

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

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

### **ABSTRACT**

This paper tests altruism of parents toward their young children using a model of family behavior that incorporates 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 field experiment involving 488 parents of children aged 3-12 years. This outcome implies that parents offset the effectiveness of public programs to reduce their children's environmental risks by reallocating family resources. Thus, current policies by governments worldwide that assign a high priority to protection of young children from environmental hazards may not be successful in achieving their intended results.

Key words: Altruism, household production, environmental risk, field experiment.

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

### ***1. Introduction***

Special protection of young children from environmental hazards has become a worldwide priority in government policies to improve human health.<sup>1</sup> 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 as parents redistribute family resources. In any case, the fundamental tension between altruism and self-interest in family exchange looms as the crucial behavioral factor determining the effectiveness of government policies to protect children's health.

What is known about altruism in families? Several prominent 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, Dickie and Messman 2004) look at how parents protect themselves and their pre-teenage children from environmental and other

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<sup>1</sup> 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 (2003) summarizes similar efforts undertaken in other countries.

hazards. In this branch of the literature, altruism is sometimes mentioned as a possible parental motivation, but implications of altruism are not tested. Instead, marginal rates of substitution between children's health and parent's health are estimated for the purpose of transferring existing benefit estimates for adults to children. Estimates of these marginal rates of substitution differ widely, as discussed by Agee and Crocker (2004). In consequence, these studies are silent on whether parents are altruistic toward their young children and additionally provide little guidance for benefits transfer in the policy arena.

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 data from a field experiment designed to estimate marginal rates of substitution between 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 field experiment (described more fully later on) is designed.

Test outcomes support the economic model of altruism and have two implications. First, and most importantly, parents offset the effectiveness of government programs to reduce environmental risks faced by reallocating family resources. Therefore, after accounting for the behavioral response of parents, government programs may not be successful in reducing levels of environmental hazards that children face. Second, accuracy in transferring existing benefit

estimates for adults to children in the policy arena can be improved by accounting for likely variations in relative marginal risk reduction costs across types of risk, ages of children, and other factors.

## 2. *Model*

This section 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 a selfish child. Because the model includes only one parent, possible divergent interests between parents in a family are not considered. 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. Extensions to the case of multiple children are briefly considered at the end of this section.

The parent has two periods of life remaining while the child has three. During the present period, the parent receives income and purchases market goods for herself and her young child, who has no separate income. In the next period the child will have his own income, which the parent may supplement, and will make his own allocation decisions. In the third and final period, the child will continue to receive income and purchase market goods while the parent will be deceased.

Each individual faces two latent environmental health risks. 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 respondents in the field experiment (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 two risks  $a$  and  $b$  while subscript  $i$  distinguishes the parent ( $p$ ) from the child ( $k$ ). The child when grown is assumed to share his parent's assessment of the two lifetime risks. Perceived lifetime risks are influenced by use of market goods that otherwise have no utility:

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

where  $G_{it}^j$  denotes individual  $i$ 's use in period  $t$  of a market good affecting the  $j$ th risk.

When the child begins to make his own consumption decisions in the next 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) and his lifetime budget constraint

$T + y_{k1} + (1+r)^{-1}y_{k2} = C_{k1} + P^a G_{k1}^a + P^b G_{k1}^b + (1+r)^{-1}[C_{k2} + P^a G_{k2}^a + P^b G_{k2}^b]$ . 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  $t=1$ ,  $r$  denotes the market interest rate and  $P^j$  denotes the market price of the protective good affecting the  $j$ th risk. The quantities of market goods that the child consumed in the previous period ( $C_{k0}$  and  $G_{k0}^j$ ,  $j=a, b$ ) will have been chosen by the parent, while the child will choose his own quantities for the last two periods.

In the present period ( $t=0$ ) the parent maximizes the altruistic utility function

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

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

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

where  $\eta$  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. In the present period the parent chooses quantities of market goods  $(C, G^a, G^b)$  that she and her young child use. When  $t = 1$ , the parent makes these choices only for herself while deciding how much income to transfer to her child. Interior solutions for both the parent's and child's maximization problems are assumed and all second-order conditions are assumed to hold.

This model demonstrates the familiar result that the altruistic parent's marginal rate of substitution between the child's consumption of  $C$  and her own consumption of  $C$  is equal to unity in all periods when both are alive. The parent's marginal rate of substitution between the child's consumption of  $G^j$  and her own consumption of  $G^j$  is equal to unity as well.

$$\frac{\eta \partial U_k / \partial C_{kt}}{\partial U_p / \partial C_{pt}} = 1 = \frac{\eta (\partial U_k / \partial R_k) (\partial R_k / \partial G_{kt}^j)}{(\partial U_p / \partial R_p) (\partial R_p / \partial G_{pt}^j)}, \quad t = 0, 1, \quad j = a, b.$$

The empirical analysis presented in Section 4 looks at risk reduction, not consumption of  $G^j$ , so the latter marginal condition is rewritten to obtain:

$$\frac{\eta (\partial U_k / \partial R_k^j)}{(\partial U_p / \partial R_p^j)} = \frac{\partial R_p / \partial G_{pt}^j}{\partial R_k / \partial G_{kt}^j} = \frac{MC_k^j}{MC_p^j}, \quad t = 0, 1, \quad j = a, b. \tag{4}$$

Equation (4) shows that the altruistic parent's marginal rate of substitution between her child's and her own latent health risk equals the ratio of marginal products of a risk-reducing market good that both parent and child consume. This ratio of marginal products is equal to the ratio of present value marginal costs of reducing risk, because the price per unit of  $G^j$  is the same no matter who uses it and because present value marginal costs are equated across periods for each

individual.<sup>2</sup> The ratio of marginal costs is not expected to equal unity because the technologies used to produce perceived risk reduction may differ between the parent and the child and, even if the technologies are the same, levels of perceived risk faced by the two people may differ. Likewise, the ratio of marginal costs for reducing the first risk need not equal the ratio of marginal costs for reducing the second risk. Finally, an additional implication of the model is that the marginal rate of substitution between the two types of risks for either individual equals the corresponding ratio of marginal costs in reducing the two risks.<sup>3</sup>

It turns out that there are advantages in the field experiment (see Section 3) and in testing for altruism from presenting risk changes as percentages rather than as absolute amounts. When 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, as shown below.

$$\frac{(\partial R_p / \partial G_{pt}^j)}{(\partial R_k / \partial G_{kt}^j)} = \frac{R_p^j}{R_k^j}, \quad t = 0, 1, \quad j = a, b.$$

This means that altruism can be tested by considering whether equation (5) holds.

$$\frac{\eta(\partial U_k / \partial R_k^j) R_k^j}{(\partial U_p / \partial R_p^j) R_p^j} = \frac{(\partial R_p / \partial G_{pt}^j) / R_p^j}{(\partial R_k / \partial G_{kt}^j) / R_k^j} = 1, \quad t = 0, 1, \quad j = a, b. \quad (5)$$

In other words, the hypothesis tested in Section 4 is that the parent's marginal rate of substitution between equal percentage risk changes for herself and for the child equals unity.

