r)^{-t}
\end{aligned}
\tag{10}
$$

where the dR_i^j denote the lifetime risk changes resulting from use of the sun lotion in all periods and n_t denotes the number of users of the sun lotion in period *t* whom the parent cares about (if $\eta > 0,\ n_0 = 2 = n_1,\ n_2 = 1$ because the parent cares about the child in all periods, while if $\eta = 0,\ n_0 = 2,\ n_1 = 1,\ n_2 = 0$ because the parent cares about the child only in $t = 0$). As shown in equation (10), the child's decision to purchase the sun lotion in periods $t = 1$ and $t = 2$ affects the parent's welfare if $\eta > 0$.

The parent's willingness to pay for the sun lotion per period, WTP^j, is the value of X^j that equates $U^*(\bullet) \equiv \bar{U},$ where $\bar{U}$ denotes the parent's maximal lifetime utility if neither she nor her child uses the sun lotion. Applying the implicit function theorem to this identity and using equation (10) implies that marginal willingness to pay for the first period of sun lotion use is

$$
\begin{aligned}
d(WTP^j) &= (1/\lambda_p)\left[\sum_{t=0}^{2} (n_t/2)(1+r)^{-t} \right]^{-1} \begin{bmatrix} (\partial U_p / \partial R_p^j)(dR_p^j) \\ + [(\partial U_p / \partial R_k^j) + \eta(\partial U_k / \partial R_k^j)](dR_k^j) \end{bmatrix} \\
&= \beta\left(\delta_p^j(-dR_p^j / R_p^j) + \delta_k^j(-dR_k^j / R_k^j) \right). \qquad j = a, b,
\end{aligned}
\tag{11}
$$

In this equation $\delta_p^j = -(\partial U_p / \partial R_p^j) R_p^j / \lambda_p$ and $\delta_k^j = -[(\partial U_p / \partial R_k^j) + \eta(\partial U_k / \partial R_k^j)] R_k^j / \lambda_p$ denote the parent's marginal willingness to pay for proportionate reductions in her own and her child's lifetime risk, and $\beta = \left[\sum_{t=0}^{2} (n_t / 2)(1+r)^{-t} \right]^{-1}$ denotes the fraction of the present value of total planned expenditures on the sun lotion that occur in the first period. Because $\beta < 1$, coefficients of lifetime risk reductions understate the parent's marginal willingness to pay for risk reduction; i.e., first-period expenditures on sun lotion do not reveal the full willingness to pay for lifetime risk reduction. Nonetheless, the ratio of coefficients of lifetime risk changes $\beta\delta_k^j / \beta\delta_p^j = [(\partial U_p / \partial R_k^j) + \eta(\partial U_k / \partial R_k^j) R_k^j] / ((\partial U_p / \partial R_p^j) R_p^j)$ equals the parent's marginal rate of substitution between equal percentage risk changes for herself and for the child. If the parent is altruistic, this marginal rate of substitution equals unity.[23]

For econometric estimation, equation (11) is specified for parent *h* as

$$WTP_h^j = \gamma_0^j + \gamma_p^j \left[\Delta_p^j / R_p^j \right]_h + \gamma_k^j \left[\Delta_k^j / R_k^j \right]_h + controls_h + \varepsilon_h^j. \quad (12)$$

In equation (12), Δ_p^j and Δ_k^j are interpreted as the discrete reduction in the *j*th risk for the parent and the child that would occur if the sun lotion was used, the R_i^j denote the last estimate the *j*th perceived risk elicited for individual *i* in the field study, and $\gamma_i^j = \beta\delta_i^j$, *i=p,k*. Thus the variables in square brackets denote the percentage risk reductions (divided by 100) shown on the sun lotion labels for the *j*th type of risk and take the value 0.1 or 0.5. Treating the γ_i^j as constants implies that willingness-to-pay per unit of risk reduction $\partial WTP^j / \partial \Delta_i^j = \gamma_i^j / R_i^j$ decreases with

