December 20, 2006
DRAFT MANUSCRIPT—PLEASE DO NOT CITE WITHOUT PERMISSION

Individual Preferences and Household Choices: The Potential Role of Dependency Relationships

Mary F. Evans*, Christine Poulos[†], V. Kerry Smith[‡]

Abstract:

Benefit estimates for policies that affect the health of children or elderly adults require the analyst to account for potential interactions among individual members of a given household. Addressing this task for air quality improvements is particularly important as these policies disproportionately affect children with asthma and older adults. Often these individuals are cared for by their parents and by grown children. These dependency relationships have the potential to affect benefit measurement. We propose a conceptual framework that underscores the importance of recognizing their role in the choice models used to recover estimates of the willingness to pay for policy changes. This paper summarizes results from a pilot survey that tests hypotheses about the effect of different dependencies on respondents' choices. Our findings indicate an apparent implicit delineation of personal responsibilities to household members of different ages. Respondents' choices appear to acknowledge the importance of care-giving for young children and teenagers. They do not appear to attach the same importance to older adults.

The U.S. Environmental Protection Agency (EPA) provided funding for this research under STAR grant 83159501. The research has not been subjected to EPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

* Department of Economics, University of Tennessee, Knoxville, Tennessee, mevans12@utk.edu
[‡]RTI International, Research Triangle Park, North Carolina
[†] Department of Economics, Arizona State University, Tempe, Arizona

I. Introduction

Two sets of research motivated this paper. The first stems from recent benefit-cost analyses of rules intended to improve air quality by reducing ambient concentrations of the criteria air pollutants. In discussing the limitations of the benefit measures used in these studies, analysts often point to the widely accepted assertion that the health effects of these pollutants fall primarily on young children and older adults.[1] This is important because conventional practices assign unit benefits to the reduced morbidity profiles and lower mortality risks as if these effects were experienced by middle-aged adults. The relevance of these measures for both groups has been questioned. Viscusi and Aldy [2006], among others, argue for applying benefit estimates to mortality risk reductions experienced by older individuals consistent with a lower marginal willingness to pay for prolonged life.[2] In contrast, it has been suggested that higher social values may be more desirable for the young, due in part to the effects of morbidity on their abilities to realize higher income/consumption patterns over their life cycle. Another potentially important reason for questioning these benefit transfers has received less attention. To the extent that air pollution-related health effects experienced by children and older individuals are

[1] The primary stimulus for these beliefs comes from two sources. In the case of air pollution effects on older adults, the first prospective report's approach to computing mortality effects as a proportionate increment to the mortality distribution by age led to this outcome (U.S. EPA, 1999). Specific documentation for a differentiated effect on older adults is not provided in that report. However, Evans and Smith [2005] note a relationship between particulate matter and new heart conditions, and ozone and new lung conditions among a sample of older adults. Their results are consistent with the mechanistic pathways, related to heart and lung functioning, that may contribute to the observed deaths discussed in the Prospective Report.

The prospective report's appendix offers a detailed summary of the effects of air pollution on infant mortality, low birth weight, and intrauterine mortality. Recent studies in economics by Chay and Greenstone [2002] and Currie and Neidell [2005] also address these issues with a quasi-random framework that exploits specific discrete changes in air pollution to test for its effects on infant health. Both offer direct evidence of a relationship. Chay and Greenstone link total suspended particles to infant mortality and Currie and Neidell find both carbon monoxide and PM10 are relevant to infant mortality but the latter effect is less robust.

[2] This perspective is the most widely held judgment. There are, however, good reasons to question this conclusion as relevant to all older adults regardless of their health condition (see Evans and Smith [2006]).

significant, they may require care from other household members. As a result, their care-givers are impacted by policies that reduce the incidence of serious health effects stemming from air pollution. While a unitary model (see Becker [1974]) of the household would imply that measures of benefits to working-age adults adequately capture marginal changes in within-household care-giving responsibilities, recent literature provides evidence that the unitary model is implausible[3]. These findings, along with recent related research by Bateman and Munro [2006], provide the second motivation for this research.[4]

Conventional practice in survey research applies one of several randomization schemes to select an adult decision maker in a household for interviews. Once we acknowledge that household valuation may require a collective or a Nash-bargained framework to describe the choice process, the task of identifying respondents and estimating the values for changes in policy is more challenging. For example, Bateman and Munro [2006] found stated willingness to pay for policies that influence the fat content or the risks due to pesticide residues in food vary depending on which household member was asked the valuation questions. Moreover, their analysis did not suggest a conceptual basis for determining how the valuation responses given by separate members of a household relate to an overall 'household' willingness to pay.[5]

[3] The classic paper questioning this conclusion is Lundberg, Pollak, and Wales [1997]. Subsequent research has confirmed their conclusions in several contexts (see Browning and Chiappori [1998]).

[4] An early set of focus groups conducted by George Van Houtven and Smith also found that household decisions associated with choices related to infertility treatments appeared to be incompatible with a unitary model. Moreover, the female household members appeared to offer more reliable information on the household's choice process.

[5] Their overall conclusion seems to support the logic of our pilot research. They noted that:

"...our results suggest it would be unwise to assume a unitary household model in stated preference exercises. Our work, however, does not tell us which (individual or household) is the better model in terms of providing the most accurate estimate of revealed household behavior...Hence, refining the practice of stated preference surveys may not only involve delving deeper into the relationship between

The problem becomes more complex when this task is extended to care-giving for older adults that are part of a household's extended family. Indeed, we undertook this research because of our inability to develop questions that successfully described environmental policies with impacts on dependent household members. When we administered candidate questions to focus groups about choices related to care-giving for different types of dependents we found considerable diversity in understanding of the situations presented.[6] Participants' interpretations were determined by their own unique experiences. Thus a stated choice survey would require a sufficient scale to assure both the recording of information about these experiences and the ability to tailor questions to each person's experiences. In the absence of these controls, we concluded it would be difficult to identify whether respondents were reporting individual choices and the associated personal willingness to pay or responses that were conditioned by a household decision processes that may have evolved in response to these past care-giving experiences.

As a result, we considered a new strategy for evaluating stated choice questions – using pilot surveys to test for differences in the wording of surveys that were specifically targeted to choices that affect a hypothetical dependency condition. Our pilot survey does not seek to estimate willingness to pay for a specific policy intervention. Instead, our goal is to integrate what might ordinarily be four or five separate survey development activities in separate pilots or convenience samples into a single survey that utilizes a specific experimental design to detect how the framing of choice questions with different

household and individual willingness to pay, but may also require accurate means for predicting where in the household behaviorally-relevant values are determined." (pp. 17-18)

[6] The focus group respondents appeared to be greatly influenced by the specific details of their own family relationships. Evaluations of hypothetical changes to associations with actual family members required a great deal of context to be presented in a way that would accommodate may different situations.

hypothetical dependency relationships influences respondents' decisions for the same policy intervention. Pilot surveys are certainly not new to large-scale CV surveys conducted for litigation.[7] What appears to be new in our proposal is the process of combining them into one composite survey with an integrated design that allows the results to focus on a control variable that will be an important element in the design of our final stated choice questions. There are two primary objectives for this research. The first is to evaluate whether hypothetical dependency relationships can be used to learn about household resource allocation processes. Secondly, we consider whether the identity/age of the individual (child, teen, or older adult), each with the same care-related needs, influences respondents' choices.

Our results offer a robust test of the effect of wording distinctions on caregivers' choices. They suggest that conditional on the level of the commodity of interest – care-giving time – the characterization of household dependency relationships do influence an individual's choices. This result holds with a simple non-parametric test. Use of a simple non-parametric format assures the result does not rely on assumptions about analytical structure that would underlie a choice model. Nonetheless, when a formal choice model is used there is strong confirmation that the stated choices are consistent with an economic decision process. Moreover, they indicate what appears to be an implicit delineation of personal responsibility to different types of household members.

[7] Pilot surveys were a significant part of the development of both the Carson et al. [1992] Alaska survey for the Exxon Valdez oil spill and for the Montrose natural resource damage assessment case (see Carson et al. [1994]). As Smith [2007] notes, the pilots were designed in a sequence, so it is difficult to reconstruct the learning process. Our strategy combines pilots into one integrated survey with a single design. Doing so, however, limits our ability to "test" small variations thought to be important as part of the design of an instrument as they are uncovered.

Respondents' choices appear to acknowledge the importance of care-giving for young children and teenagers. They do not appear to attach the same importance to older adults.