This model 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 (see Appendix A). For example, a

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

<sup>3</sup> The model also implies that the intertemporal marginal rate of substitution in consumption  $C$  equals the discount factor for both the parent and the child. The intertemporal marginal rate of technical substitution between risk-reducing goods in different periods likewise equals the discount factor for both individuals. These hypotheses are not tested because data were not collected on consumption over time.

discounted expected utility version of the model that explicitly considers fatal and nonfatal risks and allows the amount of income transferred to the child to depend on the parent's survival leads to a prediction like equation (4) for both fatal and nonfatal risks. In that version of the model, individual subjective rates of time preference explicitly appear in the marginal rate of substitution (whereas time preferences are implicit in the utility functions in the model just presented). While estimates of subjective discount factors for latent health risks would be of interest, these parameters need not be separately identified to test altruism and might be better estimated in a study that focused on timing of disease onset.

Also, if multiple children are included in the model, then the parent's marginal rate of substitution between the risks faced by any two family members equals the ratio of marginal risk reduction costs for those family members. This implies that in situations where the marginal cost of risk reduction is the same for all children in a family, the parent's marginal rate of substitution between a child's risk and her own risk will be the same, regardless of characteristics of the child such as age or gender. Also, in a simpler version of the model it is easy to show that the demand for protective goods  $G$  for both parents and children increases with income and declines with an exogenous increase in the number of children.<sup>4</sup> Considering an arbitrary number of risks, or of goods or time allocations that affect risks, does not alter the altruism prediction as long as joint production is ruled out.<sup>5</sup> Nor would allowing for an arbitrary number of time periods or for the possibility that parents and children may use a different good to reduce a given risk fundamentally change the prediction of the model. The remainder of this paper uses data from a

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<sup>4</sup> These results arise in a one-period model where parent and child each face one risk, provided that utility functions defined over  $G$  (by substitution of risk production functions) are concave and that the marginal utility of consumption declines when risk increases.

<sup>5</sup> Dickie and Gerking (1991) consider the situation in which use of  $G$  either may be a direct source of utility or may reduce two or more different risks. These cases are not of interest in this study because the sun lotion used in the experiment described in Section 3 is unlikely to be an important source of joint production. Also, Dickie and Gerking (1996) find that joint production is unimportant in a related study of sun lotion use and skin cancer risk.

field study of parents' perceptions of risk of skin cancer to themselves and to their children to test whether the condition in equation (5) is satisfied.

### **3. Data and Experimental Design**

#### **a. Background**

To test altruism, field data were collected from parents of pre-teenage children during summer of 2002 using a self-paced, interactive, computerized instrument.<sup>6</sup> 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.<sup>7</sup>

The sample consisted of 610 parents; children did not participate.<sup>8</sup> 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

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<sup>6</sup> A more complete description of these data is provided in Dickie and Gerking (2005).

<sup>7</sup> 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. Parents agreeing to participate in the study constituted 3.5% of working residential numbers, 5% of contacts 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.

<sup>8</sup> 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 experiment administrator (4 parents).

Dickie and Gerking 2005) 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.

***b. 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.<sup>9</sup> Parents made preliminary assessments of lifetime skin cancer risk using an 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

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<sup>9</sup> The ability of respondents to clearly distinguish between these two types of risk was a concern from the beginning of the study because few previous surveys have dealt with compound risks. In de-briefing sessions conducted after the pre-tests, participants were asked if they understood the meaning of the morbidity risk and conditional death risk questions. While wording changes in the questions were suggested, all of the participants understood the meaning of the risk concepts involved.

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, first 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 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. 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 3. 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 3, 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.

Finally, parents 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.<sup>10</sup> 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.

*c. Experimental Design and the Choice Experiment*

Parents valued risk reductions by expressing willingness to pay for a hypothetical sun lotion.<sup>11</sup> 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 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 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). Pre-test participants understood the concept of percentage reductions in risk and, as demonstrated in Section 2, use of percentage changes simplifies the test of altruism. Use of

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<sup>10</sup> Respondents were instructed not to look ahead or to go back to previous questions but rather to see the experiment 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.

<sup>11</sup> This approach also was used in a recent cross-country study of skin cancer risks (see Brouwer and Bateman 2005).

percentage changes in risk also has an advantage over presenting absolute risk reductions in that the post-treatment risk levels always are non-negative.<sup>12</sup>

Each parent was randomly assigned two of the eight labels and asked for willingness to pay for each.<sup>13</sup> 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, and the risk reduction the sun lotion would offer.

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.

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<sup>12</sup> 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.

<sup>13</sup> 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.

#### 4. Empirical Estimates

##### a. Methods

This section presents econometric tests of altruism. Following Cameron (1988), estimation is 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 ( $j = b$ ). Derivation of marginal willingness to pay in equation (6) (see Appendix A) treats continued use of the sun lotion as a necessary input in lifetime risk reduction ( $-dR_t^j$ ) and makes use of the fact that the first bottle was offered as a single purchase decision for both the parent and the child.

$$\begin{aligned} d(WTP^j) &= (1/\lambda_p) \left[ \sum_{t=0}^2 (n_t/2)(1+r)^{-t} \right]^{-1} \left[ (\partial U_p / \partial R_p^j)(dR_p^j) + \eta(\partial U_k / \partial R_k^j)(dR_k^j) \right] \\ &= \beta \left( \gamma_p^j (-dR_p^j / R_p^j) + \gamma_k^j (-dR_k^j / R_k^j) \right). \end{aligned} \quad (6) \quad j = a, b,$$

In this equation  $\gamma_p^j = -(\partial U_p / \partial R_p^j)R_p^j / \lambda_p$  and  $\gamma_k^j = -\eta(\partial U_k / \partial R_k^j)R_k^j / \lambda_p$  denote the parent's marginal willingness to pay for proportionate reductions in her own and her child's lifetime risk,  $n_t$  denotes the number of family members for whom the sun lotion would be purchased in period

$t$  ( $n_0 = 2 = n_1, n_2 = 1$ ), 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.

Nonetheless, the ratio of coefficients of lifetime risk changes

$\beta\gamma_k^j / \beta\gamma_p^j = \eta(\partial U_k / \partial R_k^j)R_k^j / ((\partial U_p / \partial R_p^j)R_p^j)$  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 as shown in equation (5).

