Formal Home Health Care, Informal Care, and Family Decision Making

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Abstract

We use the 1993 wave of the AHEAD data set to estimate a game-theoretic model of families' decisions concerning time spent caring for elderly individuals and financial transfers for home health care. The outcome is a Nash equilibrium where each family member jointly determines his or her consumption, transfers for formal care, and time allocation – informal care, market work, and leisure. The estimates allow us to decompose the effects of parent and child characteristics into wage effects, quality of care effects, and burden effects. They also allow us to simulate the effects of a broad range of policies of current interest.

Keywords: Long-term Care, Empirical Game Theory

1 Introduction

In recent decades, the elderly population has grown substantially. For example, the elderly population increased by 37% between 1990 and 2000. Demographers predict that the elderly population will reach 60 million, or 20% of the total population, by 2025 (Morrison, 1990). Furthermore, as of 2000, the oldest old population, those 85 years and older, was the second fastest growing age group in the population. People are living longer than ever before and, as they grow older, the elderly experience increasing physical and mental impairments. Although disability rates among the elderly decreased between 1982 and 1994 (Manton, Corder, and Stallard, 1997), the number of disabled elderly individuals has remained approximately constant at 5.5 million because of population aging,

and the level of disability among those receiving long-term care has increased (Spector, et al. 1999).

Population aging has coincided with dramatic changes in long-term care arrangements. Children have become less likely to care for elderly parents, while elderly parents have become more likely to remain independent, move to nursing homes (Boersch-Supan et al., 1988; Wolf and Soldo, 1988), or receive formal care (i.e., care provided for pay) in their homes. For example, about 7% of the oldest old lived in institutions in 1940, but approximately 25% of the individuals in this age group were institutionalized in 1990 (Kotlikoff and Morris, 1990). Until recent decades, formal home health was relatively uncommon. By 1992, 0.9 million individuals were receiving home health care (National Center for Health Statistics, 1994a, 1994b). Meanwhile the proportion of those aged 65 or older receiving long-term care from relatives other than spouses declined from 16.1% to 12.8% (National Center for Health Statistics, 1996b).

Population aging and the trends toward institutional and home health care have significant economic, social, and psychological implications. The high cost of institutional care often exhausts the resources of nursing home residents. Thus, many elderly individuals and their families rely on Medicaid to cover their long-term care expenses. Not only does nursing home care typically create a greater drain on private and public funds than does informal care (i.e., unpaid care, almost always provided by a family member), but institutionalization typically involves greater social and psychological costs for an elderly individual (Macken, 1986).

Home health care's share of health care expenditures has also increased dramatically in recent years. For example, it rose from 1% in 1980 to 2.8% in 1994 (National Center for Health Statistics, 1996a; US Dept of HHS 2000). Those receiving home health care are generally younger than those in nursing homes. Recipients of home health care are predominantly female and disproportionately black (National Center for Health Statistics, 1994a).

Despite the trends toward institutional and formal home health care, adult children remain a factor enabling elderly parents to live in the community. Researchers demonstrate that a majority of the elderly who remain in the community do so with the assistance of familial and social networks (Shanas, 1979a, 1979b, 1980; Cantor, 1983, Streib, 1983, Noelker and Wallace, 1985; Matthews and Rosner, 1988).

In this paper, we construct a model of family decisionmaking where each member of the family is choosing a level of consumption, contributions for formal care, market work, leisure, and informal care for an elderly parent. We use the model to explain how various environmental and policy factors affect care decisions and the welfare of each family member. The model is an early step in developing structural models of family decision making and long-term care decisions.

2   Literature Review

Although predominantly empirical, the long-term care literature offers several theoretical models. These models vary along several dimensions: which family members participate in the decision-making process, which types of care and/or living arrangements are considered, whether family members have common preferences, and whether other decisions are determined jointly with long-term care decisions.

Several of the existing theoretical models involve only one child in the decision-making process. For example, Kotlikoff and Morris (1990) restrict their attention to families consisting of an elderly parent and only one child. Pezzin and Schone (1997, 1999) and Sloan, Picone, and Hoerger (1997) present models that apply to families of any size, but only one child plays a role in the family's long-term care decision. As part of an effort to develop more realistic models of family decision making, Hoerger, Picone, and Sloan (1996), Hiedemann and Stern (1999), Checkovitch and Stern (2002), and Engers and Stern (2002) present models that accommodate a variable number of children and the possibility that all children play a role in long-term care decisions.

Given the variety of long-term care arrangements and the connection between care and living arrangements, one model cannot capture all possible aspects of a family's long-term care and living arrangements. Depending on the relevant research question, the choice variables in these models involve living arrangements (Kotlikoff and Morris 1990, Hoerger, Picone, and Sloan 1996), care arrangements (Sloan, Picone, and Hoerger 1997, Hiedemann and Stern 1999, Checkovitch and Stern 2002, Engers and Stern 2002), or both (Pezzin and Schone 1999). Kotlikoff and Morris (1990) present a model where parent and child decide whether to form an intergenerational household or to maintain separate households. In Hoerger, Picone, and Sloan (1996), the family faces a third possible living arrangement for the parent: nursing homes. In Hiedemann and Stern (1999) and Engers and Stern (2002), the family decides whether the parent will continue to live independently without care, receive care from one of the children, or move to a nursing home. Checkovitch and Stern (2002) model each child's provision of informal care. Pezzin and Schone (1999) jointly model living arrangements with the provision of care by the child (in this case, a daughter). In Sloan, Picone, and Hoerger (1997), the choice variables are not the type of care or living arrangement but hours of formal care and care provided by the child.

Two of the papers in this literature assume that a single household utility function is appropriate in the context of elderly parents and their adult children. Corresponding to each possible living arrangement in Hoerger, Picone, and Sloan (1996) is a family utility function and budget constraint. In Kotlikoff and Morris (1990), the parent and child solve separate maximization problems if they live separately but maximize a weighted average of their individual utility functions subject to their pooled budget constraint if they live together. In this latter case, the weights are determined by a bargaining process. The remaining models in this literature (Pezzin and Schone, 1997, 1999; Sloan, Picone, and Ho-

erger, 1997; Hiedemann and Stern, 1999; Checkovitch and Stern, 2002; Engers and Stern, 2002) are game-theoretic and thus involve separate utility functions for each family member.

The provision of care by adult children may be determined simultaneously with their labor force behavior. Accordingly, Ettner (1996) and Pezzin and Schone (1997, 1999) model labor force participation of adult children jointly with care and/or living arrangements. Similarly, inter- or intragenerational transfers may be made as part of a family's long-term care decision. This possibility may be captured by assuming that the family pools its income (e.g., Hoerger, Picone and Sloan, 1996) or by explicitly modeling side payments among family members. Pezzin and Schone (1999) model intergenerational cash transfers jointly with caregiving, intergenerational household formation, and labor force behavior. In one of the models in Engers and Stern (2002), family members choose the long-term care alternative that maximizes their joint payoff and make any necessary side payments among themselves.

In all of these models, elderly parents and their adult children jointly select living and/or caregiving arrangements. Most of these models are game-theoretic and thus accommodate the possibility that elderly parents and their adult children have different preferences. Other than Hiedemann and Stern (1999), Checkovitch and Stern (2002), and Engers and Stern (2002), the game-theoretic models in this literature are based on the assumption that only one adult child participates in the decision-making process. This assumption considerably simplifies modeling and estimation but obscures the dynamics within the younger generation. In practice, more than one adult child in a family may participate in the family's long-term care decision, and adult siblings may disagree regarding the best source of care for an elderly parent. The potential disagreement among adult siblings and between adult children and elderly parents motivates the development of a game-theoretic framework where the players include the parent and all of her[1] children. The burden associated with caregiving may generate strategic interaction among family members. For example, an adult child's provision of informal care for her father may depend on the amount of informal care provided by her siblings and by her mother. Although altruistic toward her father, the adult child may have incentive to free ride on her siblings' or her mother's informal care. Thus, her provision of informal care may depend negatively on the amount of care provided by other family members. Alternatively, in the spirit of Bernheim, Schleifer, and Summers (1985), a bequest motive could induce siblings to compete with one another for a greater share of the inheritance. Thus, an adult child's provision of informal care could depend positively on the amount of care provided by a sibling. Similarly, siblings may have incentive to free ride on one another with respect to financial transfers for formal home health care. The possibility of such strategic play suggests that a non-cooperative model may be appropriate in the context of families' caregiving decisions for the elderly.

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[1]Throughout the paper, we use female pronouns as the generic pronouns. This does not mean that only mothers need care or that only daughters provide care.

The econometric models in the long-term care literature are as varied as the theoretical models. Most papers present results based on nonstructural models (Boersch-Supan, Kotlikoff, and Morris, 1988; Wolf and Soldo, 1988; Kotlikoff and Morris, 1990; Lee, Dwyer, and Coward, 1990; Cutler and Sheiner, 1993; Ettner 1996; Hoerger, Picone, and Sloan, 1996; Boaz and Hu 1997; Diwan, Berger, and Manns 1997; Norgard and Rodgers 1997; Sloan, Picone, and Hoerger, 1997; White-Means 1997; Couch, Daly, and Wolf 1999), but several papers present results based on structural models (Kotlikoff and Morris, 1990; Pezzin and Schone 1997, 1999; Hiedemann and Stern, 1999; Checkovitch and Stern, 2002; Engers and Stern, 2002).

With the exception of Checkovitch and Stern (2002), the existing literature generally focuses on the role of a single child in each family as the primary caregiver and ignores the possibility of other children serving as sources of assistance (Frankfather, Smith, and Caro, 1981; Johnson and Catalano, 1981; Cantor, 1983; Johnson, 1983; Stoller and Earl, 1983; Horowitz, 1985; Barber, 1989; Kotlikoff and Morris 1990; Miller and Montgomery, 1990; Stern 1994, 1995, 1996; Pezzin and Schone 1997, 1999; Hiedemann and Stern 1999; Engers and Stern 2002). However, data from the 1984 National Long-term Care Survey indicate that shared caregiving is an important phenomenon, especially in large families. Checkovitch and Stern (2002) show, for example, that over 4% of families with two children, almost 10% of families with three children, and about 16% of families with four children contain multiple caregivers. Among families where at least one child provides care, the probability that children share caregiving is almost 13% in families with two children, over 25% in families with three children, and almost 35% in families with four children. Even if each family uses a single caregiver, one cannot ignore the other children in the family. Children attempt to influence both the amount and the method of caregiving provided by their siblings. Not only are there possibilities for intersibling conflict as a result of parental long-term care provision, but a large majority of distant children report emotional support received from siblings regarding the situation of their disabled parent (Schoonover, Brody, Hoffman, and Kleban, 1988).

3   Medicaid Financing Rules

Medicaid is a joint federal/state, means-tested entitlement program that finances medical assistance to persons with low income. Federal contributions to each state vary according to a matching rule that depends on which medical services are financed by the state. Medicaid is estimated to have served 31.4 million persons in fiscal year (FY) 1992, at a combined cost of $118.8 billion, about 15% of total national health spending (Congressional Research Service, 1993, p. 1).

Eligibility for Medicaid is linked to actual or potential receipt of cash assistance under the Supplemental Security Income (SSI) program or the former Aid to Families with Dependent Children (AFDC) program. Elderly persons

become eligible for SSI payments by having countable income (income less $20) and countable resources below standards set by federal law. In 1993, the year of our sample, the SSI income limit was $434 per month for individuals and $652 per month for couples. The 1993 SSI resource limits were $2000 for individuals and $3000 for couples.

In designing their Medicaid programs, states must adhere to federal guidelines. Even so, variation among state programs is considerable. Byrne, Goeree, Hiedemann, and Stern (2003) provides information on the variation in rules across states. Eligibility in each state depends on the state's policies with regard to three main groups of individuals: categorically needy, medically needy, and individuals residing in medical care institutions or needing home and community-based care.

When determining Medicaid categorical eligibility, states have the option of supplementing the federal income standard. The State Supplement Payments (SSP) are made solely with state funds. The combined federal SSI and state SSP benefit becomes the effective income eligibility standard. Alternatively, states may use more restrictive eligibility standards than those for SSI if they were using those standards prior to the implementation of SSI.