[23] Nonmonetary costs of using the sun lotion such as time costs of ensuring proper application and disutility from odor or other product attributes are assumed equal for parent and child. The description of the sun lotion attempted to minimize time requirements by indicating that one application would last all day and to control for potential sources of disutility such as odor, allergic reactions and blocking of pores. The description was constant across all labels. To the extent that nonmonetary costs differ between parent and child, however, the costs would be confounded in the δ_i^j coefficients.

the magnitude of perceived risk initially faced.[24] Also: (1) *controls* refers to effects on willingness to pay of measured parental characteristics such as income and family size, and (2) ε_h^j denotes a random disturbance term with standard properties included to capture unobserved characteristics of parent *h*. These characteristics might include willingness to try new products, the ability to process the information presented on the sun lotion label, evaluation of joint outputs such as sunburn protection and skin aging, as well as other factors that influence whether the product would be purchased.

Five aspects of equation (12) warrant further discussion before turning to the results of estimation. First, altruism implies that $\gamma_k^j / \gamma_p^j = 1$. But a test of this hypothesis does not distinguish between types of altruism that may motivate parents' stated intentions to purchase the sun lotion, because $\partial U_p / \partial R_k^j$ and η are not separately identified; both are components of γ_k^j. Distinguishing between the types of altruistic motivations considered in Section 2 must await further research that contrasts parental behavior toward both young and adult children. In any case, the test does not rest on directly estimating WTP for risk reduction, but instead on estimating the ratio of estimated contributions of risk reduction to willingness to pay. This means that γ_k^j and γ_p^j must be consistently estimated, but it is not necessary to obtain a consistent estimate of γ_0^j.

Second, the percentage risk reduction variables are randomly assigned experimental design points. Thus, they are orthogonal to other experimental design points as well as to parent

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[24] In other words, the marginal value of risk reduction $\partial U_i / \partial R_i^j$ diminishes as R_i^j rises so that γ_i^j remains constant. To test the adequacy of this specification, which treats willingness to pay as a linear function of percentage risk changes, separate regressions were run for low-risk and high-risk groups. The null hypothesis that slope coefficients in both the morbidity and conditional mortality equations are equal in the high and low risk groups was not rejected at conventional levels. This result occurred whether morbidity risk or conditional mortality risk of the parent or the child was used to distinguish between low and high risk groups. The test was based on the first specification reported in Table 5 below.

characteristics included in *controls* and to parent characteristics captured by ε_h^j. This means that if the functional form of equation (12) is correct: (1) endogeneity problems in estimating the γ_i^j are avoided and (2) estimates of the γ_i^j are unaffected by the choice of variables to include in *controls*.

Third, willingness to pay for the sun lotion is treated in an errors-in-variables framework in which stated willingness to pay (W_h^j) by parent h to reduce the jth risk differs from true willingness to pay (WTP_h^j) by both systematic and random factors according to

$$W_h^j = WTP_h^j + \alpha_h^j = WTP_h^j + \alpha^j + \nu_h^j, \qquad j = a, b. \tag{13}$$

In equation (13), α^j is the nonzero mean of α_h^j and ν_h^j is a random disturbance. α^j is assumed to represent systematic misstatement of true willingness to pay. For example, parents may misstate willingness to pay because the choice of whether to buy the sun lotion was presented as a hypothetical question and/or may not have been adequately considered in light of preferences, and financial constraints.[25] Also, ν_h^j captures unobserved parent-specific heterogeneity as well as purely random factors that may affect a parent's stated willingness to pay for the label presented. The ν_h^j are assumed to be normally distributed with mean zero and constant variance and the possibility that $E(\nu_h^a \nu_h^b) \neq 0$ motivates joint estimation of willingness-to-pay equations for the two types of risk.