For econometric estimation, equation (6) is specified for parent  $h$  as

$$WTP_h^j = \gamma_0^j + \gamma_p^j \left[ \Delta_p^j / R_p^j \right]_h + \gamma_k^j \left[ \Delta_k^j / R_k^j \right]_h + controls_h + \varepsilon_h^j. \quad (7)$$

In equation (7),  $\Delta_p^j$  and  $\Delta_k^j$  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, and the  $R_i^j$  denote the last estimate the  $j$ th perceived risk elicited for individual  $i$  in the field experiment. 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  $\gamma_i^j$  as constants implies that willingness-to-pay per unit of risk reduction  $\partial WTP^j / \partial \Delta_i^j = \gamma_i^j / R_i^j = \beta(\partial U_i / \partial R_i^j)$  decreases with the magnitude of perceived risk initially faced.<sup>14</sup> Also: (1) *controls* refers effects on willingness to pay of measured parental characteristics such as income and family size, and (2)  $\varepsilon_h^j$  denotes a random disturbance term with standard properties included to capture unobserved characteristics of parent  $h$ .

Four aspects of equation (7) warrant further discussion before turning to the results of estimation. First, altruism implies that  $\gamma_k^j / \gamma_p^j = 1$ . Thus, the altruism test does not rest on directly estimating WTP for risk reduction, but on estimating the ratio of estimated contributions

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<sup>14</sup> In other words, the marginal value of risk reduction  $\partial U_i / \partial R_i^j$  diminishes as  $R_i^j$  rises so that  $\gamma_i^j$  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 4 below.

of risk reduction to willingness to pay. This means that  $\gamma_k^j$  and  $\gamma_p^j$  must be consistently estimated, but it is not necessary to obtain a consistent estimate of  $\gamma_0^j$ .

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 characteristics included in *controls* and to parent characteristics captured by  $\varepsilon_h^j$ . This means that if the functional form of equation (7) is correct: (1) endogeneity problems in estimating the  $\gamma_i^j$  are avoided and (2) estimates of the  $\gamma_i^j$  are unaffected by the choice of variables to include in *controls*.<sup>15</sup>

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  $j$ th risk differs from true willingness to pay ( $WTP_h^j$ ) by both systematic and random factors according to

$$W_h^j = WTP_h^j + \alpha_h^j = WTP_h^j + \alpha^j + \nu_h^j, \quad j = a, b. \quad (8)$$

In equation (8),  $\alpha^j$  is the nonzero mean of  $\alpha_h^j$  and  $\nu_h^j$  is a random disturbance.  $\alpha^j$  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. Also,  $\nu_h^j$  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  $\nu_h^j$  are assumed to be normally distributed with mean zero and constant variance and the

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<sup>15</sup> Determinants of willingness-to-pay based on the model of Section 2 or its extensions discussed Appendix A include prices of market goods and the market interest rate, parental present and future income, child future income, the number of children in the family, and the length of latency periods for parent and child. These controls need not be included to estimate marginal rates of substitution because the assigned risk changes are orthogonal to the controls.

possibility that  $E(v_h^a v_h^b) \neq 0$  motivates joint estimation of willingness-to-pay equations for the two types of risk.

The marginal rate of substitution ( $\gamma_k^j / \gamma_p^j$ ) is estimated by substituting equation (8) into equation (7) to obtain

$$W_h^j = (\gamma_0^j + \alpha^j) + \gamma_p^j \left[ \Delta_p^j / R_p^j \right]_h + \gamma_k^j \left[ \Delta_k^j / R_k^j \right]_h + \text{controls}_h + \varepsilon_h^j + v_h^j, \quad j = a, b. \quad (9)$$

Notice that estimators of the constant term ( $\gamma_0^j$ ) 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 ( $\omega_h^j = \varepsilon_h^j + v_h^j$ ). Nevertheless, consistent estimators of  $\gamma_k^j$  and  $\gamma_p^j$  still can be obtained as long as equation (9) 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 pay a randomly assigned price. Parents are assumed to answer in the affirmative if  $W_h^j > P_h^j$ , where  $P_h^j$  denotes the price of sun lotion  $j$  randomly assigned to parent  $h$ . Thus a parents 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  $\omega_h^j$  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  $\rho = \sigma_{ab} / \sigma^a \sigma^b$ .<sup>16</sup> 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 ( $\gamma_i^j$ ) from the normalized estimates of  $\gamma_i^j / \sigma^j$ .

### ***b. Results***

Full information maximum likelihood bivariate probit estimates are shown in Table 4.<sup>17</sup> 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 (9)) 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  $\rho$  (=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 price presented are negative and differ significantly from zero at 1%, suggesting that parents were more reluctant to purchase the sun lotion at higher prices than at lower prices.

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

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<sup>16</sup> 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.

<sup>17</sup> 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 (see Hammitt and Graham 1999 for further discussion of this issue). Nevertheless, this conclusion should not be drawn because the (unnormalized) intercepts actually are estimates of  $(\gamma_0^j + \alpha^j)$  rather than  $\gamma_0^j$ , and  $\alpha^j > 0$  if parents tend to overstate willingness to pay. Finally, 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). As would be expected based on the theoretical analysis discussed in Section 2, coefficients of family income are positive while coefficients of the total number of children in the family are negative. These coefficients, however, are not consistently estimated if income and family size are correlated with unobserved family characteristics influencing the sun lotion purchase decision. Nevertheless, 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. 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 B) 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%.<sup>18</sup> Also, in this expanded regression, coefficients of the risk change variables were almost unchanged as compared with those presented in Table 4.

Table 5 reports tests of the null hypothesis of altruism ( $\gamma_k^j / \gamma_p^j - 1 = 0, j = a, b$ ). Column (2), Table 5, labeled “full sample,” reports results based on Table 4 estimates that control only for design points. Standard errors are computed using the delta method. As shown, altruism 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 5 summarize tests of altruism in six subsamples defined according to the gender of parent, gender of child, and age of child. Recall from Section 2 that when marginal costs of risk reduction are equal for different children, as in this field experiment, parental marginal rates of substitution should not differ between different types of children. 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.<sup>19</sup> As shown in Table 5, estimates of  $\gamma_k^j / \gamma_p^j$  for morbidity do not differ much by gender of parent or child, while larger differences occur between older and younger children and for corresponding ratios for conditional mortality. Dickie and Messman (2004) also report larger estimates of

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<sup>18</sup> 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.

<sup>19</sup> Before testing altruism in each subsample, tests were conducted for whether willingness-to-pay equations differed according to the characteristics of the parent or child. 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 5% in any comparison, although differences in slope coefficients are significant at 10% by age of child.

marginal rates of substitution for younger children. In any case, results in Table 5 are consistent with the altruism hypothesis  $\gamma_k^j / \gamma_p^j = 1$  in all six subsamples.