Medicaid also allows states to cover individuals who are not poor by the relevant income standard but who need assistance with medical expenses. To qualify for medically needy coverage, individuals first deplete their resources to the state's standard and then continue to incur medical expenses until their income meets the level required by the state. States are permitted by federal law to establish a special income standard for persons who are residents of nursing facilities or other institutions. The special income limit may not exceed 300% of the maximum SSI benefit. In states without a medically needy program, this "300% rule" is an alternative way of providing coverage to individuals with incomes above the state's limit.

Finally, under the Section 1915c waiver program, states have the option of covering individuals needing home and community-based care services if these individuals would otherwise require institutional care covered by Medicaid. States use waiver programs to provide services to a diverse long-term care population, including the elderly. Spending for 1915c waiver services has grown dramatically since the enactment of the law in 1981. Federal and state spending increased from $3.8 million in FY 1982 to $1.7 billion in FY 1991 (Congressional Research Service, 1993, p. 400). Equivalently, about 13% of Medicaid long-term care spending covered home and community based care in 1991.

4   Theoretical Model

4.1   The Model

We model a multigenerational family with varying preferences making decisions about contributing time and money to care for members of the older generation.

Consider a family[2] with I adult children and one or two elderly parents. The family includes between $I + 1$ and $2(I + 1)$ adults depending on the marital status of the parent and each child. We assume that married couples act as a single player; thus, there are $I + 1$ players indexed by $i = 0, 1, 2, .., I$. When indexing married players, we use m and p for maternal and paternal and c and s for child and spouse. The term a_{ik} ($k = m, p$ for parents, and $k = c, s$ for children) takes the value 1 if the family includes the individual in question and zero otherwise. For example, $a_{1s} = 1$ if child 1 is married, and $a_{1s} = 0$ if not. Each player makes decisions about consumption X_i, contributions for formal home health care (measured in time units) H_i, leisure L_{ik}, time spent caring for the mother t_{mik} and father t_{pik} where $k = m, p$ for parents and $k = c, s$ for children and their spouses. The children also determine their market work time, but the parents no longer participate in the labor market. For the parents, t_{p0m} is care provided for the father by the mother, and t_{m0p} is the care provided for the mother by the father. At least one of t_{m0p} and t_{p0m} is zero, and, if there is only one parent, both are zero. Finally, parents don't care for themselves, hence t_{m0m} and t_{p0p} are both zero. Market work time is $1 - L_{ik} - \sum_{j \in m,p} t_{jik}$ for the children and their spouses and zero for parents.

A health production function,

$$
\begin{aligned}
Q_m &= a_{0p}\alpha_{m0p}\left(t_{m0p} + \gamma t_{m0p}^2\right) + \sum_{i=1}^{I}\sum_{k \in c,s} a_{ik}\alpha_{mik}\left(t_{mik} + \gamma t_{mik}^2\right) \quad (1) \\
&\quad + \mu \sum_{i=0}^{I} H_i + Z_m, \\
\\
Q_p &= a_{0m}\alpha_{p0m}\left(t_{p0m} + \gamma t_{p0m}^2\right) + \sum_{i=1}^{I}\sum_{k \in c,s} a_{ik}\alpha_{pik}\left(t_{pik} + \gamma t_{pik}^2\right) \\
&\quad + \mu \sum_{i=0}^{I} H_i + Z_p,
\end{aligned}
$$

determines the health quality of each parent where Z_j is a linear combination of parent j's characteristics. The parameters α_{jik}, γ, and μ measure the effects of care provided by family members (informal care) and paid care (formal care) on health quality. The α_{jik} coefficients may depend on observed parent and child characteristics.

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[2]For now, we supress a family index n that will appear in the Estimation Section.

The parents' utility function[3] takes the form

$$
\begin{aligned}
U_0 &= \beta_0 + \beta_{10} \sum_{j \in m,p} a_{0j} \ln Q_j + \beta_{20} \varepsilon_{X0} \ln X_0 + \sum_{k \in m,p} a_{0k} \beta_{30k} \varepsilon_{L0k} \ln L_{0k} \quad (2) \\
&\quad + \sum_{\substack{j,k \in m,p \\ j \neq k}} a_{0k} a_{0j} \left(\beta_{40jk+} \varepsilon_{t0jk} \right) t_{0jk} + \varepsilon_{u0}
\end{aligned}
$$

Similarly, child i's utility function takes the form[4]

$$
\begin{aligned}
U_i &= \beta_0 + \beta_{1i} \sum_{j \in m,p} a_{0j} \ln Q_j + \beta_{2i} \varepsilon_{Xi} \ln X_i + \sum_{k \in c,s} a_{ik} \beta_{3ik} \varepsilon_{Lik} \ln L_{ik} \quad (3) \\
&\quad + \sum_{k \in c,s} \sum_{j \in m,p} a_{ik} a_{0j} \left(\beta_{4jik} + \varepsilon_{tjik} \right) t_{jik} + \varepsilon_{ui}.
\end{aligned}
$$

The coefficients β_0, β_{1i}, β_{2i}, β_{3ik}, and β_{4jik} for $i = 0, 1, 2, .., I$ may depend on observed child and parent characteristics, and the errors ε_{Xi}, ε_{Lik}, and ε_{tjik} are functions of unobserved (to the econometrician) child and parent characteristics. Each family member's utility depends positively on the parents' health as well as the family member's consumption and leisure. Thus, $\beta_{1i} \geq 0$, $\beta_{2i} \geq 0$, $\beta_{3ik} \geq 0$, $\varepsilon_{Xi} \geq 0$, and $\varepsilon_{Lik} \geq 0$ for $i = 0, 1, 2, .., I$. Each player maximizes U_i over its choices subject to budget and time constraints taking as given the decisions of the other family members. Children and their spouses face budget constraints of the form:

$$
\max \left[Y_i^*, Y_i^{**} \right] \geq p_{Xi} X_i + q H_i \quad (4)
$$

where p_{Xi} is the price of the consumption good, q is the price of a unit of paid care assistance purchased in the parents' state of residence,

$$
Y_i^* = \sum_{k \in c,s} a_{ik} w_{ik} \left(1 - L_{ik} - \sum_{j \in m,p} t_{jik} \right) \quad (5)
$$

is labor income,

$$
Y_i^{**} = Y_i + s Y_i^* \quad (6)
$$

is income net of a hypothetical negative income tax $(0 < s < 1)$, and w_{ik} is the market wage. Y_i is outside income including government welfare payments,

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[3]In the estimation section, we will have occasion to define the utility function of each parent. We define the utility of parent j as

$$
U_{0j} = \beta_{0j} + \beta_{10} \ln Q_j + \beta_{20} \varepsilon_{X0} \zeta \ln X_0 + \beta_{30j} \varepsilon_{L0j} \ln L_{0j} + \left(\beta_{40jk+} \varepsilon_{t0jk} \right) t_{0jk} + \varepsilon_{u0j}
$$

where $k = f$ if $j = m$ and $k = m$ if $j = f$ and $\zeta = .5$ if k is alive and $\zeta = 1$ if k is not alive.

[4]The model in Bernheim, Schleifer, and Summers (1985) would imply that the utility child i receives from providing informal care depends on the amount of care provided by siblings. McGarry (1999) and Checkovich and Stern (2002) reject the implication of Bernheim, Schleifer, and Summers (1985).

and the time constraint is implied by the definition of market work time. We use the structure in equations (4), (5), and (6) because there are some children with $Y_i^* = 0$. The utility function in equation (3) implies that consumption is always positive, so we need to force children's income to be positive. We use the negative income tax structure implied by equation (6) as a crude approximation of reality. We estimate Y_i and s using CPS data and allow it to vary across states.

For the parent, the budget constraint is

$$Y_0 \geq p_{X0}X_0 + qH_0 \tag{7}$$

if she is not eligible for Medicaid reimbursement of home health care expenses. If she is eligible, the budget constraint is

$$\Psi + q\min\left(\overline{H}, H_0\right) \geq p_{X0}X_0 + qH_0$$

where Ψ is the income limit and $q\overline{H}$ is the maximum reimbursable amount for home health care expenses. As discussed in Section 1, eligibility requirements and maximum reimbursable amounts vary across states. Since we know the parent's state of residence, we use the relevant policy variables in determining her budget constraint. This potentially allows us to be more precise (relative to studies using aggregate state data) about the effects of changes in Medicaid policy on families, since the impact may differ vastly by state.

The parents' time constraints are

$$1 \geq L_{0k} + t_{j0k}, \quad j, k = m, p; \quad j \neq k$$

where L_{0k} is the leisure time of parent k. This implies that $t_{j0k} = 1 - L_{0k}$ for $j, k = m, p$ and $j \neq k$. The standard nonnegativity constraints also apply: $t_{jik} \geq 0$ and $L_{0k} \geq 0$ for $k = m, p$, and $L_{ik} \geq 0$, $H_i \geq 0$, and $X_i \geq 0$ for $k = c, s$ and $i = 1, 2, .., I$.

4.2 Family Equilibrium and First Order Conditions

The outcome of the game is a Nash equilibrium. The errors are functions of characteristics unobservable by the econometrician. For each child, we can solve for X_i using equation (4) to obtain

$$X_i = \frac{\max\left[Y_i^*, Y_i^{**}\right] - qH_i}{p_{Xi}}. \tag{8}$$

For the parent, using equation (7), we obtain

$$X_0 = \frac{Y_0 - qH_0}{p_{X0}}.$$

The model accommodates the possibility that family members do not contribute financial resources or time for caregiving. Thus, for each child, the set

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of first order conditions (FOCs) for H_i is

$$\frac{\partial U_i}{\partial H_i} \leq 0, \quad H_i \geq 0, \quad \frac{\partial U_i}{\partial H_i} H_i = 0.$$

If the child provides no financial assistance ($\frac{\partial U_i}{\partial H_i} < 0$), then the FOC is

$$\varepsilon_{Xi} \geq \frac{\beta_{1i} \mu p_{Xi} X_i \overline{Q}}{\beta_{2i} q} \tag{9}$$

where

$$\overline{Q} = \sum_{j=m,f} \frac{a_{0j}}{Q_j}.$$

If the child does provide financial assistance ($H_i > 0$), then the FOC is

$$\varepsilon_{Xi} = \frac{\beta_{1i} \mu p_{Xi} X_i \overline{Q}}{\beta_{2i} q}. \tag{10}$$

The FOCs for t_{jik} depend on H_i. If $H_i > 0$, then the FOCs for t_{jik} can be written as

$$\varepsilon_{tjik} = \beta_{1i} \left[\frac{\mu s_i^* w_{ik} \overline{Q}}{q} - \frac{\alpha_{jik}}{Q_j} \left(1 + 2\gamma t_{jik}\right) \right] - \beta_{4jik} \tag{11}$$

where

$$s_i^* = \left\{ \begin{array}{ll} 1 & \text{if } Y_i^* > Y_i^{**} \\ s & \text{if } Y_i^* = Y_i^{**} \end{array} \right.$$

if $t_{jik} > 0$, and as

$$\varepsilon_{tjik} \leq \beta_{1i} \left[\frac{\mu s_i^* w_{ik} \overline{Q}}{q} - \frac{\alpha_{jik}}{Q_j} \right] - \beta_{4jik}$$

if $t_{jik} = 0$. If $H_i = 0$, then the FOCs for t_i can be written as

$$\varepsilon_{tjik} = \frac{\beta_{2i} \varepsilon_{Xi} s_i^* w_{ik}}{p_{Xi} X_i} - \frac{\beta_{1i}}{Q_j} \alpha_{jik} \left(1 + 2\gamma t_{jik}\right) - \beta_{4jik} \tag{12}$$

if $t_{jik} > 0$, and as

$$\varepsilon_{tjik} \leq \frac{\beta_{2i} \varepsilon_{Xi} s_i^* w_{ik}}{p_{Xi} X_i} - \frac{\beta_{1i}}{Q_j} \alpha_{jik} - \beta_{4jik} \tag{13}$$

if $t_{jik} = 0$.