The marginal rate of substitution (γ_k^j / γ_p^j) is estimated by substituting equation (13) into equation (12) to obtain

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[25] As discussed by Carson, Groves, and Machina (2000) the overstatement of purchase intentions arising from incentive incompatibility of hypothetical, binary discrete-choice questions for private goods is unrelated to the scope of the good and its costs. Also, joint benefits of the sun lotion are held constant across labels but the parent's evaluation of any perceived difference between joint outputs of the lotion and existing products would be reflected in the constant term.

$$W_h^j = (\gamma_0^j + \alpha^j) + \gamma_p^j \left[\Delta_p^j / R_p^j\right]_h + \gamma_k^j \left[\Delta_k^j / R_k^j\right]_h + controls_h + \varepsilon_h^j + \nu_h^j, \qquad j = a, b. \quad (14)$$

Notice that estimators of the constant term (γ_0^j) will be inconsistent if, as expected, $\alpha^j \neq 0$. Also, estimators of coefficients of parent characteristics included in *controls* will be inconsistent if the controls are correlated with the composite error ($\omega_h^j = \varepsilon_h^j + \nu_h^j$). Nevertheless, consistent estimators of γ_k^j and γ_p^j still can be obtained as long as equation (14) is correctly specified, because the two risk reduction variables are experimental design points that were assigned independently of parent characteristics.

Fourth, the dependent variable W_h^j (stated willingness to pay for a one year's supply of sun lotion) is latent: Parents only were asked to state whether they would be willing to make a randomly assigned expenditure. Parents are assumed to answer in the affirmative if $W_h^j > P_h^j$, where P_h^j denotes the expenditure for a one year supply of sun lotion *j* that was randomly assigned to parent *h*. Thus a parent states that she will purchase the sun lotion if

$$\omega_h^j / \sigma^j < (\gamma_0^j + \alpha^j)/\sigma^j + (\gamma_p^j/\sigma^j)\left[\Delta_p^j / R_p^j\right] + (\gamma_k^j/\sigma^j)\left[\Delta_k^j / R_k^j\right] - (1/\sigma^j)P_h^j,$$

where the *controls* are suppressed for notational simplicity, $E(\omega_h^j) = 0$ and $\text{var}(\omega_h^j) = (\sigma^j)^2$, and ω_h^j is symmetrically distributed. These features together with an assumption of normally distributed composite errors that have an expected non-zero covariance across equations $E(\omega_h^a \omega_h^b) = \sigma_{ab} \neq 0$ motivates estimation by bivariate probit, where $\rho = \sigma_{ab} / \sigma^a \sigma^b$.[26] Following Cameron and James (1987), the coefficient of the randomly assigned sun lotion price is interpreted as an estimate of $-1/\sigma^j$ that can be used to recover unnormalized coefficients of risk reductions (γ_i^j) from the normalized estimates of γ_i^j / σ^j.

[26] Of course, the assumption of normally distributed errors will not be exactly satisfied when non-normally distributed parent characteristics (e.g., income) are not included as covariates.

Fifth, a concern is that use of stated preference data to estimate the willingness to pay function will result in a comparatively large variance of the composite error ($\omega_h^j = \varepsilon_h^j + \nu_h^j$). Stated preference data are often "noisy" and this feature could lead to wide confidence intervals around the estimated values of marginal rates of substitution, thus making it more likely that the null hypothesis being tested will not be rejected.

4.2 Results

Full information maximum likelihood bivariate probit estimates are shown in Table 5.[27] Sample means of covariates are presented along with the regression estimates. Two pairs of estimates are reported. The first uses only design points as covariates and the second shows the outcome when two controls for parent characteristics (family income and number of children in the family) are added. Two design points measure skin cancer risk changes for the parent and the child (see equation (14)) and a third measures the randomly assigned sun lotion price. A fourth design point variable is added to control for the order in which the morbidity and conditional mortality labels were shown.