Section II develops the conceptual basis for our evaluation of how dependency among household members might be expected to influence people's responses to questions involving policies that affect the intensity of that dependency. The third section describes the Internet-based pilot survey used to test the hypotheses developed in Section II. Section IV presents our findings and the last section discusses their implications for using stated choice surveys to evaluate environmental policies that directly influence the impact of pre-existing dependencies among members of an extended family.

II. Conceptual model

Chiappori's [1988] collective model of the household motivates our conceptual analysis. Our framework is intended to consider how dependency among household members might influence a survey respondent's answers to stated choice questions. A key component of the collective model is the distinction between individual income and household income. The framework assumes that the choices of a particular individual are made conditional on a preceding allocation stage of the household decision process. Although we abstract from explicitly modeling the allocation stage, our analysis acknowledges that the outcome of this process, the distribution of household income among its members, will determine the levels of well-being each individual can realize. The collective model assumes that household income is efficiently allocated among its members to achieve a given set of realized utility levels. However, the mechanism by

which a point (solution) is chosen from the set of possible realized utility levels is typically assumed to be external to the allocation process represented by the model.

To implicitly account for the allocation stage, we represent the role of other household members through a sharing function, denoted $\theta(\cdot)$, that describes the portion of household income allocated to the respondent of interest. With more than one agent, $\theta_i(\cdot)$ represents the share of household income allocated to member *i* with $\sum_{i=1}^{I} \theta_i(\cdot) = 1$ where *I* is the total number of household members.

From the perspective of interpreting stated choice questions, the primary distinction between a unitary and a collective model of the process is whether respondents acknowledge differences between their own individual income and household income. For example, if a respondent answers failing to recognize this distinction and therefore also the possibility that the proposed change could impact the distribution of income within the household, then his choices provide information that could be used to create a measure of personal or individual willingness to pay. By contrast if a respondent answers' incorporate an anticipated income reallocation within the household due to the proposed change, then his responses imply an alternative measure of WTP consistent with the collective framework. Note however that consideration of income reallocation alone does not guarantee that his choices reflect the maximum household willingness to pay for the change.

Ideally, a measure of household WTP for a policy change would be constructed holding constant the levels of well-being realized by each member of the household at their initial levels. However, without a coordinated survey of all household members and the information necessary to separate these two stages of the decision process, we cannot

be assured this (household) WTP measure can be recovered from a survey that focuses on a single member. This appears to be the source of the variation in responses found by Bateman and Munro [2006].

Of course, our survey faces the same challenge. However, our objective is more modest. As in Bateman and Munro, we also do not ask about how allocation processes take place within each respondent's household. Instead, we seek to detect whether it is possible to judge the importance of dependency relationships without knowing all the details of the income allocation process within a household. Our survey uses a hypothetical household member with a defined source of dependency. The stated choice question defines a level of care that must be provided to this hypothetical dependent member due to a health condition. The proposed policy reduces environmental factors that affect the health condition and, thus, need for care. By introducing this hypothetical relationship we are attempting to induce the respondent to consider how the presence of the dependency would affect income allocation within the household. [8]

A policy can induce a change in $\theta(\cdot)$. To describe the implications of this change, we contrast how this policy's impacts on the hypothetical dependent would be evaluated with the assessment of the same policy's impacts on the respondent's own health. To develop what can be learned from our linked choice questions our analysis begins by considering different interpretations of how $\theta(\cdot)$ might change in response to the policy. Using a simple linear indirect utility model, we link the two sets of responses to a set of

[8] We assume that the only effect of the policy on the respondent is through changes in care-giving time. In fact, our analysis can consider additional policy effects aside from care-giving without changing our main findings. This ability stems from the linked design of the questions. Additional changes assumed to stem from the policy will contribute to the differences in a respondent's choices for the two questions -- for self versus for a dependent member. However, with our design structure, the effects of the policy on each aspect (e.g., care-giving time, other policy effects) would not be separately identified.

hypotheses that describe what distinguishes a unitary from a collective decision process. This model provides the basis for judging whether the nature of dependency is likely to affect the process of eliciting willingness to pay.

Our survey design distinguishes three types of hypothetical household members, a young child (2-5 years of age), a teen (15-17 years of age), and an older adult (63 years or older). Regardless of age, each hypothetical household member is described as asthmatic and, as a result, requires that the respondent devote a fixed amount of time each week to care-giving. The survey also describes a policy change that would improve air quality resulting in a decrease in the required weekly care-giving time. Each version of the survey had only one hypothetical household member (either a young child, teen, or older adult) and these versions were randomly assigned to respondents. As suggested above, each respondent also received a similar question about managing their own (hypothetical) asthma condition.

To understand respondents' answers to these choice questions, we must have a model of the choice process that reflects how reallocation affects the stated choice. In analytical terms, the income available to each respondent, $m_R = \theta(\cdot) \cdot m$ where m is household income, is our hypothesized window on the decision process. If the respondent is reflecting the full household willingness to pay for a proposed policy change then his or her answers will be based on $HWTP = m^0 - m^*$ where m^0 is the household income under the current or initial conditions and m^* is the income required to realize the initial level of well being for <u>each</u> household member with the policy change presented in the survey.

In this section, we derive analytical expressions for different willingness to pay measures. These expressions allow us to formulate two hypotheses. First, to consider how dependency relationships enter household decision-making, we hypothesize that the age of the household member benefiting from an environmental health improvement enters the income sharing function. Our choice of three age groups, child, teen, and older adult, is deliberate. We focus on these age groups to exploit variation among these age groups on the basis of the likelihood and intensity of care-giving requirements. Children represent those family members most likely to require care-giving while care-givers may afford teens some level of independence. Older adults, on the other hand, represent family members who may be entering a period of uncertainty with respect to dependency, where the care-giving requirement is determined in part on health outcomes. Given this proposed relationship, we derive its implications for the structure of the respondent's choice function. Second, and equally important, we describe several alternative ways each respondent could evaluate the implications of the proposed change for the income sharing process within the household. The analyst does not know whether each respondent will incorporate income re-allocation into the answers to the policy choice questions. To illustrate the importance of the distinctions based on what is assumed, we derive three WTP measures, one which ignores the impact of the policy change on the allocation of household income, and two others that account for possible changes in different ways.

To keep the analysis fairly transparent, we assume that each respondent's preferences can be characterized by a linear indirect utility function given in equation (1):

$$V = \alpha_0 + \alpha_1 P + \alpha_2 \pi(L, n, w, c) + \alpha_3 m_R \qquad (1)$$

with *P* a vector for the prices of all other goods. The respondent's income is given by $m_R = \theta(L, n, c, z)m$ where *n* denotes the number of household members, *L* is the quasi-fixed care-giving time required, *c* designates the age group of the hypothetical family member requiring care, and *z* represents other covariates that affect the sharing rule. $\pi(L, n, w, c)$ denotes a function that we describe as the implicit cost of care-giving. Our formulation presumes that the effect of the care-giving requirement depends on a variety of factors that are likely to vary across households; *L*, *n*, and *c* are defined above, *w* represents the price of materials for care (e.g., medications, equipment). Our description is admittedly simple and could be expanded. For example, one could envision that the ages of other members and their employment statuses may influence the implicit costs arising from requirements to provide care.

Let V^0 represent the respondent's initial (indirect) utility without the reduction in air pollution. Therefore equation (2) defines the benchmark condition.

$$V^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^0, n, w, c\right) + \alpha_3 m_R^0 \tag{2}$$

where $m_R^0 = \theta\left(L^0, n, c, z\right)m^0$. To describe the effects of changes in what the respondent takes as given in answering the choice questions, we solve expressions describing the respondent's indirect utility for alternative concepts of respondent and household income. To begin this process, we invert V^0 given in equation (2) to derive an expression for m_R^0:

$$\begin{aligned} m_R^0 &= -\frac{\alpha_0}{\alpha_3} + \frac{1}{\alpha_3} V^0 - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right) \\ &= a - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right) \end{aligned} \tag{3}$$

where $a \equiv -\frac{\alpha_0}{\alpha_3} + \frac{1}{\alpha_3} V^0$. With this description for respondent income, consider an improvement in environmental quality that reduces the required care-giving time from L^0 to $L^1 < L^0$. The reduction in required care-giving time changes the implied contribution of $\pi(\cdot)$ to the indirect utility function from $\pi(L^0, n, w, c)$ to $\pi(L^1, n, w, c)$. For this exposition, we assume $\pi(L^0, n, w, c) - \pi(L^1, n, w, c) > 0$.[9] With income sharing, the reduction in *L* can have an additional effect; it may result in a re-budgeting of household resources such that the individual's share of household income changes.