The FOCs for L_{ik} also depend on H_i. If $H_i > 0$, then the FOCs for L_{ik} can be written as

$$\varepsilon_{Lik} = \frac{\beta_{1i} s_i^* w_{ik} L_{ik} \mu \overline{Q}}{\beta_{3ik} q} \tag{14}$$

if $L_{ik} < 1$, and as

$$\varepsilon_{Lik} \geq \frac{\beta_{1i} s_i^* w_{ik} L_{ik} \mu \overline{Q}}{\beta_{3ik} q} \tag{15}$$

if $L_{ik} = 1$. Note that, given the specification of the utility function in equation (3), $L_{ik} > 0$. If $H_i = 0$, then the FOCs for L_{ik} can be written as

$$\varepsilon_{Lik} = \frac{\beta_{2i} \varepsilon_{Xi} s_i^* w_{ik} L_{ik}}{\beta_{3ik} p_{Xi} X_i} \tag{16}$$

if $L_{ik} < 1$, and as

$$\varepsilon_{Lik} \geq \frac{\beta_{2i} \varepsilon_{Xi} s_i^* w_{ik} L_{ik}}{\beta_{3ik} p_{Xi} X_i} \tag{17}$$

if $L_{ik} = 1$.

For interior solutions, we can summarize the FOCs as equations (10), (11), and (14), and, for the general case, they are all of the equations between equation (9) and (16).

For the parent, the FOC for H_0 is the same as the FOC for H_i:

$$\varepsilon_{X0} \geq \frac{\beta_{10} \mu p_{X0} X_0 \overline{Q}}{\beta_{20} q}$$

if $H_0 = 0$, and

$$\varepsilon_{X0} = \frac{\beta_{10} \mu p_{X0} X_0 \overline{Q}}{\beta_{20} q} \tag{18}$$

if $H_0 > 0$. The FOC for t_{j0k}, for $j \neq k$, can be written as

$$\varepsilon_{tj0k} \leq -\frac{\beta_{10}}{Q_j} \alpha_{j0k} + \frac{\beta_{30k} \varepsilon_{L0k}}{L_{0k}} - \beta_{4j0k}$$

if $t_{j0k} = 0$, and as

$$\varepsilon_{tj0k} = -\frac{\beta_{10}}{Q_j} \alpha_{j0k} (1 + 2\gamma t_{j0k}) + \frac{\beta_{30k} \varepsilon_{L0k}}{L_{0k}} - \beta_{4j0k} \tag{19}$$

if $t_{j0k} > 0$. Note that ε_{L0k} is an unnecessary error (in the sense that there is enough random variation to explain any observed event).

Define the set of first order conditions corresponding to interior solutions as

$$\varepsilon = \varphi(\xi) \tag{20}$$

where ε is the vector or errors, ξ is the vector of interior endogenous variables, and $\varphi(\cdot)$ is the vector of functions implied by the interior first order conditions in equations (10), (11), (12), (14), (16), (18), and (19). We can use these first order conditions to construct a likelihood contribution for each family.[5]

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[5] Aguirregabiria and Mira (2001) use a similar approach in another context.

4.3 Nonlinear Budget Set Issues

Equations (4) through (6) imply a kink in the children's budget constraints where $Y^* = Y^{**}$. One might think that this causes an endogeneity problem in the spirit of, for example, Hausman (1985). In particular, the error vector ε that solves the first order conditions depends on observed endogenous choices. Essentially, the inclusion of the Jacobian in the likelihood function below controls for this endogeneity because it corrects for the translation of reduced form equations into structural equations. Nevertheless consider two interesting cases in more detail. First consider a case such as that illustrated in Figure 1. Consider a child who chooses to be at point A. Our model would find an error vector ε consistent with point A. However, any point between B and C would be preferable. In fact, in a situation like that depicted in Figure 1, there would be no value of ε consistent with both point A and being at a global optimum because the solution to the first order conditions is unique. We need to be able to rule out such events.

We also have children at corner solutions. For these children there must be no value of the errors satisfying the inequalities in the relevant first order conditions that cause the child to move to a different segment of the budget line. The leading case for such a problem is a child providing no financial help for formal care. This implies that ε_{Xi} must be greater than the right hand side of equation (9). One might worry that, for large enough ε_{Xi}, the value of consumption would increase, possibly causing the child to move from a budget segment with low hours of work to one with high hours of work. However, as ε_{Xi} increases, ε_{Li} can increase to keep the child (and her spouse) on the observed budget segment.

We used the estimated parameter vector (discussed later in Table 7) to measure the empirical importance of either problem. For each child in each family at an interior solution, we computed the value of ε consistent with the observed choice. For each child in each family at a corner solution, we simulated 10 values of ε consistent with the observed choice. Conditional on ε, we allowed the child to optimize over all of her choice variables. We counted the number of times that the child chose something other than the observed choice. Over the 335,700 choices made, there were no deviations between observed choices and optimal choices conditional on ε. Thus, while there may be a theoretical problem caused by kinked budget sets, it is not an important problem empirically.

5 Data

For our empirical work, we use the 1993 wave of the Asset and Health Dynamics Among the Oldest Old (AHEAD) data set. AHEAD is a nationally representative longitudinal data set designed to facilitate study of Americans aged 70 or older. The emphasis on the joint dynamics of health, family characteristics, income, and wealth makes it a particularly rich source of information on fam-

ily decisions regarding the care of elderly relatives. The 1993 wave of AHEAD contains only noninstitutionalized individuals. While it is desirable to have data which include nursing home residents, the primary focus of our research is on the provision of informal home health care and formal home health care. Hence, the issues we wish to address are not greatly impacted by the exclusion of nursing home residents. The AHEAD response rate is over 80%. Although AHEAD oversamples blacks, Hispanics, and Florida residents, this oversampling causes no estimation bias because our analysis treats race and residential location as exogenous.

We use 3,583 of the 6,047 households in the first wave of the survey. As shown in Table 1, we excluded households for a variety of reasons. In most cases (1,116), records were missing data on the respondent, the respondent's spouse, or the respondent's children. Households with working respondents (270) or two respondents each of whom helped the other (25) were dropped to reduce the complexity of the model. Only the black and white non-Hispanic groups remained large enough for our analysis.

Households included in AHEAD contain at least one respondent 70 years old or older. Many households also include spouses, some of whom are less then 70 years old. Spouses of respondents are also respondents. As a consequence of the exclusion of nursing home residents from the 1993 wave and the inclusion of spouses regardless of age, the characteristics of our sample deviate from those of a representative individual who is 70 years old or older. The characteristics of the respondents in the our sample are shown in Table 2. On average, the male respondents (37% of the sample) are 76.7 years old with 11.7 years of education and 2.1 living children. Seventy-two percent are married, and 93% are white. On average, the female respondents are 76.3 years old with 11.8 years of education and 2.0 living children. Forty-two percent are married, and 90% are white.

Nineteen percent of men and 24% of women reported difficulty with an activity of daily living (ADL). The most common difficulty was walking across a room, reported by 15% of male respondents and 18% of female respondents. All other ADLs had prevalence rates of less than 10%. Twenty-two percent of men and 21% of women reported difficulty with an instrumental activity of daily living, most frequently difficulty with walking several blocks, pulling and lifting heavy objects, climbing stairs, or driving. Among the 65% of households reporting receipt of paid help in their home, the average payment was $31 per week, and the maximum was $570 per week. In the empirical work, contributions for home health care are measured in hours; the payment per week is divided by the cost per hour. The fraction of households reporting (paid or unpaid) help with an ADL or IADL in our sample is 43%. Of those households, 9.3% paid for help in the month prior to the interview. The average amount paid per household per week among those paying for help is $126.

The survey asks each parent whether or not she is happy. Eighty-seven percent of parents reported being "happy." We use the responses to this question to help identify some of the parameters in our structural model.

Our measure of parental income includes income from major government

transfer programs (e.g., Social Security, SSI, Food Stamps) and other nonwage income such as veteran's benefits, retirement income, annuities, IRA distributions and income from stocks and bonds. A small number of respondents report positive wage earnings which we ignore so that we can ignore the labor force decision of the respondent. The average income of parent households in our sample is $445 per week. Most respondents were covered by Medicare and received assistance from the Supplemental Security Income program. Because the data do not include residents of nursing homes, few respondents reported eligibility for Medicaid.

Table 3 contains information on the children of the respondents. Forty-nine percent of the children are male, and 69.8% are married. The average child is 47.0 years old with 14.0 years of education and 1.99 children. To model the decision-making process of the adult children of the elderly individuals, we need information on the market wages of the children, which is not part of the AHEAD survey. We impute wages using the Current Population Survey by regressing log-wages on demographic characteristics of the children available in AHEAD. Our estimates are reported in Table 4. The average imputed wage is $452 per week. We also construct a measure of the leisure time consumed by the children and the respondents by treating time not spent working or caring for the parents as leisure.[6]

Respondents and their children have a variety of living arrangements. Fifty-five percent of respondents are married or living with an unmarried partner. Twenty-three percent of respondent households have additional members, and 77% of those are their children. However, almost all children (94%) live outside the respondent's household, and 66% of these live more than 10 miles away. Note that in the first wave of the AHEAD data set, no respondents lived in a nursing home or other institutional setting by construction. Table 5 shows the raw correlations associated with caregiving in the sample. Children providing no care is the modal response, and multiple children providing care occurs somewhat infrequently. When a spouse is present, the spouse is likely to provide care and children are much less likely to provide care. A significant number of households use formal care, but, most of the time, children to not contribute financially for its provision.

Finally, we construct a number of state-specific variables including a price level (BEA, 1999), the cost of home health care[7], and the average home health care state subsidy (HCFA, 1992).

---

[6]We also observe whether the child lives with the parent, lives within ten miles of the parent, or lives further than 10 miles from the parent. However, work such as Stern (1995) shows that the effect of distance is really at greater distances. So we do not use distance as a child characteristic.

[7]We used wages for home health aide workers as reported by the Census of Population and Housing, Earnings by Occupation and Education. These can be found at http://govinfo.kerr.orst.edu/earn-stateis.html.

6 Estimation Strategy

6.1 Empirical Specification

In order to complete the specification of the model, we need to specify the variation of "parameters" across individuals within a family and the joint density of the errors. First, assume that α_{jik} in equation (1) is a function of parent and child characteristics,

$$\alpha_{jik} = \begin{cases} \exp\left\{W_j^0 \delta_\alpha^* + W_k^0 \delta_\alpha^{**}\right\} & \text{if } i = 0 \\ \exp\left\{W_j^0 \delta_\alpha^* + W_{ik} \delta_\alpha^{***}\right\} & \text{if } i > 0 \end{cases} \qquad (21)$$

where W_j^0 is a vector of parent-j ($j = m, p$) characteristics, W_k^0 is a vector of characteristics of the spouse (i.e., $k \neq j$), and W_{ik} is a vector of child characteristics for child i ($k = c$) and her spouse ($k = s$). Also, assume that $\log \mu$ is a constant, and Z_j in equation (1) are functions of parent characteristics,

$$Z_j = \exp\left\{W_j^0 \delta_z\right\}. \qquad (22)$$

Next, assume that, in equations (2) and (3), $\log \beta_{10}$, $\log \beta_{20}$, and β_{30k} are constant across families (with $\beta_{30k} = 0$), $\log \beta_{1i}$ ($= \log \beta_{11}$), $\log \beta_{2i}$ ($= \log \beta_{21}$), and $\log \beta_{3ik}$ ($= \log \beta_{31}$) for $i > 0$ are constant across families and children within each family, and

$$\beta_{4jik} = \begin{cases} W_{jk}^0 \delta_{\beta4}^* + W_k^0 \delta_{\beta4}^{**} & \text{if } i = 0 \\ W_{jik} \delta_{\beta4}^{***} + W_{ik} \delta_{\beta4}^{****} & \text{if } i > 0 \end{cases}.$$

Note that:

a) β_{30k} and β_{4j0k} can not be identified separately (except maybe by functional form) because the parents' leisure time is determined jointly with their caregiving time. Thus, we set $\beta_{30k} = 0$ with no loss in generality.

b) Increasing the coefficients on the constant term in all β terms has no effect on the first order conditions. Thus, we set $\beta_{2ik} = 1$.