Empirical results just discussed also can be used to test two other aspects of the model presented in Section 2. First, Wald tests are carried out to determine whether the marginal rate of substitution between the two types of risk for both parent and child are equal to the corresponding ratio of marginal costs in reducing these risks. This amounts to testing whether the cross-equation coefficient restrictions  $\gamma_i^a / \gamma_i^b = 1$ ,  $i = p, k$ , are valid. To control for different values of  $\sigma^j$  in the two equations, the tests were conducted using the unnormalized coefficient estimates. Standard errors of ratios of these coefficients were computed using the delta method. In separate tests involving the coefficients of risk reduction for parents and children, the null hypothesis is not rejected at conventional significance levels. Additionally, a joint test of the null hypothesis for parents and children together yields the same result. These results are consistent with altruism and suggest that parents rationally choose protective actions by equating the marginal rate of substitution for the two types of risk to the corresponding ratio of marginal risk-reduction costs.<sup>20</sup>

Second, altruism also can be tested by looking at marginal rates of substitution for unconditional mortality between the child and parent. This test can be developed using a change of variables in the model presented in Section 2. If  $R_i^a$  and  $R_i^b$  respectively denote unconditional morbidity and conditional mortality risks to person  $i$  ( $i = \text{parent, child}$ ), then

$$\pi_i^b = R_i^a R_i^b \text{ equals unconditional mortality risk and } \pi_i^a = \frac{R_i^a - \pi_i^b}{1 - \pi_i^b} \text{ equals conditional morbidity}$$

risk (the risk of contracting skin cancer, given that it is not fatal). As shown in Appendix A, the

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<sup>20</sup> The outcome of this test reinforces the conclusion that respondents sensibly considered the compound probabilities involved in the study.

parent's marginal rate of substitution between unconditional mortality risks faced by her child and herself can be expressed as

$$\left( \frac{R_p^a(1-\pi_p^b)}{R_k^a(1-\pi_k^b)} \right) \frac{(1-R_k^a)\gamma_k^a + (1-R_k^b)\gamma_k^b / R_k^b}{(1-R_p^a)\gamma_p^a + (1-R_p^b)\gamma_p^b / R_p^b}. \quad (9)$$

Equation (9) is evaluated at the sample means of risk variables using Table 4 estimates of the  $\gamma_i^j$ , and an approximate standard error is computed by applying the delta method while treating mean risks as constants. The resulting estimates (and approximate standard errors) are 3.37 (1.42) and 3.41 (1.40) based on the first and second regressions in Table 4, respectively. The model of altruism presented in Section 2 implies that the marginal rate of substitution in equation (9) should equal a corresponding ratio of marginal risk reduction costs, a prediction that is not rejected at the 10% level.

Interestingly, support for the economic model of altruism found here can be juxtaposed against the predictions of a biological model in which the degree of altruism is dictated by shared genes (Hamilton 1964, Bergstrom 2003) rather than by the interaction of consensus household preferences and constraints. The biological model recognizes that children inherit one half of their genes from each biological parent. This implies that one parent's marginal rate of substitution between her child's and her own unconditional risk of death should equal one-half. Based on estimates just discussed, the null hypothesis that a parent's marginal rate of substitution between her child's and her own unconditional mortality risk equals one-half would be rejected at the 5% level in a two-tail test. One reason, however, why results are inconsistent with the biological model may be that parents recognize that death from skin cancer would not likely affect transmission of genes to future generations because it would normally strike after one's reproductive years are over.

## 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 looms as the crucial behavioral factor determining the effectiveness of these policies. This paper tests altruism by estimating parents' marginal rates of substitution between skin cancer risks faced by 488 parents and their children between the ages of 3 and 12 years. Tests are guided by a model of altruistic family behavior that incorporates household production of latent health risk. 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.

The altruism test rests 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 experiment 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.

To test altruism, estimated marginal rates of substitution are compared to corresponding ratios of marginal skin cancer risk reduction costs. The field experiment was designed to facilitate this comparison. Test results support the economic interpretation of altruism developed

from the interaction of preferences and constraints, but not the biological interpretation of altruism based on shared genes. The main implications of this outcome are that: (1) public programs to reduce environmental risks faced by children will turn out to be less effective than expected because parents will respond by making less effort themselves, (2) parents' marginal rates of substitution between health risks to themselves and their children is not a "one-size-fits-all" constant because relative marginal costs of risk reduction will vary with the type of risk, the age of the child, and other factors, (3) existing benefit estimates for adults can be more accurately transferred to children if policy makers consider the relative marginal costs of risk reduction for each.

## *References*

- Agee, Mark D. and Thomas D. Crocker. 2004. "Transferring Measures of Adult Health Benefits to Children: A Review of Issues and Results," *Contemporary Economic Policy* 22: 468-482.
- Altonji, Joseph, Fumio Hayashi, and Laurence Kotlikoff. 1992. "Is the Extended Family Altruistically Linked? Direct Tests Using Micro Data," *American Economic Review* 82, 1177-98.
- Altonji, Joseph, Fumio Hayashi, and Laurence Kotlikoff. 1997. "Parental Altruism and Intergenerational Transfers: Theory and Evidence," *Journal of Political Economy* 105: 1121-1166.
- Barro, Robert J. 1974. "Are Government Bonds Net Wealth?" *Journal of Political Economy*, 82: 1095-1117.
- Becker, Gary S. 1974. "A Theory of Social Interactions," *Journal of Political Economy*, 82: 1063-1094.
- Becker, Gary S. 1981. *A Treatise on the Family*. Cambridge, MA: Harvard University Press.
- Bergstrom, Theodore C. 2003. "Benefit-Cost Analysis and the Entanglements of Love," University of California, Santa Barbara manuscript.
- Brouwer, Roy and Ian J. Bateman. 2005. "Benefits Transfer of Willingness to Pay Estimates and Functions for Health Risk Reductions: A Cross-Country Study," *Journal of Health Economics* 24: 591-611.
- Cameron, Trudy A. and Michelle D. James. 1987. "Efficient Estimation Methods for 'Closed-Ended' Contingent Valuation Surveys," *Review of Economics and Statistics* 69: 269-276.
- Cameron, Trudy A. 1988. "A New Paradigm for Valuing Non-market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression," *Journal of Environmental Economics and Management* 15: 355-379.

- Corso, Phaedra S., James K. Hammit and John D. Graham. 2001. "Valuing Mortality-Risk Reduction: Using Visual Aids To Improve The Validity Of Contingent Valuation," *Journal of Risk and Uncertainty* 23: 165-84.
- Cox, Donald and M. Rank. 1992. "Inter-vivos Transfers and Intergenerational Exchange," *Review of Economics and Statistics* 74: 305-314.
- Dickie, Mark and Shelby Gerking. 1991. "Valuing Reduced Morbidity: A Household Production Approach," *Southern Economic Journal* 57: 690-702.
- Dickie, Mark and Shelby Gerking. 1996. "Formation of Risk Beliefs, Joint Production and Willingness to Pay to Avoid Skin Cancer. *The Review of Economics and Statistics* 78: 451-464.
- Dickie, Mark and Shelby Gerking. (2003). "Parents' Valuation of Latent Health Risks to their Children," in *Risk and Uncertainty in Natural Resource and Environmental Economics*, (eds.) Justus Wesseler, Hans-Peter Weikard, and Robert D. Weaver, Edward Elgar: Cheltenham, UK.
- Dickie, Mark and Shelby Gerking. (2005). "Valuing Children's Health: Parental Perspectives," in *Economic Valuation of Environmental Health Risks to Children*, (ed.) Pascale Scarpecci, OECD: Paris.
- Dickie, Mark and Victoria L. Messman. 2004. "Parental Altruism and the Value of Avoiding Acute Illness: Are Kids Worth More than Parents," *Journal of Environmental Economics and Management* 48: 1146-1174.
- Federal Register*. 1997. Executive Order 13045 of April 21, 1997—Protection of Children from Environmental Health Risks and Safety Risks, 62, FR Doc. 97-10695 (April 23).