Consider first the pair of estimated regressions that use only design points as covariates. The estimated value of ρ (=0.778) is positive, as expected, and significantly different from zero, indicating an efficiency gain from joint estimation of the two equations. The coefficients of the required annual expenditure are negative and differ significantly from zero at 1%, suggesting that parents were more reluctant to purchase the sun lotion at higher costs than at lower costs. Additionally, coefficients of variables measuring percentage reductions in the two types of risk to both parent and child are positive and significantly different from zero at the 1% level in each

[27] Ordinary least squares estimates were used as initial values in computing the binomial probit estimates used as starting values for the bivariate probit routine. Coefficient estimates and estimates of the marginal rate of substitution between child and parent risks from the binomial probit estimates are broadly consistent with those reported in Tables 4 and 5, but are less precisely estimated.

of the two equations. This outcome suggests that parents are willing to pay more for larger than for smaller reductions in the two types of risk and is consistent with the conceptual model presented in Section 2. Comparing these coefficients to the estimated intercept, however, appears to suggest that increases in risk reduction do not bring about proportionate increases in willingness to pay. Many previous studies have found that stated willingness to pay does not increase proportionately with increases in risk reductions (see Hammitt and Graham 1999 for further discussion of this issue). Nevertheless, this conclusion may not apply because the (unnormalized) intercepts actually are estimates of $(\gamma_0^j + \alpha^j)$ rather than γ_0^j, and $\alpha^j > 0$ if parents tend to overstate purchase intentions. Also, as mentioned previously, coefficients understate willingness to pay for reduced risk because $\beta < 1$. Estimates show that the order in which the morbidity and conditional mortality labels were presented is unimportant.

When controls for income and family size are introduced, estimates again indicate positive correlation between the errors in the two equations (0.788). Coefficients of family income are positive while coefficients of the total number of children in the family are negative as expected. These coefficients, however, are not consistently estimated if income and family size are correlated with unobserved family characteristics influencing the sun lotion purchase decision. Income coefficients are significantly different from zero only at the 10% level under a two-tail test, suggesting a weak tendency for parents' willingness to pay to increase with income. The small effect of income may simply reflect the relatively low costs of the sun lotion, with the highest cost reaching only about $10/month. Coefficients of the number of children are significant at the 1% level, providing evidence that parents reduce protective expenditures per family member when more children are present. Because the risk change variables are orthogonal to these parent characteristics, coefficients and standard errors of risk changes are little altered from their corresponding values discussed previously. Supplementary regressions (Appendix) specified like those in the last pair of columns but also including covariates for marital status, education, age and gender of parent, age and gender of child, and whether a close relative had been diagnosed with skin cancer also demonstrated this same result. Only two of the additional 14 coefficients differed significantly from zero at 10%.[28] Also, in this expanded regression, coefficients of the risk change variables were almost unchanged as compared with those presented in Table 5.

Table 6 reports tests of whether the equilibrium condition implied by altruism holds ($\gamma_k^j / \gamma_p^j - 1 = 0,\ j = a, b$). Column (2), Table 6, labeled "full sample," reports results based on Table 5 estimates that control only for design points. Standard errors are computed using the delta method. As shown, the null hypothesis that this equilibrium condition holds is not rejected at conventional significance levels in either the unconditional morbidity or conditional mortality equations. This null hypothesis also is not rejected using a Wald test of the restriction $\gamma_k^j / \gamma_p^j - 1 = 0$ in both equations jointly.

Remaining columns of Table 6 summarize outcomes of parallel tests in six subsamples defined according to the gender of parent, gender of child, and age of child. Results for subsamples were obtained by re-estimating the willingness-to-pay equations separately by subsample using only the four experimental design points as covariates. Parent gender is considered because the unitary model assumes that families act as if maximizing a single utility function, so that decisions made by mothers should be consistent with those made by fathers. Gender and age of child are considered because parental marginal rates of substitution should not

[28] The two variables with significant coefficients were parent gender in the morbidity equation and child age in the conditional mortality equation. Also, in regressions including only experimental design points and the constructed measures of perceived latency for parents and children, three of the four latency coefficients were negative as expected, but none was significant.

differ between children as long as marginal costs of risk reduction are the same, as in this field study. As shown in Table 6, results are consistent with the hypothesis $\gamma_k^j / \gamma_p^j = 1$ in all six subsamples. Furthermore, likelihood ratio tests detect no significant differences in willingness to pay functions by gender of parent, or by age or gender of child.[29]