Define the willingness to pay (WTP) for this change as the difference between the household income required to sustain the respondent's initial utility level at the two shadow prices of care-giving[10]:

$$WTP = \tilde{m}^0 - \tilde{m}^1. \qquad (4)$$

Since we analysts do not know how respondents will answer, we use $\tilde{m}$ to denote the household income we, the analysts, infer is implied by the responses to the choice questions. We use the respondent's choices to give us information relevant to the household willingness to pay. If we assume the responses incorporate some revision in the income sharing rule, then conditional on the arguments in the sharing function, we expect one set of factors to influence responses. Alternatively, without budget reallocation, another set of factors is relevant. Each of these possibilities implies a different distribution of well-being within the household. This reiterates the importance

[9] This interpretation is consistent with considering $\pi(\cdot)$ to be a shadow price of care-giving. Of course, if we were to describe $\pi(\cdot)$ as such, it would be a function of all the parameters of the choice problem.

[10] Note that our definition of WTP only requires that the respondent's level of well-being remain constant. However, as mentioned above, this need not guarantee that other members' levels of well-being do so.

of the differences between household and individual measures of willingness to pay as discussed by Munro [2005].

When we ask specific individuals choice questions, it is important to recognize that these respondents may or may not hold the distribution of well-being among members of the household constant in responding to the question. A given level of household income along with external constraints defines a set of possible utility levels that can be realized by each household. The income sharing function assumes that a point on this locus of possibilities has been selected. Our point here is that when an exogenous change is proposed to one member of the household, the analyst does not know how he will construct the new household bargain. If the change is one that expands effective resources, the household should be willing to pay for it. The challenge for the analyst is to recover sufficient information to be able to determine if the response allows an assessment of how the distribution of income (and associated utility levels realized) changes with the intervention.

Our proposal develops different choice models based on how we describe the respondent's characterization of the household expenditure function. $\tilde{m}^0$ represents the respondent's characterization of the household income necessary to achieve his original utility level with the initial implicit cost of care-giving, $\pi\left(L^0, n, w, c\right)$ and an assumed pattern of income allocation; $\tilde{m}^1$ denotes a similar concept to sustain his baseline utility level but with the lower implicit cost of care-giving, $\pi\left(L^1, n, w, c\right)$. The WTP measure still depends on whether or not, and if so how, the respondent takes account of changes in the allocation of resources within the household when responding.

To create our first WTP measure, suppose that the respondent bases his response on the initial household income with the initial distribution, so that $\tilde{m}^0 = m^0 = m_R^0 \frac{1}{\theta\left(L^0, n, c, z\right)}$. This formulation implies that from the analyst's perspective, the choice is made assuming the expenses associated with the proposed policy change must be accommodated with the initial distribution of resources within the household unchanged. Substituting $m_R^0 = a - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right)$ into $m^0 = m_R^0 \frac{1}{\theta\left(L^0, n, c, z\right)}$ yields an alternative expression for $\tilde{m}^0$:

$$\tilde{m}^0 = \frac{1}{\theta\left(L^0, n, c, z\right)}\left[a - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right)\right] \tag{5}$$

For consistency with $\tilde{m}^0$, define $\tilde{m}^1$ as the household income necessary for the respondent to achieve his baseline utility given the reduction in required care-giving time. After the change in required care-giving time, the respondent's utility is given by

$$V^1 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^1, n, w, c\right) + \alpha_3 m_R^1 \tag{6}$$

where we assume the individual accounts for how his share of income will adjust based on the change in *L* so that $m_R^1 = \theta\left(L^1, n, c, z\right) m^0$. Therefore, the following expression implicitly defines $\tilde{m}^1$:

$$V^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^1, n, w, c\right) + \alpha_3 \theta\left(L^1, n, c, z\right) \tilde{m}^1 \tag{7}$$

Solving for $\tilde{m}^1$ yields:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[a - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^1, n, w, c\right)\right]. \tag{8}$$

We can simplify this expression by solving equation (3) for *a* and noting that $m_R^0 = \theta\left(L^0, n, c, z\right)m^0$ which yields:

$$a = \frac{\alpha_1}{\alpha_3} P + \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right) + \theta\left(L^0, n, c, z\right)m^0 . \tag{9}$$

Substitution implies:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] + \theta\left(L^0, n, c, z\right)m^0\right] \tag{10}$$

Under these conditions, WTP is the difference between $\tilde{m}^0$ and $\tilde{m}^1$ and is given by:

$$\begin{aligned} WTP^* &= \tilde{m}^0 - \tilde{m}^1 \\ &= m^0 - \left\{\frac{1}{\theta\left(L^1, n, c, z\right)}\left[\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] + \theta\left(L^0, n, c, z\right)m^0\right]\right\} \\ &= -\frac{1}{\theta\left(L^1, n, c, z\right)}\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] + \frac{\theta\left(L^1, n, c, z\right) - \theta\left(L^0, n, c, z\right)}{\theta\left(L^1, n, c, z\right)}m^0 \end{aligned} \tag{11}$$

By construction our first WTP measure, denoted WTP^*, accounts for both the reduction in the implicit cost of required care-giving associated with the reduction in *L* and the effect of the resulting reallocation of household resources. Although WTP^* reflects the implications of the policy for the distribution of income within the household, it does not assure that all household members remain at their initial levels of well-being. The respondent's choices could reflect a new point in the set of household utility combinations that are feasible with given resources and constraints.

As an alternative to WTP^*, consider the implications for our WTP measure if instead the respondent begins by accounting for the way in which the change in care-giving time would alter the distribution of resources within the household. In this case,

the respondent's initial income level and baseline utility must take account of this adjustment. The respondent's baseline utility would be given by:[11]

$$\hat{V}^0 = \alpha_0 + \alpha_1 P + \alpha_2 \pi\left(L^0, n, w, c\right) + \alpha_3 \theta\left(L^1, n, c, z\right) m^0 . \tag{12}$$

Assuming the respondent continues to base his decisions on $\tilde{m}^0 = m^0$ as implicitly defined above, then substitution implies:

$$\tilde{m}^0 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[\hat{a} - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^0, n, w, c\right)\right]. \tag{13}$$

with $\hat{a} = -\frac{\alpha_0}{\alpha_3} + \frac{1}{\alpha_3}\hat{V}^0$.

Now, define $\tilde{m}^1$ as the household income necessary for the respondent to achieve his revised baseline utility (i.e., $\hat{V}^0$) under the new care-giving time recognizing its implications for the allocation of resources within the household. The following expression therefore defines $\tilde{m}^1$:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^1, n, c, z\right)}\left[\hat{a} - \frac{\alpha_1}{\alpha_3} P - \frac{\alpha_2}{\alpha_3} \pi\left(L^1, n, w, c\right)\right]. \tag{14}$$

In this case, WTP will be given by:

$$\hat{WTP} = -\frac{1}{\theta\left(L^1, n, c, z\right)} \frac{\alpha_2}{\alpha_3} \left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] \tag{15}$$

In answering the WTP question, the respondent has acted as if any hypothetical payment would be made after the change in the distribution of household resources associated with the decrease in *L*. In doing so, $\hat{WTP}$ only accounts for the direct benefit

[11] Note that $\hat{V}^0 = V^0$ if and only if the reduction in required care-giving time does not alter the allocation of resources within the household so that $\theta\left(L^0, n, c, z\right) = \theta\left(L^1, n, c, z\right)$.

of the decrease in *L*, the reduced implicit cost of care-giving whereas WTP^* given in equation (11) above reflects the value of the change in the distribution of household resources in addition to the change in $\pi(\cdot)$. Comparing equations (11) and (15), we have

$$\begin{aligned} WTP^* &= -\frac{1}{\theta\left(L^1,n,c,z\right)}\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0,n,w,c\right)-\pi\left(L^1,n,w,c\right)\right]+\frac{\theta\left(L^1,n,c,z\right)-\theta\left(L^0,n,c,z\right)}{\theta\left(L^1,n,c,z\right)}m^0 \\ &= \hat{WTP}+\frac{\theta\left(L^1,n,c,z\right)-\theta\left(L^0,n,c,z\right)}{\theta\left(L^1,n,c,z\right)}m^0 \end{aligned} \quad .(16)$$

As demonstrated by expression (16), WTP measures vary depending upon assumptions about the role of household reallocation of resources.