For the joint density of the errors, we assume

$$\begin{aligned} \varepsilon_{Xi} &= \exp\left\{\eta_{Xi}\right\}, & (23) \\ \eta_{Xi} &\sim iidN\left(0, \sigma_{\eta X}^2\right), \\ \varepsilon_{Lik} &= \exp\left\{\eta_{Lik}\right\}, \\ \begin{pmatrix} \eta_{Lic} \\ \eta_{Lis} \end{pmatrix} &\sim iidN\left(0, \sigma_{\eta L}^2 \begin{pmatrix} 1 & \rho_L \\ \rho_L & 1 \end{pmatrix}\right), \\ \begin{pmatrix} \varepsilon_{tjic} \\ \varepsilon_{tjis} \end{pmatrix} &\sim iidN\left(0, \sigma_{\eta t}^2 \begin{pmatrix} 1 & \rho_t \\ \rho_t & 1 \end{pmatrix}\right), \\ \varepsilon_{tj0k} &\sim iidN\left(0, \sigma_{\eta t}^2\right) \text{ for } j \neq k = m, p, \\ \varepsilon_{ui} &\sim iidN\left(0, \sigma_u^2\right). \end{aligned}$$

As discussed previously, in order to estimate the effects of the explanatory variables, we must restrict the effects of many parameters. In order to determine which parameters to restrict, we considered the results of preliminary

data analysis as well as economic intuition. In general, we would restrict a parameter using economic reasoning if it could be argued that, after controlling for the relevant actions, the characteristic would not be expected to influence the health production function or utility function in the manner indicated by the parameter. For example, we would not expect the education of the child to affect how much the child enjoys caring for her parent, after controlling for the amount of care provided; therefore we restrict the child education characteristic corresponding to the parameter $\delta_{\beta 4}^{****}$. In contrast, the number of ADL problems experienced by the parents probably influences the parent's utility associated with caregiving; thus we do not restrict the number of ADLs characteristic corresponding to the parameter $\delta_{\beta 4}^{*}$. We cannot identify the constant terms in δ_{α}^{*} separately from δ_{α}^{**} or δ_{α}^{***}; hence, we restrict the constant terms for δ_{α}^{**} and δ_{α}^{***}.

6.2 The Likelihood Function

The set of parameters to estimate is

$$
\begin{aligned}
\theta \quad = \quad & (\delta_{\alpha}, \log \mu, \delta_z, \beta_0, \log \beta_{10}, \ \log \beta_{20}, \log \beta_{11}, \log \beta_{21}, \log \beta_{31}, \delta_{\beta 4}, \quad (24) \\
& \gamma, \sigma_{\eta X}^2, \sigma_{\eta L}^2, \sigma_{\eta t}^2, \sigma_u^2, \rho_\eta, \rho_t) \, ,
\end{aligned}
$$

and the set of data for observation $n = 1, 2, .., N$ is

$$
\left\{ [t_{mik}, t_{pik}, L_{ik}, w_{ik}, W_i, a_{ik}]_{k \in c, s}, \widetilde{H}_i, Y_i, p_{Xi} \right\}_{i=1}^{I_n}
$$

and

$$
\left\{ t_{m0f}, t_{p0m}, \widetilde{H}_0, \overline{H}, u_0, Y_0, p_{X0}, q, W_m^0, W_p^0, a_{0f}, a_{0m} \right\} .
$$

The variable t_{jik} is time spent caring for parent j by family member ik. Its construction is discussed in Appendix 1. The variable $\widetilde{H}_i = 1$ iff player i paid for care:[8]

$$
\widetilde{H}_i = 1 \left(H_i > 0 \right) .
$$

The variable $\overline{H}$ is the total amount of paid care:[9]

$$
\overline{H} = \sum_{i=0}^{I_n} H_i .
$$

The variable

$$
L_{ik} = 1 - \sum_{j \in m, p} t_{jik} - PT_{ik} \frac{20}{168} - FT_{ik} \frac{40}{168}
$$

---

[8] The data do not provide enough information to actually determine if $\widetilde{H}_0 = 1$. We assume that, if paid care is provided, then some of it is paid for by the parents causing $\widetilde{H}_0 = 1$.

[9] It is assumed that both parents, if alive, take advantage of paid care; i.e. that is a public good for the parents' household.

is leisure for family member ik where $PT_{ik} = 1$ iff child i (or child i's spouse) works part-time and $FT_{ik} = 1$ iff child i (or child i's spouse) works full-time. The variable w_{ik} is child i's (or child i's spouse) weekly wage. We estimate w_{ik} as a function of the observed characteristics of the child (or spouse) using a different data set. The variable Y_i is a measure of nonlabor income for player i. For the parent, Y_0 is observed. We assume that $Y_i = 0$ for $i > 0$. The variable p_{Xi} is the local price level for player i, and q is the price of care in the parents' state. The variable u_0 is the answer to the question about whether the parent considers herself happy and is treated as a discrete measure of U_0. W_{ik} are exogenous characteristics for child i (or spouse), and W_m^0 and W_p^0 are exogenous parent characteristics. Define

$$\zeta_i = \log\left(\frac{\beta_{1i}\mu p_{Xi} X_i \overline{Q}}{\beta_{2i} q}\right). \tag{25}$$

Also, define

$$
t_{ji} = \begin{cases} t_{jik} & \text{if } a_{ik} = 1,\ a_{il} = 0 \text{ for } l = c, s,\ l \neq k \\ (t_{jic}, t_{jis})' & \text{if } a_{ic} = a_{is} = 1 \end{cases},
$$

$$
L_i = \begin{cases} L_{ik} & \text{if } a_{ik} = 1,\ a_{il} = 0 \text{ for } l = c, s,\ l \neq k \\ (L_{ic}, L_{is})' & \text{if } a_{ic} = a_{is} = 1 \end{cases}
$$

for $i > 0$.

The likelihood contribution for family n, $\mathcal{L}_n$, is a product of conditional probabilities over different events (such as whether or not the child contributes time or financial resources to care for the parent). Its structure varies with characteristics of the family's choices. Below we consider two possible cases: Case 1, $H_0 = 0$:

$$
\begin{aligned}
\mathcal{L}_n &= \left\{ \Pr\left[\widetilde{H_0} = 0\right] \Pr\left[u_0 \mid \widetilde{H_0}, t_0\right] \prod_{\substack{j \in m,p \\ k \neq j}} \Pr\left[t_{j0k}\right]^{a_{0k} a_{0j}} \right\} \bullet \tag{26} \\
&\quad \prod_{i > 0 : \widetilde{H}_i = 0} \left\{ \int_{\eta_{Xi} \geq \zeta_i} |J_n(\eta_{Xi})| \prod_{j \in m,p} \Pr\left[t_{ji} \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right]^{a_{0j}} \bullet \right. \\
&\quad \left. \Pr\left[L_i \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right] \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{Xi}}{\sigma_{\eta X}}\right] d\eta_{Xi} \right\} \bullet \\
&\quad \prod_{i : \widetilde{H}_i = 1} \prod_{j \in m,p} \left\{ \Pr\left[t_{ji} \mid \widetilde{H}_i = 1\right]^{a_{0j}} \Pr\left[L_i \mid \widetilde{H}_i = 1\right] \right\} \bullet \\
&\quad \iiint_{\substack{\eta_{Xi} \leq \zeta_i \\ i : \widetilde{H}_i = 1}} 1\left(\sum_{i : \widetilde{H}_i = 1} H_i(\eta_{Xi}) = \overline{H}\right) \left(\prod_{i : \widetilde{H}_i = 1} \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{Xi}}{\sigma_{\eta X}}\right] d\eta_{Xi}\right)
\end{aligned}
$$

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where

$$H_i\left(\eta_{Xi}\right) = \frac{Y_i + w_i\left(1 - L_i - \sum_{j\in m,p} t_{ji}\right) - \frac{\beta_{2i}q}{\beta_{1i}\mu\overline{Q}}\exp\left\{\eta_{Xi}\right\}}{q} \tag{27}$$

is derived from equations (8) and (10) for the parent,

$$\Pr\left[\widetilde{H_0} = 0\right] = \Phi\left[\frac{-\log\left(\frac{\beta_{10}\mu p_{X_0} X_0 \overline{Q}}{\beta_{20} q}\right)}{\sigma_{\eta X}}\right], \tag{28}$$

$$\Pr\left[u_0 \mid \widetilde{H_0}, t_0\right] = \int\cdots\int \Pr\left[u_0 \mid \eta_{X0}, \eta_{t0}\right] f\left[\eta_{X0}, \eta_{t0} \mid \widetilde{H_0}, t_0\right] d\eta_{X0} d\eta_{t0},$$

$$\Pr\left[u_0 \mid \eta_{X0}, \eta_{t0}\right] = \begin{cases} \Phi\left[\widetilde{U}_0\left(\varepsilon_{X0}, \varepsilon_{t0}\right)\right] & \text{if } u_0 = 1 \\ 1 - \Phi\left[\widetilde{U}_0\left(\varepsilon_{X0}, \varepsilon_{t0}\right)\right] & \text{if } u_0 = 0 \end{cases},$$

$$\widetilde{U}_0\left(\varepsilon_{X0}, \varepsilon_{t0}\right) = \beta_0 + \beta_{10}\sum_{j\in m,p}\ln Q_j + \beta_{20}\varepsilon_{X0}\ln X_0$$
$$+ \sum_{k\in m,p}\beta_{30k}\ln L_{0k} + \sum_{\substack{j,k\in m,p \\ j\neq k}}\left(\beta_{4j0k} + \varepsilon_{tj0k}\right)t_{j0k},$$

$$\Pr\left[t_{j0k}\right] = \begin{cases} \Phi\left[\dfrac{-\frac{\beta_{10}}{Q_j}\alpha_{j0k} + \frac{\beta_{30k}}{L_{0k}} - \beta_{4j0k}}{\sigma_{\eta t}}\right] & \text{if } t_{j0k} = 0 \\ \dfrac{1}{\sigma_{\eta t}}\phi\left[\dfrac{-\frac{\beta_{10}}{Q_j}\alpha_{j0k}(1+2\gamma t_{j0k}) + \frac{\beta_{30k}}{L_{0k}} - \beta_{4j0k}}{\sigma_{\eta t}}\right] & \text{if } t_{j0k} > 0 \end{cases},$$

and, for each child i, if $a_{ik} = 1$, $a_{il} = 0$ for $k, l = c, s; k \neq l$,

$$\Pr\left[t_{jik} \mid \widetilde{H_i} = 0, \varepsilon_{Xi}\right] = \begin{cases} \Phi\left[\dfrac{\frac{\beta_{2i}\varepsilon_{Xi}s_i^* w_{ik}}{p_{Xi}X_i} - \frac{\beta_{1i}\alpha_{jik}}{Q_j} - \beta_{4jik}}{\sigma_{\eta t}}\right] & \text{if } t_{jik} = 0 \\ \dfrac{1}{\sigma_{\eta t}}\phi\left[\dfrac{\frac{\beta_{2i}\varepsilon_{Xi}s_i^* w_{ik}}{p_{Xi}X_i} - \frac{\beta_{1i}\alpha_{jik}}{Q_j}(1+2\gamma t_{jik}) - \beta_{4jik}}{\sigma_{\eta t}}\right] & \text{if } t_{jik} > 0 \end{cases} \tag{29}$$

$$\Pr\left[t_{jik} \mid \widetilde{H_i} = 1\right] = \begin{cases} \Phi\left[\dfrac{\beta_{1i}\left[\frac{\mu s_i^* w_{ik}\overline{Q}}{q} - \frac{\alpha_{ijk}}{Q_j}\right] - \beta_{4jik}}{\sigma_{\eta t}}\right] & \text{if } t_{jik} = 0 \\ \dfrac{1}{\sigma_{\eta t}}\phi\left[\dfrac{\beta_{1i}\left[\frac{\mu s_i^* w_{ik}\overline{Q}}{q} - \frac{\alpha_{jik}}{Q_j}(1+2\gamma t_{jik})\right] - \beta_{4jik}}{\sigma_{\eta t}}\right] & \text{if } t_{jik} > 0 \end{cases},$$