- Hamilton, William D. 1964. "The Genetical Evolution of Social Behavior, i and ii," *Journal of Theoretical Biology* 7: 1-52
- Hammitt, James K. and John D. Graham. 1999. "Willingness to Pay for Health Protection: Inadequate Sensitivity to Probability?" *Journal of Risk and Uncertainty* 18: 33-62.
- Jenkins, Robin R., Nicole Owens, and Lanelle B. Wiggins. 2001. "Valuing Reduced Risks To Children: The Case Of Bicycle Safety Helmets," *Contemporary Economic Policy* 19: 397-408.
- Krupnick, Alan, Anna Alberini, Maureen Cropper, Nathalie Simon, Bernie O'Brien, Ron Goeree, and Martin Heintzelman. 2002. Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Study of Ontario Residents. *Journal of Risk and Uncertainty* 24: 161-86.
- Laitner, John and F. Thomas Juster. 1996. "New Evidence on Altruism: A Study of TIAA-CREF Retirees," *American Economic Review* 86: 893-908.
- Liu, Jin-Tan, James K. Hammitt, Jung-Der Wang and Jin-Long Liu. 2000. "Mother's Willingness to Pay for Own and Her Child's Health: A Contingent Valuation Study in Taiwan," *Health Economics* 9: 319-26.
- Nastis, Stefanos A. and Thomas D. Crocker. 2003. "Pregnant Mother's Valuation of Own and of Child Health," presented at USEPA/University of Central Florida conference, "Valuing Environmental Health Risk Reductions to Children," Oct 20-21, <http://yosemite.epa.gov/EE/epa/erm.nsf/vwRepNumLookup/EE-0475?OpenDocument>.
- Ries, L.A.G., M.P. Eisner, C.L. Kosary, B.F. Hankey, B.A. Miller, L. Clegg, A. Mariotto, M.P. Fay, E.J. Feuer, B.K. Edwards (eds). 2003. *SEER Cancer Statistics Review, 1975-2000*, National Cancer Institute. Bethesda, MD, [http://seer.cancer.gov/csr/1975\\_2000](http://seer.cancer.gov/csr/1975_2000).

Scapecchi, Pascale. 2003. "Valuation Differences between Adults and Children," presented at Organization of Economic Cooperation and Development "Workshop on the Valuation of Children's Health," Paris, Sep. 11-12 2003.

U.S. Environmental Protection Agency. 1996. *A National Agenda to Protect Children's Health from Environmental Threats*, Washington, D.C.: U.S. Government Printing Office.

**Table 1. Frequency Distribution of Parents' Perceived Risks.**

N=488.

Risk Range (%)	Risk of Getting Skin Cancer <sup>a</sup>		Conditional Risk of Dying from Skin Cancer	
	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

<sup>a</sup>Initial risk assessment.

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

<b>Sample</b>	<b>Risk of Getting Skin Cancer<sup>a</sup></b>	<b>Conditional Risk of Dying from Skin Cancer</b>	<b>Sample Size</b>
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

<sup>a</sup>Initial risk assessment.

**Table 3. Frequency Distribution of Expected Age at Onset.**

N=488

<b>Age Range (years)</b>	<b>Parents</b>	<b>Children</b>
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 4. Willingness to Pay to Reduce Skin Cancer Risks: Bivariate Probit Estimates (N=488).**

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

**Table 5. Estimates of  $\gamma_k^j / \gamma_p^j$  and Altruism Tests.**

Estimates of $\gamma_k^j / \gamma_p^j$ (Standard Errors) and Tests of Altruism							
	Full Sample	Mothers	Fathers	Daughters	Sons	Child Age 3-7	Child Age 8-12
Morbidity ratio	0.936 (0.415)	0.927 (0.456)	0.88 (0.678)	0.902 (0.777)	0.96 (0.503)	1.354 (0.731)	0.432 (0.461)
z-test ratio=1 ( $p$ )	0.878	0.873	0.860	0.900	0.937	0.628	0.218
Conditional Mortality ratio	2.005 (0.853)	1.816 (0.837)	3.746 (6.133)	1.512 (0.702)	3.003 (2.688)	4.727 (4.617)	0.685 (0.425)
z-test ratio=1 ( $p$ )	0.240	0.329	0.654	0.465	0.456	0.420	0.458
Wald test, both ratios=1 ( $p$ )	0.493	0.608	0.883	0.761	0.750	0.644	0.399
Sample Size	488	368	120	242	246	275	213



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

**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 |

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

### *APPENDIX A: Theoretical Model and Extensions*

Section A1 gives details of the model presented in the paper while sections A2-A3 outline extensions to multiple-child families and A4 sketches a discounted expected utility approach.

#### *A1. The model used in the paper*

First-order conditions for the child's ( $t=1$ ) utility maximization problem are:

$$\begin{aligned} \partial U_k / \partial C_{kt} - \lambda_k (1+r)^{t-1} &= 0 \\ (\partial U_k / \partial R_k^j)(\partial R_k^j / \partial G_{kt}^j) - \lambda_k P^j (1+r)^{t-1} &= 0 \\ T + y_{k1} + (1+r)^{-1} y_{k2} - [C_{k1} + P^a G_{k1}^a + P^b G_{k1}^b] - (1+r)^{-1} [C_{k2} + P^a G_{k2}^a + P^b G_{k2}^b] &= 0, \end{aligned} \quad (A1)$$

for  $t=1,2$  and  $j=a,b$ , where  $\lambda_k$  denotes the child's marginal utility of period  $t=1$  income and consumption, and second order conditions are assumed to hold. The child's indirect utility function, denoted  $U_k^*(C_{k0}, G_{k0}^a, G_{k0}^b, T, y_{k0}, y_{k1}, r, P^a, P^b)$ , can be used to find the impact of parental choices on the child's lifetime utility:

$$\begin{aligned} \partial U_k^* / \partial C_{k0} &= \partial U_k / \partial C_{k0}, \quad \partial U_k^* / \partial T = \lambda_k, \\ \partial U_k^* / \partial G_{k0}^j &= (\partial U_k / \partial R_k^j)(\partial R_k^j / \partial G_{k0}^j), \quad j = a, b. \end{aligned} \quad (A2)$$