To further illustrate this point, consider one final measure of WTP in which the respondent's choices reflect no redistribution of resources within the household as a result of the change in *L*. Initial indirect utility is given in equation (2), as in our construction of WTP^*, so that $\tilde{m}^0 = \frac{1}{\theta\left(L^0,n,c,z\right)}\left[a-\frac{\alpha_1}{\alpha_3}P-\frac{\alpha_2}{\alpha_3}\pi\left(L^0,n,w,c\right)\right]$. Now, suppose the respondent considers only the impact of a change in *L* on $\pi(\cdot)$ and ignores any increase or decrease in his own personal income that results from a reallocation of household resources following the change. In this case, his utility after the change is given by:

$$\tilde{V}^1 = \alpha_0+\alpha_1 P+\alpha_2\pi\left(L^1,n,w,c\right)+\alpha_3\theta\left(L^0,n,c,z\right)m^0 . \quad (17)$$

Define $\tilde{m}^1$ as the household income necessary for the respondent to achieve his baseline utility given the reduction in required care-giving time implicitly defined by:

$$V^0 = \alpha_0+\alpha_1 P+\alpha_2\pi\left(L^1,n,w,c\right)+\alpha_3\theta\left(L^0,n,c,z\right)\tilde{m}^1 \quad (18)$$

Solving equation (18) for $\tilde{m}^1$ yields:

$$\tilde{m}^1 = \frac{1}{\theta\left(L^0, n, c, z\right)}\left[a - \frac{\alpha_1}{\alpha_3}P - \frac{\alpha_2}{\alpha_3}\pi\left(L^1, n, w, c\right)\right]. \tag{19}$$

Under this final construction, WTP, the difference between $\tilde{m}^0$ and $\tilde{m}^1$, is given by:

$$\begin{aligned} \tilde{WTP} &= \tilde{m}^0 - \tilde{m}^1 \\ &= -\frac{1}{\theta\left(L^0, n, c, z\right)}\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right] \end{aligned} \tag{20}$$

Note that this expression differs from both WTP^* and $\hat{WTP}$ above. Comparisons of equations (11), (15), and (20) highlight how the interpretation of the treatment of redistribution of resources within the household helps to explain Bateman and Munro's results. Evaluations of a respondent's decisions must be based on how they are assumed (or not) to account for resource reallocation.[12]

We now turn to this issue in using the model to frame our hypotheses about how the dependency characterization affects the modeling of individual responses to policies. All three formulations imply the WTP governing choice will be a nonlinear function of the care-giving time. Nevertheless, the framework does inform an empirical examination of individuals' responses to the choice questions. First, if dependency relationships affect the evaluation of care-giving time then we should expect comparisons of our linked choice questions, which hold all other dimensions constant and vary only who is affected, should offer a fairly robust test of the role of *c*. The simple analysis developed above indicates that, under a wide range of specifications of $\pi(\cdot)$ together with what we might assume about income sharing, this effect will be isolated by the paired question strategy.

[12] Note that while our three WTP formulations recognize income reallocation albeit in different ways, the WTP measure implied by a similarly structured unitary model would fail to do. WTP in this case would be given by: $-\frac{\alpha_2}{\alpha_3}\left[\pi\left(L^0, n, w, c\right) - \pi\left(L^1, n, w, c\right)\right]$.

That is, by describing the same policy change for the respondent and for a hypothetical dependent, we should be able to isolate some of the key dimensions in how the dependency relationships influence choices.

Second, once we move to parameterize the model, the implications of sharing seem most likely to be isolated through the household income term. Note that household income drops out of the WTP expressions given in equations (15) and (20). The parametric models used in the next section to describe respondents' choices are best interpreted as linear approximations to their underlying structure. Thus, we should expect to observe the influence of departures from a unitary framework through the income terms in estimated WTP functions (or choice models). Interactions between income and the age group of the hypothetical dependent may also be important as it seems reasonable to assume the relative effects of different types of dependencies will depend on household income levels. In the next section, we describe our pilot data collection activity beginning with a discussion of our pilot survey instrument.

III. Design of the Pilot Survey

Context

As noted at the outset, this pilot survey was designed in response to the results from focus groups that highlighted the difficulties in both framing and understanding questions that affect dependency relationships in households. To design a survey evaluating how environmental policies influence financial and time responsibilities associated with dependent older parents or relatives, we conducted a series of focus groups in August 2005. They were intended to be part of developing a larger survey

examining the distinctions between dependent adults and children. The interactions in the focus group suggested that explaining the time and financial responsibilities associated with these household relationships was especially challenging. Each individual had different care-giving experiences, suggesting that questions that assumed a comparable context were unlikely to be successful. As a result, we considered a "hypothetical dependency" as a mechanism to evaluate whether the decision process varies with the nature of dependency relationships among household members. To our knowledge, hypothetical dependency relationships had not been explored in stated preference research. Before considering further refinement in a set of choice questions for different dependency relationships we designed a pilot study to test this strategy. Our objective was to determine if this framing would be understandable and if it would be consistent with household behaviors that reflect jointness in the allocation of time and money among household members in the primary and extended household unit.

Finally, our analysis was intended to gauge the complexities associated with using one household member's answers to interpret overall household behavior and willingness to pay for policy alternatives. Because our focus is on evaluating the interactions between hypothetical dependency and choice models the survey was not designed to provide estimates of willingness to pay. Rather, our survey evaluates alternative ways of framing the choice questions that will appear in a larger study of household willingness to pay for policies with direct effects on dependency relationships.

The Pilot Sample

Our pilot sample was developed using Knowledge Network's (KN) Internet panel. Members of the panel are contacted by email to participate in surveys, permitting rapid

and cost-effective surveys. KN's Internet panel members are selected from households that are recruited using random digit dialing (RDD). If participants do not have access to the Internet, KN provides access and hardware. While these recruiting procedures help KN overcome the sample selection problems present in other Internet panels, which include only individuals with Internet access who volunteer for research, there are concerns that other sample selection threats remain. Cameron and DeShazo [2005], for example, examine the possibility of sample selection bias in KN surveys by analyzing households omitted from the sample due to one of five attrition processes:

1. initial recruitment to the panel
2. initial collection of profile data
3. active participation in the panel at the time a sample is drawn for the particular study
4. selection for a particular study
5. completion of a particular survey and inclusion in the final estimating sample.

While 35 percent of the 500,000-plus members of the initial RDD recruiting list are recruited to the KN panel, a very small percentage of households contacted are sampled for particular survey – only 0.8 percent were drawn for Cameron and DeShazo's survey and only 0.6 percent were in our estimating sample.

To evaluate the potential impact of this extremely limited final response rate, Cameron and DeShazo [2005] modeled the sample selection processes at all stages using census data matched to the KN data by phone numbers to capture demographic differences. While they find evidence of selection bias, they do not find that parameter estimates of models based on the KN samples were markedly affected by the inclusion of

sample selection correction terms. This work is consistent with other research by Holbrook, Krosnick and Pfent [2005] that suggests that the rules of thumb calling for high response rates may not be as important as the past literature (and survey guidance rules) implies. Their detailed evaluation of 100 RDD telephone studies over a 10 year period indicated that "…lower response rates seem not to substantially decrease demographic representativeness with the range we examined" (p38). While research continues in this area, the Cameron and DeShazo results along with other recent studies imply that sample selection effects related to overall participation in these Internet panels may be relatively small. Below, our models incorporate an adjustment for the final selection process identified by Cameron and deShazo.

An email inviting a random sample of KN panelists to take the survey was sent to 2,670 panelists aged 18 and over on June 7, 2006. The email indicated that the survey was about respondents' health.[13] A reminder email was sent three days later to respondents who had not yet completed the survey. By June 22, 2006, a total of 2,110 panelists (79% of panelists who received the email invitation) completed interviews. The duration of the interview is measured by KN as the number of minutes between when the survey is begun and when it is completed. Fifty percent of respondents completed the interview within 10 minutes and 92% completed the interview within 30 minutes. Only four percent of the sample took longer than 60 minutes to complete the interview.

KN provided socioeconomic and demographic data on all of the panelists that were invited to take the survey – including both survey respondents and non-respondents.

[13] The subject of the email was "Your Health" and the body of the email read: "This week we'd like you to participate in a survey about your health. We believe that you will find the survey very interesting. We'd appreciate your completing the survey at your first convenience. Thank you in advance for your time and participation."

These data on non-respondents permit us to estimate a selection model and implement sample selection correction in the regression analysis described in Section IV.