Although not reported in Table 6, a comparable analysis was undertaken based on subsamples defined by family income, by age and education of parent, and by presence of one versus more than one child in the family. This analysis is motivated by the assumed constancy of coefficients of the willingness to pay functions, relative to the possibility that the marginal utility of income, the β term, or other parameters may vary with characteristics of the parent.[30] Also, the model in Section 2 includes only one child in the family and the survey asked parents to consider using the sun lotion for only one of their children, even though most parents in the sample reported having more than one child. However, the null hypothesis that parameters of willingness to pay functions are equal between families with high or low income, or between parents with and without college educations, or between older and younger parents, or between single or multi-child families, is not rejected. Also, the hypothesis $\gamma_k^j / \gamma_p^j = 1$ is not rejected in any of these additional subsamples.

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[29] The null hypotheses that slope coefficients of the equations do not differ by gender of parent, or by gender or age of child, after allowing for different intercepts, were each separately tested using likelihood ratio tests. Results indicated that the null hypothesis would not be rejected at conventional significance levels in any comparison. Further analysis of the role of parent gender was conducted by re-estimating the model in the last two columns of Table 5 while including a dummy variable for parent gender and interactions of this variable and all covariates. The only statistically significant difference between male and female parents was found in the coefficient of the number of children in the morbidity equation, where female willingness to pay for the sun lotion declined less than male willingness to pay with increases in the number of children. Coefficients of risk changes, annual cost and income appear to be the same for mothers and fathers. Also, outcomes of all of these tests by parent gender are the same if the comparison is restricted to married parents.

[30] A related issue involves whether parents differed in their perceptions of available substitutes for the hypothetical sun lotion. The survey would have been improved had parents been asked how skin cancer risks could have been reduced by the amounts shown on the labels if the product were not available or if they chose not to buy it. In the absence of this information, we assume that either substitution opportunities are negligible or are the same for all parents.

The analysis presented assumes that the parent would use the sun lotion for herself and her sample child but not for anyone else. The apparent decline in willingness to pay for the sun lotion with increases in the number of children in the family (Table 5) along with the lack of significant differences in slope coefficients of willingness to pay functions between single- and multiple-child families suggests that parents did not envision using the sun lotion to protect additional children when stating their purchase intentions. Also, parents who indicated that they would buy the sun lotion were asked about the intended users. The majority of parents indicated that the lotion would be used for the parent and the sample child (85% for the morbidity labels and 90% for the conditional mortality labels), with almost all of the remaining purchasers intending to use the lotion for the child only.[31] Excluding parents who envisioned purchasing the sunscreen but using it for only one individual does not change the outcome of any of these statistical tests. Additionally, because parents were told that achieving the stated risk reductions required use of the lotion as directed, the above tests were performed again after adjusting the risk change measures of Table 5 so that the risk change would be zero for the parent or child if the parent did not envision that person using the sun lotion. The null hypothesis is not rejected using these adjusted measures of risk changes.

5. Summary and Conclusions

Special protection of young children from environmental hazards has become a worldwide priority of government policies to improve human health. The fundamental tension between altruism and self-interest in families looms as the crucial behavioral factor determining the effectiveness of these policies. This paper estimates parents' marginal rates of substitution between skin cancer risks faced by 488 parents and their children between the ages of 3 and 12

[31] Four parents who indicated that they would purchase one of the sun lotions envisioned using it for themselves only (three for the morbidity labels and one for the conditional mortality labels).

years. A model of altruistic family behavior that incorporates household production of latent health risk guides the estimates. The model demonstrates that the marginal rate of substitution between risks faced by the parent and child is equal to the ratio of marginal risk reduction costs. Resulting empirical estimates then focus on whether this equality holds.

Tests rest on an examination of stated preference values for a hypothetical sun lotion. Although stated preference valuation is a controversial method of obtaining willingness to pay to reduce environmental risks, it supports consistent estimation of parents' marginal rates of substitution between health risks to themselves and corresponding health risks to their children in the field study described here. Consistent estimation of marginal rates of substitution is made possible by: (1) allowing for both systematic and random errors in parents' stated willingness to pay for the sun lotion and (2) randomly assigning skin cancer risk reductions offered by sun lotion to the sample of parents. Together, these innovations imply that the skin cancer risk reductions assigned are orthogonal both to parent characteristics and to errors parents may make in assessing their willingness to pay for the sun lotion.