First-order conditions for the parent's ( $t=0$ ) utility maximization problem are

$$\begin{aligned} \partial U_p / \partial C_{pt} - \lambda_k (1+r)^{-t} &= 0, & t = 0,1, \\ \eta(\partial U_k / \partial C_{k0}) - \lambda_p &= 0 \\ T[\eta\lambda_k - \lambda_p (1+r)^{-1}] &= 0 \\ (\partial U_p / \partial R_p^j)(\partial R_p^j / \partial G_{pt}^j) - \lambda_p P^j (1+r)^{-t} &= 0, & t = 0,1, \quad j = a, b, \\ \eta(\partial U_k / \partial R_k^j)(\partial R_k^j / \partial G_{k0}^j) - \lambda_p P^j &= 0, & j = a, b, \\ y_{p0} + (1+r)^{-1} y_{p1} - [C_{p0} + C_{k0} + P^a (G_{p0}^a + G_{k0}^a) + P^b (G_{p0}^b + G_{k0}^b)] \\ - (1+r)^{-1} [C_{p1} + T + P^a G_{p1}^a + P^b G_{p1}^b] &= 0, \end{aligned} \quad (A3)$$

where  $\lambda_p$  denotes the parent's marginal utility of present income and consumption. An interior solution is assumed (with  $T > 0$ ) and second-order conditions are assumed to hold.

Equations (A1) through (A3) can be manipulated to derive three implications. First, intertemporal marginal rates of substitution in consumption equal the discount factor, as do intertemporal marginal rates of technical substitution for protective goods ( $j=a,b$ ):

$$\begin{aligned} (\partial U_p / \partial C_{p1}) / (\partial U_p / \partial C_{p0}) &= (1+r)^{-1} = (\partial R_p^j / \partial G_{p1}^j) / (\partial R_p^j / \partial G_{p0}^j) \\ (\partial U_k / \partial C_{kt}) / (\partial U_k / \partial C_{k0}) &= (1+r)^{-t} = (\partial R_k^j / \partial G_{kt}^j) / (\partial R_k^j / \partial G_{k0}^j), \quad t=1,2. \end{aligned} \quad (A4)$$

Second, the parent's present valuation of reduced latent risk to herself or her child equals the present-value marginal cost of reducing risk, which is equated across periods:

$$\begin{aligned} -(\partial U_p / \partial R_p^j) / \lambda_p &= -(1+r)^{-t} MC_{pt}^j = -MC_p^j, \quad t=0,1, \\ -\eta(\partial U_k / \partial R_k^j) / \lambda_p &= -(1+r)^{-t} MC_{kt}^j = -MC_k^j, \quad t=0,1,2, \end{aligned} \quad (A5)$$

for  $j=a,b$ , where  $MC_{it}^j = P^j / (\partial R_i^j / \partial G_{it}^j)$ , and  $MC_i^j$  denotes the present value marginal cost for reducing risk  $j$  to individual  $i$ . The valuation result for the child occurs because from equation (A3) the parent's present valuation of the child's future risk equals  $-\eta(\partial U_k / \partial R_k^j) / \lambda_p = -MC_{k0}^j$ , which in turn based on equations (A1)-(A2) equals the discounted value of the amount the child would be willing to pay when he is an adult  $-(\partial U_k / \partial R_k^j) / \lambda_k = -(1+r)^{1-t} MC_{kt}^j$ , for  $t=1,2$ .

It further follows that the marginal rate of substitution between the two latent risks for each individual equals the corresponding ratio of marginal costs:  $\frac{\partial U_i / \partial R_i^a}{\partial U_i / \partial R_i^b} = \frac{MC_i^a}{MC_i^b}$ , for  $i=p,k$ .

Third, the parent equates her marginal rate of substitution between her child's and her own consumption of market goods to unity in all periods where both persons are alive:

$$\frac{\eta \partial U_k / \partial C_{kt}}{\partial U_p / \partial C_{pt}} = 1 = \frac{\eta(\partial U_k / \partial R_k)(\partial R_k / \partial G_{kt}^j)}{(\partial U_p / \partial R_p)(\partial R_p / \partial G_{pt}^j)}, \quad t=0,1, \quad j=a,b.$$

But equation (A5) implies that the parent's marginal rate of substitution for latent health risk equals the corresponding ratio of present value marginal costs of risk reduction:

$$\frac{\eta(\partial U_k / \partial R_k^j)}{(\partial U_p / \partial R_p^j)} = \frac{MC_k^j}{MC_p^j} = \frac{\partial R_p / \partial G_{pt}^j}{\partial R_k / \partial G_{kt}^j}, \quad t = 0, 1, \quad j = a, b. \quad (\text{A6})$$

Equation (A6) motivates empirical tests of the altruism model presented in the paper.

Altruism is tested using purchase intentions for a hypothetical new sun protection lotion that reduces risk. The new sunscreen is treated as a potential increment,  $S_{it}^j$ , in the planned amount of protective goods so that  $dG_{it}^j = S_{it}^j = 1$  if individual  $i$  uses sunscreen  $j$  during period  $t$ ; otherwise  $dG_{it}^j = S_{it}^j = 0$ . The resulting changes in lifetime risk are  $dR_i^j = \sum_t (\partial R_i^j / \partial G_{it}^j) S_{it}^j$ .

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 continued use of the sunscreen in the future.” If use of the sunscreen in each period is treated as a necessary input, then 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. Therefore assume that 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 ( $S_{it}^j = S = 1$ ).

Suppose that the cost of 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, the sun protection can be purchased in an amount for one person at half the price. Then the parent’s maximal lifetime altruistic utility assuming continuing use of the sun lotion is

$U^*(y_{p0} - X^j, y_{p1} - X^j/2, y_{k1} - X^j/2, y_{k2} - X^j/2, r, P^a, P^b; S = 1)$ , where  $U^*(\bullet)$  denotes the indirect utility function. Derivatives of this function include

$$\begin{aligned} (\partial U^* / \partial S) &= (\partial U_p / \partial R_p^j) dR_p^j + \eta (\partial U_k / \partial R_k^j) dR_k^j \\ (\partial U^* / \partial X^j) &= - \left[ \lambda_p + (1/2)(1+r)^{-1}(\lambda_p + \eta \lambda_k) + (1/2)(1+r)^{-2} \eta \lambda_k \right] \\ &= -\lambda_p \sum_{t=0}^2 \left( \frac{n_t}{2} \right) (1+r)^{-t} \end{aligned} \quad (\text{A7})$$

where the  $dR_t^j$  denote the lifetime risk changes resulting from use of the sun lotion in all periods and  $n_t$  denotes the number of family members for whom the sun lotion would be purchased in period  $t$  ( $n_0 = 2 = n_1, n_2 = 1$ ).