Questionnaire

The survey comprised four main sections: family support, asthma, contingent valuation, and debriefing. The first section asked respondents whether they provided either financial support and/or spent time providing care for any family members in the following eight age groups: 0-1 years, 2-5 years, 6-11 years, 12-14 years, 15-17 years, 18-55 years, 56-62 years, and 63+ years. To help respondents understand these questions, the survey described examples of these types of support. They were told that financial support includes buying food, paying for housing or healthcare, and paying for education, and that time spent providing care for a family member includes helping a family member run errands or helping them with daily activities such as preparing food or bathing. Respondents were also told that family members include live-in relatives and non-relatives (e.g., step-children), as well as family who live elsewhere.

The second section described asthma[14] and asked respondents whether any of the family members they support (with time or money) had been diagnosed with asthma. These responses were recorded such that the age categories correspond with the family support questions.

[14] Asthma was described as follows:

> "Asthma is a disease that affects an individual's airways. When an individual has asthma, the inside walls of the airways are swollen and can be irritated by triggers such as pollen, dust, and air pollution. A person with asthma may have difficulty sleeping. It may be difficult for them to walk or climb stairs, or to be physically active.
>
> When asthma symptoms are worse than usual, it is called an asthma attack. Asthma attacks are not all the same—some are more serious than others. A mild or moderate asthma attack causes symptoms like wheezing, coughing, chest tightness, and trouble breathing. In a severe asthma attack, the airways can close so much that air does not get to vital organs. This condition is a medical emergency."

The third section described a hypothetical dependency relationship as part of a series of two double bounded contingent valuation questions. The order of the two scenarios was randomly assigned. Respondents were asked to consider each situation independently. One of the scenarios asked the respondent to assume that he had asthma and the other scenario asked him to assume that he spends time caring for someone (other than himself) who has asthma. The respondent was told that this other person was in one of three age groups: young child (2-5 years), teenager (15-17 years), or older adult (63+ years). The age groups were randomly assigned as described below.

Each scenario has the same structure, beginning by describing two methods that deliver asthma medicine but take different amounts of time for administration.[15] The slower delivery method is described as using a nebulizer to create a medicated mist that is inhaled through a mask and takes 10 to 20 minutes per use. The second method proposes that the patient uses an inhaler, which delivers asthma medication more quickly (1-2 minutes). Respondents were told that physicians prescribe the delivery method based on several factors including the presence of uncontrollable asthma triggers. Respondents

[15] Asthma treatment was described as follows:

> "Asthma cannot be cured, but doctors help many people with asthma control their symptoms using medications and other treatments. There are two different ways that some asthma medications can be delivered – one that is slower and one that is faster.
>
> The slower delivery method uses a device called a nebulizer. The nebulizer creates a mist out of the asthma drug which makes it easy and pleasant to breathe the drug into the lungs using a mask or mouthpiece. By taking slow, deep breaths, the medicine gets into the lungs.
>
> The faster method uses a device called an inhaler. The inhaler delivers the same medication as the nebulizer in less time. The two ways cost the same and have the same side effects.
>
> A doctor determines which delivery method is appropriate for a person with asthma. Many factors influence the doctor's choice of method, including the presence of uncontrollable asthma triggers. The doctor may recommend changing methods if the conditions that affect a person's asthma change.
>
> The way people take asthma medicine affects the amount of time they spend taking medicine as well as the amount of time they have available to do other things."

were also told that the medications delivered using the two methods were similar in terms of price, side effects, and effectiveness.

Respondents were told that the asthma was moderately severe, requiring the use of a nebulizer and L^0 hours per week of the respondent's time to assist the person with the nebulizer. L^0 took on a value of 3 hours or 8 hours and was randomly assigned to respondents. "Moderately severe" asthma was described by saying that without medicine the person would frequently experience asthma symptoms that would make it difficult to breathe, sleep, play, or exercise.

Respondents were then told that a proposed new policy requiring cleaner industrial technologies in their area would reduce air pollutants and, as a direct result, reduce one important influence on this person's asthma. As a consequence, respondents are told that the person they care for with asthma will be able to use an inhaler instead of the nebulizer, reducing the amount of time the respondent would spend each week helping the person manage asthma.

While the cost of medication would remain the same, the policy would reduce the respondent's weekly time commitment for managing asthma from L^0 (3 hours or 8 hours) to L^1, which was always one hour, saving $L^0 - L^1$ (2 hours or 7 hours) hours each week. The respondent was also told that the policy will lead to higher electricity prices and increased income taxes that would amount to *T* dollars each month. *T* took on values of $5, $30, $70, or $150, also randomly assigned. Respondents were reminded that these costs would occur each month for many years and would be in addition to their typical monthly expenditures. They were also asked to assume that the person they care for does not have any other health problems.

After viewing a table that summarized the key attributes of the choice, the respondents faced a double-bounded discrete choice willingness-to-pay question. The question was: "Would you support this policy and be willing to pay for it?" If the respondent said "no," then they were asked whether they would support and pay for the policy if the cost were reduced to 0. 5*T ($2.50, $15, $35, or $75) per month. If the respondent said "yes" to the initial question, they were asked whether they would support and pay for the policy if the cost were increased to 2T ($10, $60, $140, or $300).

There are four different choice attributes with levels as follows: age of "other person" involved in the hypothetical dependency relationship to the household has three levels (young child, teenager, older adult), time savings due to the program has two levels (2 hours or 7 hours), the monthly expenditure for the policy has four levels ($5, $30, $70, and $150) and the order of the scenarios has two levels (self first, self second). These attribute levels were combined to create 48 (=3x2x4x2) different versions of the questionnaire (see Table 1 in the Appendix). Respondents were randomly assigned to one of these versions. Each version of the questionnaire holds the values of L^0, L^1, and T constant across the two scenarios. As described above in the conceptual framework, this design feature permits analyses, discussed in more detail in the next section, of the importance of dependency relationships.

IV. Analysis and results

Empirical methodology

We rely on two sets of tests of the hypotheses stemming from the conceptual model presented above. The first set involves non-parametric tests that allow the impact of dependency relationships on proposed changes in care-giving time to be examined

without imposing a formal structure for the choice model. This avoids making more explicit the treatment of the income sharing issues we raised above. The survey design is structured to link two choice situations for each respondent, with questions varying only in the hypothesized dependency relationship. Thus the design makes explicit an issue that often goes unstated in traditional stated preference applications—the nature of dependency relationships among household members. If the nature of these relationships is unimportant, then we should see no differences across responses based merely on a difference in the identity of the hypothetical family member receiving care.

We conduct two types of non-parametric tests. Our first set of non-parametric tests involves testing for differences in the response pattern variable for the "self" question and the respective "other family member" question. For each such test, we first split the sample according to the hypothetical family member question received by each respondent (i.e., child, teen, or older adult). Then we create categorical variables based on the sequence of responses, one variable for each double-bounded dichotomous choice variable. Each categorical variable takes the value of one, two, three, or four based on a response sequence of yes/yes, yes/no, no/yes, or no/no respectively. Because responses to these questions are dependent (each respondent provides two of the categorical variables), we conduct McNemar tests[16]. We conduct separate tests for "self" verses "child", "self" verses "teen", and "self" verses "older adult." Our second set of non-parametric tests allows us to make comparisons of response patterns across all four types of questions, "self," "child," "teen," and "older adult." To do so, we pool the data so that

[16] These tests were implemented using the symmetry command in Stata 9.0 SE.

each respondent is represented twice and conduct additional non-parametric χ^2 tests assuming independence of the responses for a given respondent.

While the non-parametric tests avoid the need to make specific assumptions about the choice model, they do not allow control for observable features of respondents that would likely be associated with some aspects of the differences in response patterns. Some of the most important of these factors would be family size and experience with the conditions being discussed. Other considerations that were a part of our survey design could also impact our findings. These include question order, bid levels, and the magnitude of the time savings. All of these are constant *for a given* respondent and thus will not impact the McNemar tests. To explore the effects of question order, bid levels, and reduction in care-giving time, we also conduct the χ^2 tests after splitting the sample based on whether or not the "self" question was asked first, by initial bid received, and by the reduction in care-giving time.

Our parametric models focus on using the responses to the choice questions to isolate the factors influencing how dependency relationships within the household would be relevant to willingness to pay functions. We do not attempt to estimate WTP functions that might be used in policy applications associated with air quality regulations. The conceptual model presented in section III suggests several factors that may impact the respondent's WTP function and therefore his responses to our choice questions. These include the size of the household, the change in required care-giving time, the identity of the hypothetical household member receiving care, and other factors that may influence the distribution of resources within the household.