In the theoretical model, an altruistic parent's marginal rate of substitution between risk to her child and risk to herself equates with the corresponding ratios of marginal skin cancer risk reduction costs. This prediction is the basis of the null hypothesis for econometric tests using data from the field study. The null hypothesis is not rejected, so test results support the notion that parents are altruistic toward their young children. This outcome stands in contrast to findings in related studies that present evidence against altruism of parents toward their children. This study, however, looks at behavior of parents toward pre-teenage children living at home, rather than behavior of parents toward their adult children who have formed households of their own. An important implication is of findings from this study is that effectiveness of public intervention programs to reduce environmental risks faced by children may be compromised to some extent because parents will respond by redistributing family resources.

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Table 1. Frequency Distribution of Parents' Perceived Risks.

N=488.

	Risk of Getting Skin Cancer[a]		Conditional Risk of Dying from Skin Cancer	
Risk Range (%)	**Parents**	**Children**	**Parents**	**Children**
0 - 4.75	53	46	78	111
5 - 9.75	24	48	140	169
10 - 14.75	53	78	112	97
15 - 19.75	55	62	59	40
20 - 24.75	55	59	33	28
25 - 29.75	61	63	22	17
30 - 34.75	39	32	9	5
35 - 39.75	22	16	7	5
40 - 44.75	33	23	4	5
45 - 49.75	6	4	5	1
50 - 54.75	49	29	16	9
55 - 59.75	4	2	1	1
60 - 64.75	5	5	0	0
65 - 69.75	0	1	0	0
70 - 74.75	4	2	2	0
75 - 79.75	6	5	0	0
80 - 84.75	2	3	0	0
85 - 89.75	2	2	0	0
90 - 94.75	9	5	0	0
95 – 100	6	3	0	0

[a]Initial risk assessment.

Table 2. Parents' Mean Risk Perceptions (%).

Sample	Risk of Getting Skin Cancer[a]	Conditional Risk of Dying from Skin Cancer	Sample Size
All Parents	26.93	12.05	488
All Children	22.46	9.36	488
Mothers	29.17	12.46	368
Fathers	20.08	10.82	120
Daughters	22.31	9.38	242
Sons	22.61	9.33	246
Children aged 3 to 7 years	23.84	10.10	275
Children aged 8 to 12 years	20.68	8.39	213

[a]Initial risk assessment.

Table 3. Use of Sun Protection Products.

Fraction of Time Outdoors that Sun Protection Products Used	Parents	Children
Never	44	15
Less than half	115	80
About half	109	106
More than half	91	106
Always/almost always	129	181

Sun Protection Factor Normally Used	Parents	Children
Less than 15	67	15
15 to less than 30	185	103
30 or higher	192	355

Table 4. Frequency Distribution of Expected Age at Onset.

N=488

Age Range (years)	Parents	Children
Before age 40	45	68
40 - 44	63	42
45 - 49	64	52
50 - 54	111	84
55 - 59	61	66
60 - 64	84	55
65 - 69	41	46
70 - 74	13	49
75 - 79	1	12
Age 80 or later	5	14
Mean age at onset (years)	53	55
Mean age (years)	35	7
Implied mean expected latency period (years)	18	48

Table 5. Willingness to Pay to Reduce Skin Cancer Risks: Bivariate Probit Estimates (N=488).