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 equations (A7) implies that marginal willingness to pay for the first period of sun lotion is

$$\begin{aligned} d(WTP^j) &= \left[ \sum_{t=0}^2 \left( \frac{n_t}{2} \right) (1+r)^{-t} \right]^{-1} \left[ \left( \frac{\partial U_p / \partial R_p^j}{\lambda_p} \right) dR_p^j + \eta \left( \frac{\partial U_k / \partial R_k^j}{\lambda_p} \right) dR_k^j \right] \\ &= \beta \left( \delta_p^j (-dR_p^j) + \delta_k^j (-dR_k^j) \right), \end{aligned} \quad (\text{A8})$$

where  $\beta = \left[ \sum_{t=0}^2 \left( \frac{n_t}{2} \right) (1+r)^{-t} \right]^{-1}$ ,  $\delta_p^j = -(\partial U_p / \partial R_p^j) / \lambda_p$ , and  $\delta_k^j = -\eta (\partial U_k / \partial R_k^j) / \lambda_p$ .

Next consider the valuation of unconditional mortality risk. Suppose that the two risks faced by the parent and child are the risk of getting skin cancer and the risk of dying from the disease if is contracted:  $R_i^a =$  unconditional morbidity risk,  $R_i^b =$  conditional mortality risk. If the parent and the child when an adult understand the rules of probability, then utility functions could be defined over the unconditional mortality risk  $\pi_i^b = R_i^a R_i^b$  and the conditional morbidity risk (the

risk of contracting skin cancer, given that one does not die from the disease)  $\pi_i^a = \frac{R_i^a - \pi_i^b}{1 - \pi_i^b}$  that

would reflect the same preferences as the original utility functions defined over  $R_i^a$  and  $R_i^b$ :

$$\begin{aligned} U_p(C_{p0}, C_{p1}, R_p^a, R_p^b) &\equiv \hat{U}_p(C_{p0}, C_{p1}, \pi_p^a, \pi_p^b) \\ U_k(C_{k0}, C_{k1}, C_{k2}, R_k^a, R_k^b) &\equiv \hat{U}_k(C_{k0}, C_{k1}, C_{k2}, \pi_k^a, \pi_k^b). \end{aligned}$$

Differentiating these identities and using the relations between the  $\pi$ 's and the  $R$ 's implies that the marginal utility of a change in unconditional mortality risk,  $d\pi_i^b$ , holding  $\pi_i^a$  constant (by

imposing  $dR_i^a = R_i^a \frac{1 - R_i^a}{1 - R_i^b} dR_i^b$ ) is

$$\begin{aligned} (\partial \hat{U}_i / \partial \pi_i^b) d\pi_i^b &= \left( \frac{1}{R_i^a (1 - R_i^a)} \right) \left[ R_i^a (1 - R_i^a) (\partial U_i / \partial R_i^a) + (1 - R_i^b) (\partial U_i / \partial R_i^b) \right] dR_i^a \\ &= \left( \frac{1}{1 - R_i^b} \right) \left[ R_i^a (1 - R_i^a) (\partial U_i / \partial R_i^a) + (1 - R_i^b) (\partial U_i / \partial R_i^b) \right] dR_i^b. \end{aligned}$$

Consequently the parent's interpersonal marginal rate of substitution for unconditional mortality risks faced by herself and her child can be expressed as

$$\left( \frac{R_p^a (1 - \pi_p^b)}{R_k^a (1 - \pi_k^b)} \right) \frac{(1 - R_k^a) \gamma_k^a + (1 - R_k^b) \gamma_k^b / R_k^b}{(1 - R_p^a) \gamma_p^a + (1 - R_p^b) \gamma_p^b / R_p^b}, \quad (\text{A9})$$

where  $\gamma_i^j = \beta \delta_i^j R_i^j$ . Using parental altruism predictions that

$$-(\partial U_p / \partial R_p^j) / \lambda_p = -MC_p^j = -P^j / dR_p^j, \text{ and } -\eta(\partial U_k / \partial R_k^j) / \lambda_p = -MC_k^j = -P^j / dR_k^j, \text{ where}$$

$P^j$  does not vary between parent and child, implies that the marginal rate of substitution for unconditional mortality risk should equal

$$\left( \frac{(1 - R_k^b) R_p^b}{(1 - R_p^b) R_k^b} \right) \left( \frac{R_p^a (1 - \pi_p^b)}{R_k^a (1 - \pi_k^b)} \right) \left( \frac{dR_p^b / R_p^b}{dR_k^b / R_k^b} \right). \quad (\text{A10})$$

Recalling that estimates obtained from the econometric model pertain to the same proportionate risk changes for parent and child and eliminating common terms in equations (A9) and (A10) a test of parental altruism based on unconditional mortality risk is based on the prediction that

$$\frac{(1-R_k^a)\gamma_k^a + (1-R_k^b)\gamma_k^b / R_k^b}{(1-R_p^a)\gamma_p^a + (1-R_p^b)\gamma_p^b / R_p^b} = \left( \frac{(1-R_k^b)R_p^b}{(1-R_p^b)R_k^b} \right). \quad (\text{A11})$$

## **A2. Multiple Children**

If there is an arbitrary number of children in the family then each child  $k = 1, \dots, N$  in period  $t=1$  has an optimization problem parallel to the one-child case considered above. The parent in period  $t = 0$  maximizes lifetime utility

$$U_p(C_{p0}, C_{p1}, R_p^a, R_p^b) + \eta_k \sum_{k=1}^N U_k^*(C_{k0}, G_{k0}^a, G_{k0}^b, T_k, y_{k0}, y_{k1}, r, P^a, P^b), \text{ subject to the } 2(N+1)$$

perceived risk production functions, non-negative transfers to each child  $T_k \geq 0$  and budget

$$\begin{aligned} y_{p0} + (1+r)^{-1}y_{p1} &= C_{p0} + \sum_{k=1}^N C_{k0} + P^a(G_{p0}^a + \sum_{k=1}^N G_{k0}^a) + P^b(G_{p0}^b + \sum_{k=1}^N G_{k0}^b) \\ &+ (1+r)^{-1}[C_{p1} + \sum_{k=1}^N T_k + P^a G_{p1}^a + P^b G_{p1}^b]. \end{aligned}$$

The altruistic parent's marginal rate of substitution between any one of her children's and her own latent health risk equals the ratio of marginal products of a risk-reducing market good that both parent and child consume, which in turn equals the ratio of present value marginal costs of reducing risk. This implies that only the characteristics of children that alter marginal costs of risk reduction result in differences in the altruistic parent's marginal rate of substitution across different children.

## **A3. Effects of the Number of Children on Purchases of Risk-Reducing Goods**

To examine effects of the number of children on family expenditures to reduce risk, consider a simpler, one-period model where the parent and each of  $N$  identical children face one risk. The parent

maximizes  $U_p = U_p [C_p, R_p(G_p)] + N\eta U_k [C_k, R_k(G_k)]$ , subject to her budget constraint

$$y_p = C_p + NC_k + P(G_p + NG_k), \text{ where all children is treated equally.}$$

In this model, protective expenditures for the parent and children decline with an exogenous increase in the number of children if in the parental and child utility functions: (1) the marginal utility of consumption is lower when risk is higher and (2) utility functions defined over  $C$  and  $G$  (by substitution of production functions for risk into the direct utility functions) are concave. Also, the elasticity of demand for risk-reducing goods with respect to the number of children equals the negative of the share of income spent on children times the income elasticity:

$$(N/G_i)(\partial G_i/\partial N) = -N((C_k + PG_k)/y_p)(\partial G_i/\partial y_p)(y_p/G_i), \quad i = p, k. \text{ Under the two curvature}$$

assumptions mentioned above, demand for protection from risk should increase with income while declining as the number of children in the family increases.