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$$\Pr\left[L_i \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right] = \begin{cases} \dfrac{1}{\sigma_{\eta L}} \phi \left[\dfrac{\log\left(\frac{\beta_{2i}\varepsilon_{Xi}s_i^* w_{ik} L_{ik}}{\beta_{3ik}p_{Xi}X_i}\right)}{\sigma_{\eta L}} \right] & \text{if } L_{ik} < 1 \\[4ex] \Phi \left[\dfrac{-\log\left(\frac{\beta_{2i}\varepsilon_{Xi}s_i^* w_{ik} L_{ik}}{\beta_{3ik}p_{Xi}X_i}\right)}{\sigma_{\eta L}} \right] & \text{if } L_{ik} = 1 \end{cases} \text{, and}$$

$$\Pr\left[L_i \mid \widetilde{H}_i = 1\right] = \begin{cases} \dfrac{1}{\sigma_{\eta L}} \phi \left[\dfrac{\log\left(\frac{\beta_{1i}\mu s_i^* w_{ik} L_{ik}\overline{Q}}{\beta_{3i}q}\right)}{\sigma_{\eta L}} \right] & \text{if } L_{ik} < 1 \\[4ex] \Phi \left[\dfrac{-\log\left(\frac{\beta_{1i}\mu s_i^* w_{ik} L_{ik}\overline{Q}}{\beta_{3i}q}\right)}{\sigma_{\eta L}} \right] & \text{if } L_{ik} = 1 \end{cases} \text{,}$$

and, if $a_{ic} = a_{is} = 1$,

$$\Pr\left[t_{ji} \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right] = \begin{cases} B\left[\tau_{t00c}, \tau_{t00s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} = t_{jis} = 0 \\ B_1\left[\tau_{t01c}, \tau_{t00s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} > 0, t_{jis} = 0 \\ B_2\left[\tau_{t00c}, \tau_{t01s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} = 0, t_{jis} > 0 \\ B_{12}\left[\tau_{t01c}, \tau_{t01s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} > 0, t_{jis} > 0 \end{cases} \tag{30}$$

$$\tau_{t00k} = \frac{\frac{\beta_{2i}\varepsilon_{Xi}s_i^* w_{ik}}{p_{Xi}X_i} - \frac{\beta_{1i}\alpha_{jik}}{Q_j} - \beta_{4jik}}{\sigma_{\eta t}}, \ k \in c, s,$$

$$\tau_{t01k} = \frac{\frac{\beta_{2i}\varepsilon_{Xi}s_i^* w_{ik}}{p_{Xi}X_i} - \frac{\beta_{1i}}{Q_j}\alpha_{jik}\left(1 + 2\gamma t_{jik}\right) - \beta_{4jik}}{\sigma_{\eta t}}, \ k \in c, s,$$

$$\Pr\left[t_{ji} \mid \widetilde{H}_i = 1\right] = \begin{cases} B\left[\tau_{t10c}, \tau_{t10s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} = t_{jis} = 0 \\ B_1\left[\tau_{t11c}, \tau_{t10s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} > 0, t_{jis} = 0 \\ B_2\left[\tau_{t10c}, \tau_{t11s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} = 0, t_{jis} > 0 \\ B_{12}\left[\tau_{t11c}, \tau_{t11s}; \rho_t, \sigma_{\eta t}\right] & \text{if } t_{jic} > 0, t_{jis} > 0 \end{cases} \text{,}$$

$$\tau_{t10k} = \frac{\beta_{1i}\left[\frac{\mu s_i^* w_{ik}\overline{Q}}{q} - \frac{\alpha_{jik}}{Q_j}\right] - \beta_{4jik}}{\sigma_{\eta t}}, \ k \in c, s,$$

$$\tau_{t11k} = \frac{\beta_{1i}\left[\frac{\mu s_i^* w_{ik}\overline{Q}}{q} - \frac{\alpha_{jik}}{Q_j}\left(1 + 2\gamma t_{jik}\right)\right] - \beta_{4jik}}{\sigma_{\eta t}}, \ k \in c, s,$$

$$\Pr\left[L_i \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right] = \begin{cases} B_{12}\left[\xi_{0ic}, \xi_{0is}; \rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} < 1, L_{is} < 1 \\ B_1\left[\xi_{0ic}, -\xi_{0is}; -\rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} < 1, L_{is} = 1 \\ B_2\left[-\xi_{0ic}, \xi_{0is}; -\rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} = 1, L_{is} < 1 \\ B\left[-\xi_{0ic}, -\xi_{0is}; \rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} = 1, L_{is} = 1 \end{cases},$$

$$\xi_{0ic} = \frac{\log\left(\frac{\beta_{2i}\varepsilon_{Xi}w_{ic}L_{ic}}{\beta_{3ic}p_{Xi}X_i}\right)}{\sigma_{\eta L}}, \xi_{0is} = \frac{\log\left(\frac{\beta_{2i}\varepsilon_{Xi}w_{is}L_{is}}{\beta_{3is}p_{Xi}X_i}\right)}{\sigma_{\eta L}},$$

$$\Pr\left[L_i \mid \widetilde{H}_i = 1\right] = \begin{cases} B_{12}\left[\xi_{1ic}, \xi_{1is}; \rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} < 1, L_{is} < 1 \\ B_1\left[\xi_{1ic}, -\xi_{1is}; -\rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} < 1, L_{is} = 1 \\ B_2\left[-\xi_{1ic}, \xi_{1is}; -\rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} = 1, L_{is} < 1 \\ B\left[-\xi_{1ic}, -\xi_{1is}; \rho_L, \sigma_{\eta L}\right] & \text{if } L_{ic} = 1, L_{is} = 1 \end{cases},$$

$$\xi_{1ic} = \frac{\log\left(\frac{\beta_{1i}\mu w_{ic}L_{ic}\overline{Q}}{\beta_{3ic}q}\right)}{\sigma_{\eta L}}, \xi_{1is} = \frac{\log\left(\frac{\beta_{1i}\mu w_{is}L_{is}\overline{Q}}{\beta_{3is}q}\right)}{\sigma_{\eta L}},$$

$B\left[\bullet, \bullet; \rho, \sigma\right]$ is the bivariate normal distribution with mean 0 and covariance matrix

$$\sigma^2 \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix},$$

$B_k\left[\bullet, \bullet; \rho, \sigma\right]$ and $B_{kl}\left[\bullet, \bullet; \rho, \sigma\right]$ are first and second partial derivatives, and J_n is the Jacobian corresponding to those errors with interior solutions.

Case 2, $H_0 > 0$:

$$\begin{aligned} \pounds_n = & \prod_{i:\widetilde{H}_i=0} \left\{ \int_{\eta_{Xi} \geq \zeta_i} |J_n(\eta_{Xi})| \prod_{j \in m,p} \Pr\left[t_{ji} \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right]^{a_{0j}} \bullet \right. \quad (31) \\ & \left. \Pr\left[L_i \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right] \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{Xi}}{\sigma_{\eta X}}\right] d\eta_{Xi} \right\} \bullet \\ & \prod_{\substack{j \in m,p \\ k \neq j}} \Pr\left[t_{j0k}\right]^{a_{0k}a_{0j}} \Pr\left[u_0 \mid \widetilde{H}_0, t_0\right] \cdot \\ & \prod_{i>0:\widetilde{H}_i=1} \left\{ \prod_{j \in m,p} \Pr\left[t_{ji} \mid \widetilde{H}_i = 1\right]^{a_{0j}} \Pr\left[L_i \mid \widetilde{H}_i = 1\right] \right\} \bullet \\ & \iiint_{\substack{\eta_{X0} \leq \zeta_0 \\ \eta_{Xi} \leq \zeta_i \forall i>0:\widetilde{H}_i=1}} 1\left(\sum_{i:\widetilde{H}_i=1} H_i(\eta_{Xi}) = \overline{H}\right) \left(\prod_{i:\widetilde{H}_i=1} \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{Xi}}{\sigma_{\eta X}}\right] d\eta_{Xi}\right) \end{aligned}$$

where all terms are defined in equations (28), (29), and (30).

Some of the terms in the likelihood function need to be simulated. While simulation of most terms is straightforward, simulation of the last term is more complicated. We discuss how to do this using a GHK algorithm (Hajivassiliou, McFadden, and Ruud, 1996) in Appendix 2.

6.3 Identification

The set of parameters to estimate is listed in equation (24). δ_z in equation (22) is identified by covariation between parent characteristics and the "happy variable," u_0. $\delta_{\beta 4}$ in equation (**??**) and $\log \beta_{10}$, $\log \beta_{20}$, $\log \beta_{11}$, $\log \beta_{21}$, and $\log \beta_{31}$ are identified by covariation between parent and child characteristics and parent and child choices. For example, the degree that parent ADLs move with child informal care t identifies the effect of parent ADLs on β_4. Note that covariation between parent characteristics and children's care decisions does not identify δ_z because parent characteristics can directly affect care decisions through $\delta_{\beta 4}$. δ_α in equation (21) is identified by the covariation between $\partial \Pr[u_0 = 1 \mid t] / \partial t$ and parent and child characteristics. For example, because the partial correlation between parent happiness and informal care provision decreases with the distance between the parent and the child caregiver, the δ_α coefficient on distance is negative. γ in equation (1) is identified by $\partial^2 \Pr[u_0 = 1 \mid t] / \partial t^2$. $\log \mu$ is identified by the covariation between u_0 and the provision of formal care, $\overline{H}$. β_0 in equations (2) and (3) is not of interest by itself. But it is needed to match the mean of the "happy variable" data and is identified by the mean. Second moment terms, $\sigma_{\eta X}^2$, $\sigma_{\eta L}^2$, $\sigma_{\eta t}^2$, σ_u^2, ρ_η, and ρ_t, are identified by variances and correlations of generalized residuals (Gourieroux et al. 1987) associated with the likelihood function.

Note that the provision of informal care t affects a family member's utility in two ways: it directly affects utility through the satisfaction (or sense of burden) one receives (the β_4 effect), and it improves the parent's health thus affecting child utility (the β_1 effect). In much of the literature on informal care, the theory does not really specify which mechanism is relevant. In almost all of the literature, there is no attempt to identify the two effects separately. $\left(\text{ci-}\right.$ $\left.\text{tations}\right)$ Hiedemann and Stern (1999) argue that all children derive utility from the health benefits of informal care but only the caregiver derives satisfaction or burden from it. Thus, Hiedemann and Stern identify the separate effects by variation in care provision across families of different sizes. We are making the same assumption, but the effect of informal care on identification is completely different because the games being played in the two models are so different. In this work, the inclusion of the "happy variable" allows us to directly measure the effect of formal and informal care on parent well-being, and that allows us to disentangle the two effects. For example, if we were to observe the provision of informal care by children with a very small empirical effect on the parent's happiness relative to the effect of variables affecting Z, we would conclude that α is very small and $\beta_4 > 0$. Alternatively, if we were to observe that very little informal care is provided but those parents who receive it are usually happier, we would conclude that α is large and $\beta_4 < 0$. Note that the inclusion of the "happy data" allows us to nonparametrically identify all of the parameters because terms like $\partial \Pr[u_0 = 1 \mid t] / \partial t$ and its covariation with observed variables are nonparametrically identified. The model structure tells us how to decompose $\partial \Pr[u_0 = 1 \mid t] / \partial t$ into $\partial \Pr[u_0 = 1 \mid t] / \partial Q$ and $\partial Q / \partial t$, but the model works regardless of the decomposition.