We estimate interval regression models based on responses to the choice questions asked of each respondent. Each respondent answers two double-bounded dichotomous questions, one based on proposed changes in the time he spends managing his own asthma and another based on changes in the time spent caring for another household member. These responses allow the WTP to be bounded. Let WTP_{ic} represent respondent *i*'s latent willingness to pay for the proposed policy change that affects the required care-giving time devoted to individual *c* where *c* denotes child, teen, older adult, or the respondent himself. WTP_{ic} is not observed by the analyst. Instead, the analyst observes two choices. We interpret these responses as follows where b_{1i} and b_{2i} represent the initial and follow-up bids respectively presented to respondent *i*:

(i) $WTP_{ic} \geq b_{2i}$ if respondent chooses yes for both questions;

(ii) $WTP_{ic} < b_{2i}$ if respondent chooses no for both questions;

(iii) $b_{1i} \leq WTP_{ic} < b_{2i}$ if respondent chooses yes for the first question and no for the follow-up;

(iv) $b_{2i} \leq WTP_{ic} < b_{1i}$ if respondent chooses no for the first question and yes for the follow-up.

Initial bids vary randomly across respondents and follow-up bids depend on responses to the initial bid such that $b_{2i} = 2b_{1i}$ if the response to the initial bid is yes and $b_{2i} = \frac{1}{2}b_{1i}$ if the initial bid receives a response of no.

The interval-censored (iii and iv), right-censored (i) and left-censored (ii) data that result from our interpretation of the responses suggest likelihood contributions for each

respondent based on his sequence of responses.[17] In estimating our proposed parametric models, we pool all responses so that each respondent makes two contributions to the likelihood function, one based on each double-bounded dichotomous choice question he answers.[18] Our basic empirical model assumes the latent WTP can be represented as follows:

$$WTP_{ic} = \beta_0 + \beta_1 n_i + \beta_2 \Delta L_i + \beta_5 c_i + \beta_6 m_i + \beta_7 x_i + \varepsilon_i \,. \tag{21}$$

where n_i represents the number of household members in respondent *i*'s household, ΔL_i denotes the change in required care-giving time, c_i is the identity of the individual receiving care, m_i is respondent *i*'s household income, and x_i is a vector of other variables hypothesized to affect WTP. The β s are parameters to be estimated and ε_i represents an error term. The conceptual model described above suggests a method for discriminating between the collective and unitary model through the household income term, m_i. To be specific, if respondents' choices are consistent with the underlying WTP described by equation (11), which results from the collective model and a specific assumption about how respondents account for income reallocation, then we expect household income to be a significant factor in our parametric models. An insignificant coefficient on m_i would be inconsistent with this underlying (collective) WTP measure.[19]

[17] We use the intreg command in Stata 9.0SE to estimate these models. See Stewart [1983] for a description of interval regression and the associated maximum likelihood estimator.

[18] This analysis does not account for the correlation among responses that arises because each respondent contributes two responses to the parametric analysis. We use a robust covariance matrix for the estimated standard errors. This estimator corresponds to Stata's implementation of the Huber sandwich estimator for the interval regression model. This procedure offers an asymptotically consistent estimate for the effects of the selection term in the model but it does not fully address the correlation induced by correlation across the two questions asked of each respondent.

[19] Note that an insignificant coefficient on income would not permit us to distinguish between those WTP measures described in equations (15) and (20) and the WTP measure that would arise from a unitary model.

Note that in this parsimonious model we do not allow for interactions between household income and other factors such as c_i. We discuss variations on this basic specification when discussing our results below.

As discussed in our description of the survey instrument, the multiple-stage nature of KN's sampling procedures raises concerns of potential sample selection bias. Our data permit us to investigate this possibility for the final stage of the sampling procedure. To be specific, we can distinguish among those individuals who were invited to participate in our survey and chose not to (or failed to complete the survey) and those individuals represented in the final sample used in our parametric model. To formally correct for potential bias resulting from sample selection, we adopt a variant of Heckman's [1979] two-step procedure. First, we estimate a probit selection model where we hypothesize that selection into our sample depends on factors such as gender, race, education, employment status and income. Then, we use predictions from this model to form inverse Mills ratios for each respondent and include this factor as an independent variable in our interval regression models.

Results

Before discussing our non-parametric and parametric results, we present some information describing our sample. Of the 2,670 Knowledge Network panelists invited to participate in our survey 2,110 did so. Thirteen observations had missing values for key variables and were subsequently dropped from the analysis. Table 1 summarizes the sample characteristics of the 2097 respondents who were included in the regression analyses described below.

Fifty-one percent of respondents were female and the average age of respondents in our sample was 47 years. Almost one-third of respondents (31%) graduated from high school and 17% graduated from college. The majority of respondents (71%) identified themselves as white, while 11% and 12% reported that they were black or Hispanic, respectively.

While household size ranged from one to nine persons, most households were fairly small. Fifty-nine percent had 2 members or less (77% had 3 members or less and 91% had 4 members or less), and the average household size was 2.58 persons. Twenty-three percent of respondents were from households with only one adult aged 18 or older; 55% were from households with 2 adults; and 22% of households had more than 2 adults. One percent of households had at least one child under two years old; ten percent had at least one child aged 2 through 5; fourteen percent had at least one child aged 6-12 years; and twelve percent had at least one child between 13 and 17 years.

Most households represented by respondents in the sample own their own home (68%) and average annual household income was $52,872. Thirty-two percent of households earned $27,500 or less; 35% earned between $27,500 and $55,000; 27% earned between $55,000 and $112,500; and only 5% earned more than $112,500. Fifty-five percent of respondents were from dual income households and the majority worked full-time (60%). Seventeen percent of respondents were retired; 4% were unemployed; and 6% were disabled.

In an effort to gauge existing care-giving responsibilities, respondents were asked to indicate whether or not they currently provide financial support or spend time caring for family members in various age categories. Table 2 shows the patterns of respondent

support for family members. Slightly less than half of respondents provided financial or time support to at least one family member. Overall, about 47% of respondents indicated providing support in the form of time or money to a child, teen, or older adult; 30% of respondents indicated providing such support to a child, 16% to a teen, and 14% to an older adult. Within a given age category, the percent of respondents providing financial support and providing time support was fairly consistent except for the 18-55 and 63 years plus age categories. Nearly twice as many respondents provided financial support to adults aged 18 to 55 (17.5%) as provided time support (9.5%). Conversely, more respondents provided time support to older adults 63 years or older (9.6%) than provided financial support (6.2%). Respondents were also asked whether or not any family members for whom they provided care, either time or financial, had been diagnosed with asthma. The final column of Table 2 reports this information. Of those respondents who indicated providing care for a family member, between 11 and 20 percent of those receiving care had been diagnosed with asthma. Asthma prevalence was slightly higher among adults receiving care.

We first discuss the results of our non-parametric tests. Table 3 presents the results of one of three McNemar tests that we conduct. The results presented in the table indicate significant differences between the response pattern for the "self" question and the response pattern for the "child" question (p-value = 0.00).[20] We also find significant differences between the "self" question and the "teen" question (p-value = 0.003).

[20] The χ^2 distribution is generally used to evaluate the McNemar test statistic as it provides an approximation of the exact sampling distribution, the binomial distribution [Sheskin, 2000]. Stata can conduct an exact (rather then asymptotic) symmetry test only in small samples.

However, the tests suggest no significant differences between the "self" question and the "older adult" question (p-value = 0.213).

To further examine the potential role of dependency relationships using non-parametric tests, we pool the data so that each survey respondent is represented twice, one based on his responses to the "self" question and another based on his responses to the "other" question he received. We create a categorical variable taking values between one and four denoting the respective question type as "self," "child," "teen," or "older adult." Our non-parametric test involves examining differences between the distribution of this variable and our categorical variable indicating response patterns. With the pooled data, we reject equivalence of these distributions, suggesting that dependency matters provided the effect does not vary with the level of the WTP. This result is further evidence of the importance of dependency relationships. When we begin to split the pooled data into sub-samples based on differences in initial bids, question order, and reductions in care-giving time, our results are mixed. We explore these relationships further in our parametric models.