Covariate (Parameter Notation)	Sample Mean (Std. Dev.) or Proportion: Morbidity Risk	Sample Mean (Std. Dev.) or Proportion: Conditional Mortality Risk	Coefficients (Standard Errors): Morbidity Risk	Coefficients (Standard Errors): Conditional Mortality Risk	Coefficients (Standard Errors): Morbidity Risk	Coefficients (Standard Errors): Conditional Mortality Risk
Parent's Percentage Risk Reduction	0.289	0.302	0.912	0.717	0.901	0.739
(γ_p^j / σ^j)	(0.200)	(0.200)	(0.272)	(0.267)	(0.274)	(0.267)
Child's Percentage Risk Reduction	0.300	0.299	0.854	1.426	0.843	1.487
(γ_k^j / σ^j)	(0.200)	(0.200)	(0.270)	(0.267)	(0.275)	(0.272)
Cost of Sun Lotion ($/year)	64.518	64.150	-0.011	-0.011	-0.011	-0.011
$(-1/\sigma^j)$	(34.520)	(34.897)	(0.002)	(0.002)	(0.002)	(0.002)
Order (=1 if risk change in column presented last, 0 if first)	0.488	0.512	-0.149	-0.087	-0.151	-0.105
			(0.122)	(0.122)	(0.126)	(0.125)
Family Income ($10,000/year)	5.957				0.028	0.029
	(3.569)				(0.018)	(0.017)
Number of Children in Family	2.078				-0.190	-0.004
	(0.952)				(0.069)	(0.068)
Constant			0.733	0.520	0.981	0.347
$((\gamma_0^j + \alpha^j)/\sigma^j)$			(0.171)	(0.170)	(0.251)	(0.229)
Error Correlation			0.778		0.788	
(ρ)			(0.044)		(0.044)	
Log-Likelihood			-512.553		-505.391	

Table 6. Estimates of γ_k^j / γ_p^j and Altruism Tests.

	Estimates of γ_k^j / γ_p^j (Standard Errors) and Tests of Altruism						
	Full Sample	Mothers	Fathers	Daughters	Sons	Child Age 3-7	Child Age 8-12
Morbidity ratio	0.936	0.927	0.88	0.902	0.96	1.438	0.441
$(\gamma_k^a / \gamma_p^a)$	(0.415)	(0.456)	(0.678)	(0.777)	(0.503)	(0.766)	(0.462)
z-test ratio=1 (*p*)	0.878	0.873	0.860	0.900	0.937	0.568	0.226
Conditional Mortality ratio $(\gamma_k^b / \gamma_p^b)$	2.005	1.816	3.746	1.512	3.003	5.018	0.661
	(0.853)	(0.837)	(6.133)	(0.702)	(2.688)	(4.962)	(0.417)
z-test ratio=1 (*p*)	0.240	0.329	0.654	0.465	0.456	0.418	0.416
Wald test, both ratios=1 (*p*)	0.493	0.608	0.883	0.761	0.750	0.601	0.398
Sample Size	488	368	120	242	246	275	213
LR test, equal parameters between groups (*p*)		0.975		0.958		0.214	

SkinSaver

Sun Protection Lotion

For Adults & Children

Developed with dermatologists to protect skin from harmful effects of sun exposure.

Skin Cancer Protection	**Ultra Waterproof**
SPF ___	**Parsol®1789**

"Making the outdoors safer for you and your family."

(Back of bottle)

New SkinSaver® sun protection lotion.

Skin Cancer Protection			
✓ Used as directed in clinical trials, SkinSaver reduced risk of skin cancer by:			
10% for Adults			10% for Children
✓ Used as directed in clinical trials, SkinSaver had no effect on the risk of dying if skin cancer occurred.			
More Skin Protection			
Parsol®1789			SPF_____
Protects against premature skin aging			Protects against sunburn

More Added Features

* Ultra long-lasting waterproof formula – One application lasts all day *

* Non-comedogenic–Won't block pores * Oil-free–Won't feel greasy *

* Hypoallergenic * PABA-free * Unscented *

DIRECTIONS: Apply generously and evenly to all exposed areas of skin at least 15 minutes before sun or water exposure.

ACTIVE INGREDIENTS: Oxybenzone, octocrylene, 2-ethylhexyl salicate, homosalate, avobenzone.

APPENDIX: Supplemental Data and Empirical Results

Table A-1

Hypothetical Sun Protection Product Labels

	Percent Change in Morbidity Risk		Percent Change in Mortality Risk	
Label	Parent	Child	Parent	Child
A	10	10	0	0
B	10	50	0	0
C	50	10	0	0
D	50	50	0	0
E	0	0	10	10
F	0	0	10	50
G	0	0	50	10
H	0	0	50	50

Table A-2. Sample Means by Experimental Design Point.