7 Results

7.1 Model Without Covariates

We estimated several variants of our model. The results of a preliminary model with no covariates are displayed in Table 6. The relevant unit is a util as measured by the standard deviation of ε_{ui} in equation (3). A fruitful approach to interpreting estimates involves comparing derivatives of utility with respect to two different choice variables. For example, the cost to a child of spending an extra hour caring for a parent relative to taking the time as leisure is $\left(\beta_{4jik} + \varepsilon_{tjik}\right) / \left[\beta_{3ik}\varepsilon_{Lik}\frac{\partial \ln L_{ik}}{\partial L_{ik}}\right]$.

The estimates suggest that both formal and informal care have little effect on the parent's health and that there are diseconomies of scale associated with informal care. The effects of an additional hour of formal care and informal care provided by a particular family member on the parent's health are μ and $\alpha\left(1 + 2\gamma t\right)$, respectively. Although $\log \mu$ is significantly less than 0, the estimated effect of formal care on the parent's health is very small. An additional hour of informal care provided by a particular family member enhances the parent's health for levels of care of 8.1 hours per week or less. Beyond that point, additional informal care provided by the family member in question actually diminishes the parent's health. Note, however, that $\log \alpha$ is not significantly different from 0. The results suggest that, while not very productive in terms of enhancing the parent's health, informal care is burdensome: β_{40} and β_{4i} are significantly less than 0. Moreover, the burden associated with caregiving is large relative to the estimated effects of informal care on the parent's health α (ignoring γ effects) and the effect of the parent's health on her utility β_{10}. These relative magnitudes may explain why few children and spouses provide care for elderly individuals.

The estimates of $\sigma_{\eta X}$ and $\sigma_{\eta L}$ relative to $\beta_2 (\equiv 1)$ and β_3 suggest that there is significant variation in the marginal value of consumption and leisure across families. For example, while the mean marginal utility with respect to log consumption is 1, 10% have marginal utility above 4.16 and 10% have marginal utility below 0.24.[10] Similarly, for leisure, the average marginal utility is 1.40, but 10% have marginal utility above 6.98, while 10% have marginal utility below 0.28.

The estimate of $\sigma_{\eta t}$ suggests that 9.9% of elderly spouses and 3.5% of adult children enjoy spending time caring for the elderly individual ($\beta_4 + \varepsilon_t > 0$). The estimates of ρ_L and ρ_t suggest that the variation in child/spouse-specific marginal values of leisure and caregiving are very highly positively correlated. Thus, the results suggest that the child and his or her spouse tend to view their time as strong complements.

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[10] $\widehat{\sigma}_{\eta X} = 1.114$, so the 80% confidence interval for $\eta_X = \pm 1.426$. This implies the reported 80% confidence interval for $\beta_2 \varepsilon_x$.

7.2 Model With Covariates

We estimated a model with covariates that allows the α and Z terms in equation (1) and the β_4 in equations (2) and (3) to depend on covariates. This model allows family members' characteristics to affect both the quality of care provided and the burden associated with caregiving.

Parents care about their health in that it affects their utility ($\log \beta_1 = -0.722$). Checkovitch and Stern (2002) and Pezzin and Schone (1999) provide evidence that children provide more informal care as the parent ages. Similarly, our results suggest that children receive insignificantly more utility from caregiving as the parent ages. However, care provided by a child becomes significantly less productive as a parent ages. Thus, children may provide less informal care as the parent ages. These two effects are identified from one another because both effects influence the amount of time children spend providing care, but only the former effect influences the parent's utility.

As the parent accumulates ADL problems, caregiving becomes less effective and more burdensome. These results imply that, as a parent accumulates ADL problems, she will recieve less care from her children. In contrast, Checkovitch and Stern (2002) and Sloan, Picone, and Hoerger (1997) report evidence that children provide more informal care as the parent develops more problems with ADLs.

Previous studies provide mixed evidence on the relationship between the parent's gender and informal care provision by children. Hiedemann and Stern (1999) report that family members value care provided for mothers more than care provided for fathers, while Pezzin and Schone (1999) indicate that daughters are more likely to provide care for fathers than for mothers. We find that informal care is significantly more effective and insignificantly less burdensome for mothers than for fathers. Informal care is significantly more effective and insignificantly less burdensome for mothers than for fathers. Not surprisingly in light of the mixed evidence reported by other studies (Stern 1995, Wolf 1984, and Spear and Avery 1993), race does not significantly influence the effectiveness or the burden associated with caregiving. As expected, the parent's health declines with age and ADL problems. Married parents are healthier than their single counterparts.

As expected, care provided by the spouse becomes less effective as the spouse accumulates ADL problems. But, counter to expectations, care provided by the spouse become more effective as the spouse ages. Care provided by children becomes less effective as the child ages, but older children receive more utility from caregiving.

The existing literature provides evidence on the relationship between a child's gender and the provision of care for elderly parents. Engers and Stern (2002), Checkovitch and Stern (2002), and Sloan, Picone, and Hoerger (1997) find that, all else equal, daughters are significantly more likely than sons to provide care. Interestingly, however, Sloan, Picone, and Hoerger's findings indicate that sons provide significantly more care than daughters. This result holds regardless of whether they control for selection into the primary caregiving role. Hiedemann

and Stern's (1999) results suggest that family members value care provided by daughters more than care provided by sons. The results presented in this paper suggest that sons are slightly and statistically insignificantly less effective as caregivers than are daughters ($0.389 - 0.449 = -0.06$). In addition, sons receive less utility caring for parents than do daughters ($-1.262 + 0.851 = -0.411$) but again by a statistically insignificant amount. Recall that, on average, sons earn more than daughters, and we control for differences in opportunity costs. Thus, the results suggest that gender differences in the provision of care for elderly parents are partially due to variation in opportunity costs and partially due to variation in care effectiveness and preferences.

Sons provide lower quality care than sons-in-law ($0.110 - 0.449 = -0.339$),[11] and daughters provide statistically insignificantly better care than do daughters-in-law (0.110). Sons receive more utility from providing care than do sons-in-law ($-0.376 + 0.851 = 0.475$), but daughters-in-law receive more utility from providing care than do daughters (-0.376) but both effects are statistically insignificant.

Sloan, Picone, and Hoerger (1997) report that married children provide less care to elderly parents. Similarly, Pezzin and Schone (1999) report that the probability that a daughter who lives separately from her parents provides informal care depends negatively on the number of her own children. Our results indicate that married children provide higher quality care but experience greater disutility providing care. Similarly, the quality of care and the burden associated with caregiving depend positively on the number of one's own children. These results suggest that caring for elderly parents is particularly burdensome for adult children with family responsibilities. The results reveal diminishing marginal productivity of time spent caring for elderly parents ($\gamma < 0$). Informal care becomes counterproductive ($\partial Q / \partial t \leq 0$) at $t = 0.0855$ (14.4 hours per week).

Given the unobserved and observed variation in α, β, Z, and utility across family members and across families, interpreting some of the coefficients is difficult. Table 8 provides the first two moments of these parameters across the population. Informal care appears to be somewhat ineffective (the average $\log \alpha$ is a large negative number), particularly when provided by children or children-in-law rather than by the spouse. Parents and children care about the health of the parent, suggesting that altruism is an important motivation for family decision making. Finally caregiving is almost always burdensome: β_4 is almost always negative.

Table 9 illustrates the implications of the magnitude of $\log \alpha$ by way of two "representative individuals" described in the notes to the table. For both individuals, increasing informal care from zero to 20 hours per week ($t = 0.12$) mitigates a small but nontrivial part of the effect on well being (Q) of accumulating an ADL problem. For example, for individuals 1 and 2, 20 hours of informal care increases Q by 2.3% and 18.9% respectively, while the first ADL problem decreases Z, and therefore Q, by 28.7%. One might wonder how much

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[11]Sons-in-law may provide better care than sons because they are the husbands of daughters.

of an increase in caregiving by a child would be necessary to offset the effect of an extra ADL on Q. In fact, one child can not counterbalance the effect of an extra ADL. For example, for the first representative individual in Table 9, an extra ADL decreases Z/α by 0.69; this would have to be the increase in $t + \gamma t^2$. But, given the large, negative value of γ, $\max_t \left(t + \gamma t^2\right) = 0.043$.

To shed light on gender differences in the provision of informal care, we first examine the roles of opportunity costs, effectiveness in the caregiving role, and burden associated with caregiving in adult children's likelihood of providing informal care. Table 10 decomposes these effects by the child's marital status and the number of children. For all family sizes, the benchmark is an unmarried daughter. For example, consider families that consist of only one adult child who is not married. As indicated in the first column, the overall probability that the child provides care is 0.033 for daughters and 0.011 for sons. Each of the next three columns allows for one of the three types of effects: 1) opportunity costs as measured by wages, 2) effectiveness as a caregiver (quality of care), or 3) burden. For example, allowing for gender differences in wages but not in quality or burden, the probability that a son provides care is 0.030. Allowing for gender differences in quality only, the probability that a son provides care is 0.041. Allowing for gender differences in burden only, this probability falls to 0.009. As indicated in the last column, in the absence of wage, quality, or burden effects, the gender gap virtually disappears for only children: the probability that an only child provides care is 0.033 for daughters and 0.032 for sons. Thus there are no other important characteristics varying with child gender that affect care.

In the case of married daughters, the table provides the probability that daughters and/or their husbands provide informal care; similarly, for married sons, the table provides the probability that sons and/or their wives provide care.

Table 10 reports the probability that an adult child provides informal care conditional on gender, marital status, and family size and isolates the effects of opportunity costs, caregiving effectiveness, and caregiving burden on these probabilities. But the more interesting question concerns the extent to which opportunity costs, quality, and burden contribute to gender differences in the propensity to provide informal care. Table 11 reports cross partial differences of log probabilities with respect to the effect in question and gender. Consider families that consist of only one adult child who is not married. Table 11 indicates that opportunity costs reduce the probability that a son provides informal care by 7%, quality of care effects increase the probability by 28%, and the burden associated with caregiving reduces the probability by 73% relative to the same effects for a daughter. Sons feel significantly more burden caring for parents than do daughters ($\frac{\partial \beta_4}{\partial Male} = -1.262 + .851 = -0.411$ from Table 7), so

$$\frac{\Delta^2 \log \Pr\left[t > 0\right]}{\Delta \beta_4 \Delta Male} \approx \frac{\partial \log \Pr\left[t > 0\right]}{\partial \beta_4} \frac{\Delta \beta_4}{\Delta Male} \approx -1.3.$$

Allowing for all effects reduces the probability that a son provides care by 66% relative to a daughter.

Now consider families that consist of only one adult child who is married. The effects change because each household consists of one adult male and one adult female. Overall sons and/or their wives are 15% less likely to provide care than are daughters and/or their husbands. Allowing for gender differences in quality but not in burden or wages, sons and/or their wives are 30% less likely to provide care as daughters and/or their husbands. Allowing for gender differences in burden only, sons and/or their wives are 19% more likely to provide care than are daughters and/or their husbands. Allowing for gender differences in wages only, there is virtually no difference in the probability that sons and/or their wives or daughters and/or their husbands provide care. The results are fairly robust to changes in family size.

We also performed a similar exercise for race. Table 12 shows the effects of changing various characteristics of blacks to make them similar to whites. On average, blacks spend more time caregiving than do whites. Although differences in opportunity costs by race contribute to differences in caregiving time, burden plays a larger role. As discussed earlier, blacks experience greater burden from caregiving. Black parents receive greater benefit from informal care than do white parents, somewhat offsetting the effects of opportunity cost and burden.

7.3 Specification Tests

We performed two types of specification tests. First, we tested for the existence of state fixed effects. We aggregated residuals for 34 states with at least 4 observations. We could not reject the null hypothesis of no state fixed effects for time spent caring for the parent, financial contributions, and leisure.

Next we performed a set of χ^2 goodness-of-fit tests for informal care, financial contributions towards formal care, and leisure. For each variable x (time spent helping per family member, proportion of family members offering financial help, and leisure per family member), we simulated x twenty times for each family n and computed the mean $\widehat{x}$ and the standard deviation $\widehat{s}$. Then we constructed

$$\chi^2_{1n} = \frac{(x_n - \widehat{x})^2}{\widehat{s}^2 + \sigma^2_m} \tag{32}$$

where σ^2_m is a correction for measurement error. Its construction is discussed in Appendix 3. We then summed χ^2_{1n} over n. The results of this exercise are presented in Table 13, disaggregated by family size. The χ^2 statistics are all very large, but, with the exception of financial help in small families, the mean residuals are quite small. For example, the mean residual on "time help" for families of size 4 means that we overestimate time help in such families by 1% on average.