Table 4 presents the results of our parametric analysis. The second column presents the results of the parsimonious model described in equation (21). First, we discuss the results with respect to measures of household income which, as discussed, above permit a test of the collective model as represented in equation (11). We include four household income variables, "income1" through "income4," derived from a categorical household income variable (with 18 categories) provided by KN. Our household income variables allow the marginal effect of income to vary based on household income class. They are created by interacting four dummy variables

representing household income classes (less than $27,500; between $27,500 and $55,000; between $55,000 and $112,500; greater than $112,500) with a measure of actual household income. Actual income levels were created by taking the midpoint of the 18 income intervals and then putting a Pareto tail on the upper category to assign a point value for the upper interval. The income classes assign approximately equal numbers of respondents to the first three groups. We investigated the correspondence of the groups to approximate income tax rates using Stata's marginal tax rate computation scheme. The lowest interval would be consistent with two marginal tax rates, the highest of which overlaps with the second income interval. The other two intervals have the same marginal tax rate. Three of the four income variables are positive and significant while "income1" is insignificant. However, the four variables taken as a group are jointly significantly different from zero (p-value = 0.00). These results suggest that respondents' choices are inconsistent with the unitary model.[21]

Other variables suggested by equation (21) include household size, which is negative and significant as expected, and the proposed reduction in care-giving time. Because the change in care-giving time takes only two values, we create a dummy variable, denoted "low time," which equals one if the response was based on the small reduction in care-giving time (from three hours to one hour) and zero if the large reduction (from eight hours to one hour) was assigned. As expected, a smaller reduction in the required care-giving time reduces willingness to pay. However, the effect is not significant at conventional levels (p-value = 0.134). To gauge the effect of familiarity with asthma we include a dummy variable indicating whether or not the respondent or a

[21] We also estimated an alternative specification in which we replace our four income measures with a single measure of household income. The coefficient on this variable was positive and highly significant.

family member had ever been diagnosed with asthma (based on the respondent's self report). As anticipated, the coefficient on this variable is positive and significant.

We use a set of dummy variables, "child question", "teen question", and "older adult question" to indicate the hypothetical household member associated with each response. The excluded category is the respondent himself. Inclusion of this set of dummy variables allows us to further examine the importance of dependency relationships among household members. The coefficients on these terms suggest that estimated WTP is higher for child and teen questions relative to self questions. However, there is no significant difference between responses based on older adult and self questions. Pair-wise hypothesis tests suggest significant differences between child and older adult (p-value = 0.000), and teen and older adult (p-value = 0.014) but no significant differences between child and teen (p-value = 0.253). These results are consistent with our non-parametric results and suggest important effects of different hypothetical dependency relationships.

The variable "current care-giver" allows us to explore the effects of existing dependency relationships on respondents' choices. This variable indicates whether or not the respondent currently provides care, either financial or time, to a child, teen, or older adult. The coefficient on this variable is positive and (marginally) significant as we expect. In order to further explore current relationships among household members that may impact respondents' choices, we include a variable indicating whether or not the respondent indicated belonging to a dual-income household. This variable is negative and (marginally) significant. This may suggest differences in the perceived reallocation

of income resulting from the policy change between respondents in dual-income households and those in single-income households.

We include two variables in addition to those suggested by (21). The first variable, denoted "question1st," controls for possible ordering effects. This variable takes a value of one if the question associated with an observation came first in the survey and zero if the question came second. The negative and significant coefficient on this term indicates significant ordering effects that reduce WTP estimates for those responses based on first questions. The second variable represents a selection control resulting from the probit model of sample selection described above. Based on the results of this model, we compute the inverse Mills ratio for each respondent and include this as an independent variable in our WTP equations. The results of the selection model suggest that, relative to invited KN panelists who chose not to participate, respondents represented in our sample are older, from lower income households, and are more likely to be white and male.[22] The positive and significant coefficient on the inverse Mills ratio in Table 4 suggests significant selection effects. As we have seen above, neither the ordering nor selection effects confound our ability to test for the importance of different dependency relationships.

While the parsimonious model does not allow for interaction variables, our conceptual model, equation (11) in particular, does not preclude the possibility that interaction variables will be important in explaining differences in respondents' choices. The second specification explores these effects by augmenting the first specification with various household income interaction terms. To be specific, we investigate whether the effect of differences in the age of the hypothetical household member receiving care on

[22] Full results of the selection model are available by request from the authors.

respondents' choices will vary with income. To do so, we create a set of 12 interaction variables among our household income variables, "income1" through "income4", and our three dummy variables identifying the hypothetical dependent as child, teen, or older adult. We do not report the coefficients on these variables because, taken individually, they are of limited interest. However, using combinations of the estimated coefficients on these interaction terms and non-interacted variables, we can test for differences in WTP estimates for child, teen, older adult, and self within various income classes. The third column of Table 4 reports the results of our second parametric specification. Note that with the inclusion of interaction terms, the interpretation of the coefficients on the income terms as well of those variables indicating question type varies between the two specifications. In the second specification, these coefficients cannot be interpreted independently as in the first specification.

The results of pair-wise hypothesis tests of differences in estimated WTP by hypothetical family member for different income classes are reported in Table 5. The results of these tests suggest estimated WTP is higher for the child question relative to the older adult question for three of the four income classes. We also find differences between estimated WTP for the child and self questions although the results vary with income class. Overall, the tests suggest that WTP estimates based on observed choices of those respondents in the highest income class do not seem to vary with the nature of the hypothesized dependency relationships. However, these distinctions become important at lower income classes.

V. Implications

Environmental policies do not uniformly affect all members of households. Indeed, the protocol for establishing standards for the criteria air pollutants calls for identifying how each pollutant affects a sensitive group and then selecting a standard to protect an average member of that group under the premise that all other less sensitive individuals will also be protected. To the extent that the more sensitive members of a household are cared for by other household members, benefit estimates should reflect these dependencies and how they might change in response to policies changes.

Bateman and Munro's [2006] findings confirm results that have appeared in multiple applications unrelated to recovering information about preferences for environmental resources. We should expect different adult decision makers in a given household to react differently to the same choice situation, even when they are asked to answer for the household. This analysis has taken a first step at analyzing how to learn about the relationship between dependency and choice.

Using a pilot survey that was designed to focus a respondent's attention on a hypothetical dependent we find that choices display properties that are inconsistent with a unitary model. Respondent's choices vary with the type of dependency and the level of household income also appears to influence the relative importance of these effects. This latter effect would not be present with a unitary model. The stated preference responses also display patterns that are consistent with treating them as situations the respondent took seriously. A respondent's past experience with asthma and with care-giving influenced the decisions he made. The observed response patterns also underscore the difficulty in using multiple stated preference questions in a single survey. Our empirical

analysis suggests significant ordering effects. In addition, we find a significant selection effect for the Internet panel members who agreed to take the survey. However, these effects do not appear to influence our primary conclusions.

While these findings are quite encouraging, we believe several steps remain before it will be possible to frame stated preference questions that elicit household preferences in ways that allow identification of the budget allocation and choice processes. First, we need to consider the alignment between choices related to hypothetical versus real dependency relationships. Second, we need to consider how individuals evaluate the effects of policies that influence time or financial resources available to the household and internal reallocation activities. Finally, we need a clear picture of how to ask about who participates in these reallocation decisions.

We undertook a pilot survey because we experienced little success with focus groups. The information on framing derived from this pilot may offer new strategies for focus groups to answer these questions.

More generally, these pilot results seem to offer a broader message. Even though we framed a questionnaire that induced a high level of correlation in two stated choice questions, it was nonetheless possible to discriminate among independently designed dependency relationships with very little parametric structure. Stated choice questions do elicit discriminating choices.