	Morbidity Risk				Conditional Mortality Risk			
Label	A	B	C	D	E	F	G	H
Percentage risk change for parent	10	10	50	50	10	10	50	50
Percentage risk change for child	10	50	10	50	10	50	10	50
Perceived risk of getting skin cancer for parent	30.26	25.58	26.19	25.44	27.40	25.08	27.59	27.63
Perceived risk of getting skin cancer for child	23.37	22.88	22.18	21.27	23.13	18.90	23.47	24.27
Perceived conditional risk of dying from skin cancer for parent	11.89	11.89	12.05	12.41	11.83	10.66	13.21	12.47
Perceived conditional risk of dying from skin cancer for child	9.30	8.76	9.85	9.59	8.58	8.73	10.43	9.66
Family Income ($10,000/year)	5.67	6.49	5.99	5.66	6.03	6.00	6.14	5.67
Number of Children in Family	2.10	2.10	2.04	2.07	2.23	1.97	2.05	2.07
Parent is female	0.85	0.78	0.68	0.70	0.78	0.78	0.73	0.74
Child is female	0.45	0.53	0.46	0.55	0.46	0.56	0.52	0.45
Child age	7.18	7.12	7.25	6.72	6.95	7.40	6.86	7.07
Sample Size	130	127	114	117	121	120	124	123

Table A-3. Willingness to Pay to Reduce Skin Cancer Risks: Bivariate Probit Estimates (N=488).

	Mean (s.d.) or Proportion		Coefficients (Standard Errors)			
	Morb. Risk	Cond. Mort. Risk	Morb. Risk	Cond. Mort. Risk	Morb. Risk	Cond. Mort. Risk
Parent's Percentage Risk Reduction	0.289	0.302	0.990	0.711	0.918	0.749
	(0.200)	(0.200)	(0.300)	(0.277)	(0.278)	(0.271)
Child's Percentage Risk Reduction	0.300	0.299	0.849	1.412	0.850	1.384
	(0.200)	(0.200)	(0.279)	(0.288)	(0.271)	(0.272)
Cost of Sun Lotion ($/year)	64.518	64.150	-0.011	-0.011	-0.011	-0.011
	(34.520)	(34.897)	(0.002)	(0.002)	(0.002)	(0.002)
Order (=1 if risk change in column presented last, 0 if first)	0.488	0.512	0.026	0.024	-0.146	-0.104
			(0.022)	(0.021)	(0.123)	(0.123)
Parent Perceived Latency Period	18.092				-0.045	-0.077
	(9.811)				(0.072)	(0.073)
Child Perceived Latency Period	48.148				0.012	-0.028
	(12.239)				(0.060)	(0.059)
Family Income ($10,000/year)	5.957		0.026	0.024		
	(3.569)		(0.022)	(0.021)		
Number of Children in Family	2.078		-0.194	-0.022		
	(0.952)		(0.073)	(0.073)		
Parent is Married	0.830		0.104	-0.019		
			(0.182)	(0.188)		
Parent is College Graduate	0.576		0.081	0.072		
			(0.138)	(0.137)		
Parent Age	35.117		-0.004	-0.004		
	(6.63)		(0.012)	(0.011)		
Parent is Female	0.754		0.271	0.161		
			(0.154)	(0.149)		
Child Age	7.070		0.011	0.051		
	(2.937)		(0.025)	(0.025)		
Child is Female	0.496		0.156	0.061		
			(0.128)	(0.127)		
Close Relative of Parent Diagnosed with Skin Cancer	0.252		0.036	-0.177		
			(0.150)	(0.158)		
Constant			0.063	0.520	0.751	0.815
			(0.144)	(0.170)	(0.303)	(0.296)
Error Correlation			0.791		0.777	
			(0.0443)		(0.0445)	
Log-Likelihood			-500.121		-511.018	