The large χ^2 statistics are caused by outliers to a great degree. In fact, if we censor each χ^2_{1n} statistic in equation (32) at the 1% level, i.e.,

$$\chi^{2*}_{1n} = \min\left[\frac{(x_n - \widehat{x})^2}{\widehat{s}^2 + \sigma^2_m}, 6.63\right],$$

then the χ^2 statistics reduce to the numbers in the column labeled "Censored." The next column shows the number of χ^{2*}_{1n} statistics that are actually censored, and the last column turns the censored χ^2 statistic into a standard normal random variable. The results suggest that we are still missing some aspect of decision making with respect to time help though not in terms of average help. On the other hand, after controlling for a small number of outliers, we are predicting financial help and leisure decisions quite accurately.

7.4   Policy Experiments

We consider the effects of six experiments on family behavior given the parameter estimates reported in Table 9. The six experiments involve:

1. providing a subsidy of qF to each parent that must be used for formal care (formal care stamps);

2. providing a subsidy of F to each child or child-in-law for each unit of time she provides informal care;

3. providing a subsidy of F for each dollar spent on formal care (reduction in the price of formal care);

4. providing a lump sum of F to the parent;

5. increasing Ψ, the income limit for Medicaid; and

6. providing a subsidy of qF to each parent for each ADL problem; this subsidy must be used for formal care.

Appendix 4 provides the details of how to evaluate the effects of each of these policy experiments. Given the small marginal product of formal and informal care on Q implied by the parameter estimates in Table 7, almost all of the policy experiments would have essentially no effect on behavior. Experiment (1) suggests that formal care stamps would increase expenditures by about \$0.35 for every dollar spent on the program for families with children. Most families without formal care expenditures prior to the experiment would exhaust their formal care stamps but spend no out of pocket funds on formal care. To a significant degree, those with formal care expenditures would replace their own expenditures with program expenditures with little effect on the level of formal care.

Experiments (2) and (3) essentially reduce the price of informal and formal care. In the average family with two children, a \$1.00 subsidy per hour would result in an increase of 2.1 hours per week of caregiving by children (with a corresponding small reduction of hours per week of caregiving by parents). However, since the family resources expended on both are small and both marginal products are small, the effects of the subsidy would be small. Experiment (3) would have only trivial effects because formal care expenditures are very small. Experiment (4) indicates that a lump sum subsidy to the parent would be used to

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supplement consumption. Thus, a lump sum subsidy would have very little effect on formal or informal care or the health (Q) of the parent. Experiments (5) and (6) are small deviations of experiment (1) and would have similar though smaller effects.

Overall, the results of these experiments suggest that variation in state Medicaid policy would have little effect on long-term care decisions. These results are consistent with results in Engers and Stern (2002) where no significant state effects were found but inconsistent with Cutler and Sheiner (1993) that found small macro effects. We measure the effect of policy changes given respondents reside in the community and hence, under some situations, underestimate the effect of changes in policy on community-based care giving. For example, policy changes with regard to Medicaid income limits or subsidies for home health care may imply different choices for community-based care versus institutionalization. Institutional care may be a decision under some policy parameters, while other policy parameters may induce families to care for the elderly parent at home.

8   Conclusions

We develop and estimate a game-theoretic model of families' decisions concerning the provision of formal and informal care for elderly individuals. Our game-theoretic framework allows preferences over consumption, leisure, and the health status of the elderly individual(s) to vary across family members. In our model, each individual or married couple makes caregiving decisions conditional on the decisions of the other family members. We use the first-order conditions of the model to solve for the errors as relatively simple functions of the parameters and construct a likelihood function for estimation.

The structure of the model allows us to distinguish among three underlying explanations for patterns in care provision. First, some family members find providing care more burdensome than do others. Second, some members are more adept at providing care. Third, opportunity costs in the form of foregone earnings vary across the family. We find that caring for an elderly parent or spouse is burdensome for most individuals and that informal care has a relatively small effect on health quality. Consequently, children and spouses provide little informal care. We use the structure to shed light on why, in the raw data, daughters are more likely than sons to provide care and why blacks are more likely than whites to provide care. Differences in burden and quality of care dominate opportunity costs, but the effects vary by marital status of the children.

Goodness of fit tests show that our model fits the data fairly well. In addition, we fail to reject the hypothesis that there is no additional variation across states not captured in our model. This result suggests that our simplification of the Medicaid benefit structure performs well.

We exploit the structural nature of the estimates to perform policy experiments similar to those suggested in public policy discussions. For example, we

simulate the provision of a lump sum that can be spent only on care as well as price subsidies for informal and formal home care. Consistent with the finding that formal and informal home care are largely ineffective in increasing health quality, we find little effect of these policy changes.

These results should be interpreted carefully in light of the nature of our data. The first wave of AHEAD data does not include any nursing home residents. Subsequent waves of AHEAD contain nursing home residents and will thus allow us to include them in the model. The survey instrument was also improved in later waves to elicit information about more caregivers.

In addition, the availability of panel data will enable us to estimate dynamic models of care arrangements for elderly individuals. In particular, we plan to estimate a dynamic extension of our structural model with more waves of AHEAD data. Using panel data, we can explore whether siblings take turns caregiving or whether certain children specialize in caregiving while others specialize in market production or other forms of nonmarket production. If children do, in fact, take turns caregiving, the use of panel data will enable us to examine possible causes of this behavior including burnout.

Moreover, the inclusion of nursing home residents in subsequent waves of AHEAD provides us with an opportunity to investigate the effects of proposed or actual policies on the use of institutional care. For example, subsidies for home health care may induce some families to care for the elderly at home rather than in an institution.

9   Appendix 1:   Construction of Child Caring Time

A key issue in estimation concerns the interpretation of data on caregiving time t_{jik}. In the survey, there are two relevant questions:

1) How many days per week does the helper provide help?; and

2) How many hours per day does the helper provide help on days when she helps?

While the responses to the second question provide a continuous measure of hours per day, responses to the first question are categorical: a) every day, b) several times a week, c) once per week, d) less than once per week, and e) never. We can use the answers to these two questions to construct a "pseudo" continuous variable:

$$t_{jik} = \begin{cases} 7\pi_{jik}/168 & \text{if she helps every day} \\ 3.5\pi_{jik}/168 & \text{if she helps several times a week} \\ \pi_{jik}/168 & \text{if she helps once per week} \\ 0.5\pi_{jik}/168 & \text{if she helps less than once per week} \\ 0 & \text{if she never helps} \end{cases} \tag{33}$$

where π_{jik} is the answer to the second question.[12]

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[12] Alternatively, we could have set up bracketed amounts that are truer to the nature of the

Unfortunately, the AHEAD respondents were asked about help from children only if they had an ADL or IADL problem. This feature of the survey design may bias the amount of reported care downwards. However, it is reasonable to assume that parents needing care from children are likely to have an ADL or IADL, and, at the time we constructed our data, there were no better data available.

10 Appendix 2: Simulation

In order to evaluate the likelihood contributions in equation (26) and (31), we must be able to simulate the last term, e.g. in equation (26),

$$
\iiint_{\substack{\eta_{Xi} \leq \zeta_i \\ i:\widetilde{H}_i=1}} 1\left(\sum_{i:\widetilde{H}_i=1} H_i\left(\eta_{Xi}\right) = \overline{H}\right)\left(\prod_{i:\widetilde{H}_i=1} \frac{1}{\sigma_{\eta X}^2}\phi\left[\frac{\eta_{Xi}}{\sigma_{\eta X}}\right] d\eta_{Xi}\right). \qquad (34)
$$

Such a term is the probability of a vector of η_{Xi}'s (for those with $\widetilde{H}_i = 1$) conditional on each η_{Xi} being small enough to cause $\widetilde{H}_i = 1$ and also $\sum_{i:\widetilde{H}_i=1} H_i\left(\eta_{Xi}\right) = \overline{H}$. Consider the following GHK-type simulation algorithm:

1) Order $\left\{i : \widetilde{H}_i = 1\right\}$ according some criterion. Let (i) be the ith element of the ordered set. Let $I^* = \#\left\{i : \widetilde{H}_i = 1\right\}$.
2) Initialize $S_{(1)} = 0$ and $P^r = 1$.
3) For each $(i) < I^*$,
  a) Let

$$
\overline{b}_{(i)} = H_{(i)}^{-1}\left(\max\left\{0, \Psi_{(i)}\right\}\right)
$$

be an upper bound where $H_{(i)}^{-1}(\bullet)$ is the inverse of $H_{(i)}\left(\eta_{X(i)}\right)$ implied by equation (27):

$$
H_{(i)}^{-1}(x) = \log\left\{\frac{\beta_{1(i)}\mu}{\beta_{2(i)}q}\overline{Q}\left[\max\left(Y_{(i)}^*, Y_{(i)}^{**}\right) - qx\right]\right\}
$$

where

$$
Y_{(i)}^* = \begin{cases} \sum_{k \in c,s} a_{(i)k}w_{(i)k}\left(1 - L_{(i)k} - \sum_{j \in m,p} t_{j(i)k}\right) & \text{if } i > 0 \\ Y_{(i)} & \text{if } i = 0 \end{cases},
$$

$$
Y_{(i)}^{**} = \begin{cases} \max\left(Y_{(i)}^*, Y_{(i)} + sY_{(i)}^*\right) & \text{if } i > 0 \\ Y_{(i)} & \text{if } i = 0 \end{cases},
$$

---

first question. Using the brackets is much harder, and it adds precision only for two out of the five categories. These two occur for 949 helpers out of a total of 3144 helpers (30.1%).

and

$$\Psi_{(i)} = \overline{H} - S_{(i)} - \sum_{(l)>(i)} \max\left(Y_{(l)}^*, Y_{(l)}^{**}\right)$$

is the least player (i) can contribute; i.e., it is how much she would have to contribute if all remaining players used all resources for $\overline{H} - S_{(i)}$. Note that, if $0 \geq \Psi_{(i)}$,

$$\overline{b}_{(i)} = \log\left(\frac{\beta_{1(i)}\mu p_{Xi}X_{(i)}\overline{Q}}{\beta_{2(i)}q}\right).$$

Also, let

$$\underline{b}_{(i)} = H_{(i)}^{-1}\left(\overline{H} - S_{(i)}\right)$$

be a lower bound.

    b) Update

$$P^r = P^r\left[\Phi\left(\frac{\overline{b}_{(i)}}{\sigma_{\eta X}}\right) - \Phi\left(\frac{\underline{b}_{(i)}}{\sigma_{\eta X}}\right)\right].$$

    c) Simulate $\eta_{X(i)}$ conditional on $\underline{b}_{(i)} \leq \eta_{X(i)} \leq \overline{b}_{(i)}$ as

$$\eta_{X(i)}^r = \sigma_{\eta X}\Phi^{-1}\left\{\left[\Phi\left(\frac{\overline{b}_{(i)}}{\sigma_{\eta X}}\right) - \Phi\left(\frac{\underline{b}_{(i)}}{\sigma_{\eta X}}\right)\right]u^r + \Phi\left(\frac{\underline{b}_{(i)}}{\sigma_{\eta X}}\right)\right\}$$

where $u^r \sim U(0,1)$.

    d) Compute $H_{(i)}\left(\eta_{X(i)}^r\right)$ using $\eta_{X(i)}^r$ and equation (27).

    e) Compute $S_{(i+1)} = S_{(i)} + H_{(i)}\left(\eta_{X(i)}^r\right)$.