Table 1. Sample characteristics

Variable	Mean	Std. Dev.
Age (years)	46.82	16.88
Education dummy variables		
Did not attend high school	0.14	0.35
High school graduate	0.31	0.46
College graduate	0.17	0.38
Post graduate	0.12	0.33
Race dummy variables		
White	0.71	0.45
Black	0.11	0.32
Hispanic	0.12	0.32
Female dummy variable	0.51	0.50
Own home dummy variable	0.68	0.47
Occupation dummy variables		
Work full-time	0.60	0.49
Unemployed	0.04	0.19
Retired	0.17	0.39
Disabled	0.06	0.25
Homemaker	0.08	0.28
Work part-time	0.001	0.03
Household size	2.58	1.36
Dual income household dummy variable	0.55	0.50
Annual household income ($)	52,872	41,830
Income groups dummy variables		
$0-$27,500	0.32	0.47
>$27,500-$55,000	0.35	0.48
>$55,000-$112,500	0.27	0.46
>$112,500	0.05	0.22
Number of respondents	2097	--

Table 2. Percent of respondents providing support for family members in different age groups and the presence of asthma

Age group	Provide financial support for member in age group	Provide time providing care for member in age group	Household member in age group for whom respondent provides care (time or financial) has asthma
No time or financial support provided	52.5	53.3	N/A
5 years and under	15.8	18.1	11.5
6-11 years	15.5	16.0	17.2
12-14 years	9.0	7.9	17.2
15-17 years	9.0	7.2	18.8
18-55 years	17.5	9.5	20.9
56-62 years	2.1	1.9	19.5
63 years and more	6.2	9.6	13.8

Table 3. Results of McNemar test comparing response patterns for “self” and “child” questions

Responses to child question	Responses to self question				Total
	yes/yes	yes/no	no/yes	no/no	
yes/yes	188	34	10	8	240
yes/no	7	73	19	21	120
no/yes	5	13	54	24	96
no/no	4	6	104	239	217
Total	204	126	104	239	673

Symmetry (asymptotic) chi2(6) = 30.44, Pr = 0.000

Table 4. Interval regression models of willingness to pay for proposed policy change[a]

Variable name	Specification 1	Specification 2
Household size	-4.70* (-2.42)	-4.60* (-2.37)
Asthma	18.62* (3.92)	18.86* (3.98)
Low time	-6.48 (-1.50)	-6.19 (-1.44)
Child question	24.01* (3.73)	57.69* (2.65)
Teen question	14.96* (2.38)	7.16 (0.35)
Older adult question	-3.37 (-0.57)	-19.13 (-0.98)
Current care-giver	7.66 (1.67)	7.19 (1.56)
Dual income	-7.75 (-1.60)	-7.80 (-1.61)
Income1	-0.00016 (-0.37)	-0.00024 (-0.41)
Income2	0.00066* (3.48)	0.00068* (2.68)
Income3	0.00051* (4.97)	0.00050* (3.66)
Income4	0.00040* (5.67)	0.00048* (4.73)
Constant	17.39 (1.27)	16.43 (1.08)
Question1st	-19.83* (-4.54)	-20.30* (-4.65)
Inverse mills ratio	82.84* (3.34)	83.72* (3.37)
Household income interaction terms included?	No	Yes
Number of observations	4193	4193

[a] Numbers in parentheses are *z*-statistics for the null hypothesis of no association based on the robust covariance matrix. * indicates p-value of 0.05 or less.

Table 5: Results of pair-wise hypothesis tests for differences in WTP estimates based on responses to self, child, teen, or older adult questions by household income group[a]

	Self	Child	Teen	Older adult
Income class 1 ($\leq$ \$27,500)				
Self		0.006*	0.124	0.633
Child			0.275	0.066*
Teen				0.417
Older adult				
Income class 2 ($\in$ (\$27,500,\$55,000])				
Self		0.127	0.028*	0.505
Child			0.435	0.068*
Teen				0.016
Older adult				
Income class 3 ($\in$ (\$55,000,\$112,500])				
Self		0.009*	0.296	0.744
Child			0.157	0.012*
Teen				0.255
Older adult				
Income class 4 (> \$112,500)				
Self		0.526	0.200	0.271
Child			0.117	0.155
Teen				0.704
Older adult				

[a] Table reports p-values of hypothesis that estimated WTP based on responses to question in column one equals estimated WTP based on responses to question in row one.
* indicates significant differences at p-value of 0.10 or smaller.

REFERENCES

Bateman, Ian J. and Alistair Munro. 2006. “Household Versus Individual Valuation: What’s the Difference?” Discussion Papers in Economics from Department of Economics, Royal Holloway University of London, No. 06/02.

Becker, Gary. 1974. "A Theory of Social Interactions." *Journal of Political Economy*. 82(6): 1063-1094.

Browning, M. and P.A. Chiappori. 1998. “Efficient Intra Household Allocation: A General Characterization and Empirical Tests.” *Econometrica* 66: 1241-1279.

Cameron, Trudy Ann and J.R. deShazo. 2005. “Sample Selection in a Major Consumer Panel: Assessment and Correction Using Year 2000 Census Characteristics and County-Level Presidential Voting Records.” draft manuscript.

Carson, R.T., W.M. Hanemann, R.J. Kopp, J.A. Krosnick, R.C. Mitchell, S. Presser, P.A. Ruud, and V.K. Smith. 1994. “Prospective Interim Lost Use Values Due to DDT and PCB Contamination in Southern California.” Report to NOAA, La Jolla, California: Natural Resource Damage Assessment, Inc., September.

Carson, R.T., R.C. Mitchell, W.M. Hanemann, R.J. Kopp, S. Presser, and P.A. Ruud. 1992. “A Contingent Valuation Study of Lost Passive Use Values Resulting from the Exxon Valdez Oil Spill.” Unpublished report to the Attorney General of the State of Alaska, La Jolla, California: Natural Resource Damage Assessment, Inc., November 10.

Chay, Kenneth Y. and Michael Greenstone. 2003. “The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession.” *Quarterly Journal of Economics* 118(3): 1121-1167.

Chiappori, Pierre-André. 1988. ”Rational Household Labor Supply.” *Econometrica* 56(1): 63-90.

Currie, Janet and Matthew Neidell. 2005. “Air Pollution and Infant Health: What Can We Learn from California’s Recent Experience?” *Quarterly Journal of Economics* 120(3): 1003-1030.

Evans, Mary F. and V. Kerry Smith. 2005. “Do New Health Conditions Support Mortality-Air Pollution Effects?” *Journal of Environmental Economics and Management* 50(3): 496-518.

Evans, Mary F. and V. Kerry Smith. 2006. “Do We Really Understand the Age-VSL Relationship?” *Resource and Energy Economics*, 28: 242-261.

Heckman, James J. 1979. “Sample Selection Bias as a Specification Error.” *Econometrica* 47: 153-161.

Holbrock, Allyson L., Jon A. Krosnick, and Alison M. Pfent. 2005. "The Causes and. Consequences of Response Rates in Surveys by the News Media and Government Contract Survey Research Firms." Discussion paper.

Lundberg, Shelly J., Robert A. Pollak, and Terence J. Wales. 1997. "Do Husbands and Wives Pool Their Resources? Evidence from the United Kingdom Child Benefit." *Journal of Human Resources* 32(3): 463-480.

Munro, Alistair. 2005. "Household willingness to pay equals individual willingness to pay only if and only if the household income pools." *Economics Letters* 88: 227-230.

Sheskin, David J. 2000. Handbook of Parametric and Nonparametric Statistical Procedures, 2nd Edition. New York: Chapman and Hall/CRC.

Smith, V. Kerry. 2007. "Judging Quality." Forthcoming in B. Kanninen (ed.),Valuing Environmental Amenities Using Stated Choice Studies. Dordrecht: Springer, pp. 297-333.

Stewart, Mark B. 1983. "On Least Squares Estimation when the Dependent Variable is Grouped." *Review of Economic Studies* 50(163): 737-753.

U.S. Environmental Protection Agency, 1999, *The Benefits and Costs of the Clean Air Act 1990 to 2010*, EPA-410-R-99-001, prepared for U.S. Congress, November.

Viscusi, W. Kip and Joseph E. Aldy. 2006. "Labor Market Estimates of the Senior Discount for the Value of Statistical Life." *Journal of Environmental Economics and Management*, Forthcoming, RFF Discussion Paper 06-12.

Appendix. Table of pilot survey versions

Order of scenarios	Age of hypothetical dependent household member	Time savings	Program fee (T)	Version No.
Respondent first, then other household member	Young child (2-5 years)	7 hours	$5	1
			$30	2
			$70	3
			$150	4
		2 hours	$5	5
			$30	6
			$70	7
			$150	8
	Teenager (15-17)	7 hours	$5	9
			$30	10
			$70	11
			$150	12
		2 hours	$5	13
			$30	14
			$70	15
			$150	16
	Older adult (63+ years)	7 hours	$5	17
			$30	18
			$70	19
			$150	20
		2 hours	$5	21
			$30	22
			$70	23
			$150	24
Other household member first, respondent second	Young child (2-5 years)	7 hours	$5	25
			$30	26
			$70	27
			$150	28
		2 hours	$5	29
			$30	30
			$70	31
			$150	32
	Teenager (15-17)	7 hours	$5	33
			$30	34
			$70	35
			$150	36
		2 hours	$5	37
			$30	38
			$70	39
			$150	40
	Older adult (63+ years)	7 hours	$5	41
			$30	42
			$70	43
			$150	44
		2 hours	$5	45
			$30	46
			$70	47
			$150	48