#### ***A4. A Discounted Expected Utility Version of the Model***

The two latent environmental health risks are the risk of contracting a disease ( $R_i^a, i = p, k$ ), and the risk of dying from the disease given that it is contracted ( $R_i^b, i = p, k$ ). Neither the parent nor the child will contract the disease during the present period ( $t=0$ ). The parent may contract the disease in the next period. In that period ( $t=1$ ), the parent purchases risk-reducing goods for herself ( $G_{p1}^j, j = a, b$ ). If she does not contract a fatal case of the disease, she lives until the end of the period, consuming  $C_{p1}$  and transferring  $T \geq 0$  to her child, and dies at the end of the period. If she contracts a fatal case of the disease, she dies immediately at the beginning of period  $t=1$  and the child receives as a bequest  $B$  the sum of the amounts the parent intended to transfer and to consume if alive  $B = T + C_{p1}$ .

Consequently the child's period  $t=1$  income depends on the parent's survival; it is

$y_{k1D} = Y_{k1} + B$  if the parent dies from the disease and  $y_{k1L} = Y_{k1} + T$  if she survives to the end of

period  $t=1$ , where  $Y_{k1}$  is a state-independent income. The child may contract the disease in the

final period ( $t=2$ ). If he contracts a fatal case, he dies immediately; otherwise he lives to

consume  $C_{k2}$  and dies at the end of the period. At the beginning of period  $t=1$  the child

maximizes his discounted lifetime expected utility

$$U_k(C_{k1}) + (1 + \rho_k)^{-1} \left[ (1 - R_k^a)U_k(C_{k2}) + (1 - R_k^b)U_k(C_{k2}) + R_k^a(1 - R_k^b)V_k(C_{k2}) + R_k^a R_k^b W_k(C_{k2}) \right],$$

where  $U_k$  denotes the child's utility if he does not contract the disease,  $V_k$  denotes his utility if he

contracts the disease but does not die from it,  $W_k$  denotes a bequest utility if he contracts the

disease and dies from it, and  $\rho_k$  denotes the child's subjective rate of discount. The child is

constrained by production functions for risk as specified in the text of the paper, and by his

budget  $y_{k1l} + (1 + r)^{-1} y_{k2} = C_{k1} + P^a G_{k1}^a + P^b G_{k1}^b + (1 + r)^{-1} [C_{k2} + P^a G_{k2}^a + P^b G_{k2}^b]$ , for  $l=D, L$ , where

$y_{k1L} = Y_{k1} + T$  and  $y_{k1D} = Y_{k1} + B$ . Let  $U_{kl}^*(G_{k0}^a, G_{k0}^b, y_{k1l}, y_{k2}, r, P^a, P^b)$  represent the indirect

objective function associated with the child's maximization problem given his income  $y_{k1l}$ ,

$l=L, D$ . The parent's present expectation ( $t=0$ ) of the child's future utility is

$$E \left[ U_{kl}^*(G_{k0}^a, G_{k0}^b, y_{k1l}, y_{k2}, r, P^a, P^b) \right] \\ = (1 - R_p^a R_p^b) U_{kL}^*(G_{k0}^a, G_{k0}^b, y_{k1L}, y_{k2}, r, P^a, P^b) + R_p^a R_p^b U_{kD}^*(G_{k0}^a, G_{k0}^b, y_{k1D}, y_{k2}, r, P^a, P^b).$$

In the present period ( $t=0$ ) the parent maximizes the altruistic utility function

$$U_p(C_{p0}) + (1 + \rho_p)^{-1} \left[ (1 - R_p^a)U_p(C_{p1}) + R_p^a(1 - R_p^b)V_p(C_{p1}) \right] \\ \eta U_k(C_{k0}) + \eta(1 + \rho_p)^{-1} \left[ (1 - R_p^a R_p^b)U_{kL}^*(\bullet) + R_p^a R_p^b U_{kD}^*(\bullet) \right],$$

subject to the four perceived risk production functions and lifetime budget constraint given in the paper and  $T \geq 0$ , where  $U_p$  and  $V_p$  respectively denote the parent's utility without the disease and with a nonfatal case of it. The parent's bequest utility is determined by the lifetime expected utility of her child in the event that the parent dies from the disease at the beginning of period  $t=1$  ( $U_{kD}^*$ ), and  $\rho_p$  denotes the parent's subjective rate of discount.

The parent's marginal rate of substitution between her child's and her own risk equals the ratio of present-value marginal costs of risk reduction. For the unconditional morbidity risk,

$$\frac{(1+\rho_p)^{-1}(1+\rho_k)^{-1}\eta E\left[U_k(C_{k2})-V_k(C_{k2})+R_k^b(V_k(C_{k2})-W_k(C_{k2}))\right]}{(1+\rho_p)^{-1}\left[U_p(C_{p1})-V_p(C_{p1})+R_p^b(V_p(C_{p1})-\eta(U_{kD}^*-U_{kL}^*))\right]} = \frac{MC_k^a}{MC_p^b}, \quad (\text{A13})$$

while for conditional mortality risk,

$$\frac{(1+\rho_p)^{-1}(1+\rho_k)^{-1}\eta E\left[R_k^b(V_k(C_{k2})-W_k(C_{k2}))\right]}{(1+\rho_p)^{-1}R_p^a(V_p(C_{p1})-\eta(U_{kD}^*-U_{kL}^*))} = \frac{MC_k^b}{MC_p^b}. \quad (\text{A14})$$

When the model is set up using time-separable discounted expected utility functions, rates of subjective time preference explicitly appear in the altruistic parent's marginal rate of substitution, and the longer latency period for the child is reflected in the additional period of discounting in the numerator. Also, the effective per-period discount factor that the parent applies to her child's risk,  $\sqrt{(1+\rho_p)^{-1}(1+\rho_k)^{-1}}$ , may differ from the discount factor she applies to her own risk  $(1+\rho_p)^{-1}$ . Nonetheless, the discount rates are just components of the marginal rate of substitution that need not be separately identified to test the altruism prediction that the rate of substitution equals the ratio of present-value marginal costs.

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

*APPENDIX B: Supplemental Data and Empirical Results*

**Table B-1**

**Hypothetical Sun Protection Product Labels**

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Label	Percent Change in Morbidity Risk		Percent Change in Mortality Risk	
	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 B-2. Sample Means by Experimental Design Point.**

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