4) For $(i) = I^*$,

    a) Let

$$\eta_{X(I^*)}^r = H_{(I^*)}^{-1}\left(\overline{H} - S_{(I^*)}\right).$$

    b) Update

$$P^r = \frac{P^r}{\sigma_{\eta X}}\phi\left[\frac{\eta_{X(I^*)}}{\sigma_{\eta X}}\right].$$

5) P^r is our simulator of equation (34). Note that, if there is only one player

who satisfies the conditions in the integral in equation (34), then the equation becomes

$$\frac{1}{\sigma_{\eta X}^2}\phi\left[\frac{H_{(i)}^{-1}\left(\overline{H}\right)}{\sigma_{\eta X}}\right]$$

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which can be evaluated analytically.

Consider how to interpret the GHK algorithm as an importance sampling simulator. Rewrite equation (34) as

$$\iiint_{\substack{\eta_{X(i)} \leq \zeta_i \\ \sum_{(i)=1}^{I^*} H_{(i)}(\eta_{X(i)}) = \overline{H}}} f(\eta_X)\, d\eta_X$$

$$= \iiint_{\substack{\eta_{X(i)} \leq \zeta_i \\ \sum_{(i)=1}^{I^*} H_{(i)}(\eta_{X(i)}) = \overline{H}}} \frac{f(\eta_X)}{g(\eta_X)} g(\eta_X)\, d\eta_X$$

where $\eta_X = \left(\eta_{X(1)}, \eta_{X(2)}, .., \eta_{X(I)}\right)$,

$$f(\eta_X) = \prod_{(i)=1}^{I^*} \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{X(i)}}{\sigma_{\eta X}}\right] \prod_{(i)=1}^{I^*-1} 1\left(\underline{b}_{(i)} \leq \eta_{X(i)} \leq \overline{b}_{(i)}\right)$$

$$g(\eta_X) = \prod_{(i)=1}^{I^*-1} \frac{\frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{X(i)}}{\sigma_{\eta X}}\right]}{\Phi\left(\frac{\overline{b}_{(i)}}{\sigma_{\eta X}}\right) - \Phi\left(\frac{\underline{b}_{(i)}}{\sigma_{\eta X}}\right)} 1\left(\underline{b}_{(i)} \leq \eta_{X(i)} \leq \overline{b}_{(i)}\right),$$

which implies that

$$\frac{f(\eta_X)}{g(\eta_X)} = \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{X(I)}}{\sigma_{\eta X}}\right] \prod_{(i)=1}^{I^*-1} \left[\Phi\left(\frac{\overline{b}_{(i)}}{\sigma_{\eta X}}\right) - \Phi\left(\frac{\underline{b}_{(i)}}{\sigma_{\eta X}}\right)\right].$$

Note that we are simulating $E\frac{f(\eta_X)}{g(\eta_X)}$ with errors η_X simulated from density $g(\eta_X)$. The fact that we can write our simulator as an importance sampling simulator means that it is unbiased.

We want to minimize the variance of our simulator, especially because we are using maximum simulated likelihood estimation rather than the method of simulated moments. First, we can improve on the variance of our simulator by using antithetic acceleration. Second, we can use a criterion for ordering $\left\{i : \widetilde{H}_i = 1\right\}$ in Step 1 of the algorithm that reduces the variance. Consider a case with $I^* = 2$. In Figure 2, the $\overline{H}$ curve represents those values of $\left(\eta_{X(1)}, \eta_{X(2)}\right)$ that result in total formal care expenditures of $\overline{H}$. Note that the curve asymptotes at $\underline{b}_{(1)}$ and $\overline{b}_{(1)}$. At $\underline{b}_{(1)}$, as $\eta_{X(2)}$ increases, $H_{(2)}$ approaches 0 (and reaches 0); thus $\eta_{X(1)}$ must converge to that value such that child (1) will provide $\overline{H}$. On the other hand, as $\eta_{X(2)}$ decreases, $H_{(2)}$ converges to the income of child (2); thus $\eta_{X(1)}$ must converge to that value such that child (1) will provide $\overline{H}$ minus the income of child (2). Our GHK algorithm first computes the probability that $\underline{b}_{(1)} \leq \eta_{X(1)} \leq \overline{b}_{(1)}$. Next the GHK algorithm

simulates a value of $\eta_{X(1)}$ conditional on $\underline{b}_{(1)} \leq \eta_{X(1)} \leq \overline{b}_{(1)}$. Then it computes the probability that $\eta_{X(2)}$ is such that the simulated values of $\eta_{X(1)}$ and $\eta_{X(2)}$ are on the $\overline{H}$ curve. The simulator is the product of the two probabilities. The variance of the simulator is proportional to the variance of the second probability as a function of the simulated value of $\eta_{X(1)}$. Thus, we should arrange $\left\{ i : \widetilde{H}_i = 1 \right\}$ in descending order of the variance of the contribution to the simulator with respect to the elements of η_X that precede it.

Such an ordering rule is too expensive to evaluate and may depend upon realizations of early elements of η_X. Instead, we want an alternative rule that approximates the rule described above but that is easy to employ and does not depend upon realizations of early elements of η_X. A simple example of such a rule is to order $\left\{ i : \widetilde{H}_i = 1 \right\}$ in descending order with respect to

$$\left| \frac{\phi\left[\frac{\overline{b}_i}{\sigma_{\eta X}}\right] - \phi\left[\frac{b_i^*}{\sigma_{\eta X}}\right]}{\Phi\left(\frac{\overline{b}_i}{\sigma_{\eta X}}\right) - \Phi\left(\frac{b_i^*}{\sigma_{\eta X}}\right)} \right|$$

where

$$b_i^* = H_i^{-1}\left(\overline{H}\right).$$

We also need to simulate terms like the second term in equation (26):

$$\int\limits_{\eta_{Xi} \geq \zeta_i} \prod_{j \in m, p} \Pr\left[t_{ji} \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right]^{a_{0j}} \Pr\left[L_i \mid \widetilde{H}_i = 0, \varepsilon_{Xi}\right] \frac{1}{\sigma_{\eta X}^2} \phi\left[\frac{\eta_{Xi}}{\sigma_{\eta X}}\right] d\eta_{Xi}$$

But this requires just drawing $\eta_{Xi} \mid \eta_{Xi} \geq \zeta_i$ and then evaluating the integrand conditional on the draw of η_{Xi}.

Finally, we need to be able to simulate

$$\Pr\left[u_0 \mid \widetilde{H}_0, t_0\right] = \int \cdots \int \Pr\left[u_0 \mid \eta_{X0}, \eta_{t0}\right] f\left[\eta_{X0}, \eta_{t0} \mid \widetilde{H}_0, t_0\right] d\eta_{X0} d\eta_{t0}.$$

This is a straightforward application of GHK.

11   Appendix 3: Correction for Measurement Error in Specification Tests

Let $y_i^* \sim iidF$, let

$$y_i = k1\left(c_k \leq y_i^* < c_{k+1}\right),$$

and let

$$\widehat{y}_i^* = \sum_k g\left(c_k, c_{k+1}\right) 1\left(y_i = k\right).$$

What are the moments of $z_i^* = \widehat{y}_i^* - y_i^*$?

$$
\begin{aligned}
Ez_i^* &= E\sum_k g\left(c_k, c_{k+1}\right) 1\left(y_i = k\right) - y_i^* \\
&= \sum_k g\left(c_k, c_{k+1}\right) \Pr\left(y_i = k\right) - Ey_i^* \\
&= \sum_k g\left(c_k, c_{k+1}\right) \left[F\left(c_{k+1}\right) - F\left(c_k\right)\right] - Ey_i^*,
\end{aligned}
$$

and

$$
\begin{aligned}
Var\left(z_i^*\right) &= Var\left[\sum_k g\left(c_k, c_{k+1}\right) 1\left(y_i = k\right) - y_i^*\right] \\
&\quad E\left[\sum_k g\left(c_k, c_{k+1}\right) 1\left(y_i = k\right) - y_i^* - Ez_i^*\right]^2 \\
&= \int \left[\sum_k g\left(c_k, c_{k+1}\right) 1\left(y_i = k\right) - y_i^* - Ez_i^*\right]^2 dF\left(y_i^*\right) \\
&= \sum_k \int_{c_k}^{c_{k+1}} \left[g\left(c_k, c_{k+1}\right) - y_i^* - Ez_i^*\right]^2 dF\left(y_i^*\right).
\end{aligned}
$$

If $y_i^* \sim iidU\left(0,1\right)$ and

$$g\left(c_k, c_{k+1}\right) = \frac{c_k + c_{k+1}}{2},$$

then

$$F\left(c_{k+1}\right) - F\left(c_k\right) = c_{k+1} - c_k,$$

$$
\begin{aligned}
Ez_i^* &= \sum_k \frac{c_k + c_{k+1}}{2}\left(c_{k+1} - c_k\right) - \frac{1}{2} \\
&= \sum_k \frac{c_{k+1}^2 - c_k^2}{2} - \frac{1}{2} = 0,
\end{aligned}
$$

and

$$Var\left(z_i^*\right) \quad = \quad \sum_k \int_{c_k}^{c_{k+1}} \left[\frac{c_k + c_{k+1}}{2} - y_i^*\right]^2 dy_i^*$$

$$= \quad \sum_k \int_{c_k}^{c_{k+1}} \left[\frac{c_k + c_{k+1}}{2} - y_i^*\right]^2 \frac{c_{k+1} - c_k}{c_{k+1} - c_k} dy_i^*$$

$$= \quad \sum_k \frac{(c_{k+1} - c_k)^3}{12}.$$

In the data, the values of c are $(0,1/7,1/7,1,1)$. Thus,

$$Var\left(z_i^*\right) \quad = \quad \sum_k \frac{(c_{k+1} - c_k)^3}{12}$$

$$= \quad \frac{\left(\frac{1}{7}\right)^3 + \left(\frac{6}{7}\right)^3}{12}$$

$$= \quad .229^2.$$

We multiply $Var\left(z_i^*\right)$ by $(1.6/168)^2$ where 1.6 is the average value of π in equation (33) in the data. Thus, $\sigma_m = (1.6/168) \cdot .229 = .002$.

12 Appendix 4: Simulating Policy Experiment Effects

Consider the general problem where we have a set of agents indexed by i, each with a utility function

$$U_i\left(v_i, P\right)$$

with choice variables v_i and some (government) policy variable or environmental characteristic P. In general, we can solve for the derivatives of choice variables with respect to policy variables as follows. Let v be the $m-$vector of choice variables, let ε be the $m-$vector of errors in the model, and let the set of first order conditions be written as

$$\underset{m_r \times m}{D_n'\left(\varepsilon\right)} \left[\underset{m \times 1}{\varepsilon} - \underset{m \times 1}{\psi}\left(\underset{m \times 1}{v}, P\right)\right] = 0 \tag{35}$$

where $D_n\left(\varepsilon\right)$ is a matrix that pulls the m_r rows of $\varepsilon - \psi\left(v, P\right)$ corresponding to interior solutions of first order conditions (conditional on ε) for family n. Conditional on ε, we can differentiate equation (35) to get

$$0 \quad = \quad \underset{m_r \times m}{D_n'\left(\varepsilon, P\right)} \left[\underset{m \times m}{\psi_v} \underset{m \times m_r}{D_n\left(\varepsilon, P\right)} \underset{m_r \times m}{D_n'\left(\varepsilon, P\right)} \underset{m \times 1}{dv} + \underset{m \times 1}{\psi_P \, dP}\right]$$

$$\Rightarrow \quad \underset{m_r \times m}{D_n'\left(\varepsilon, P\right)} \frac{dv}{dP} = - \left[\underset{m_r \times m}{D_n'\left(\varepsilon, P\right)} \underset{m \times m}{\psi_v} \underset{m \times m_r}{D_n\left(\varepsilon, P\right)}\right]^{-1} \left[\underset{m_r \times m}{D_n'\left(\varepsilon, P\right)} \underset{m \times 1}{\psi_P}\right].$$

Now we are interested in

$$E\frac{dv}{dP} = \int \cdots \int D'_n(\varepsilon, P)\frac{dv}{dP}f(\varepsilon)\,d\varepsilon \tag{36}$$

where $f(\varepsilon)$ is the joint density of ε. Note that we do not have to worry about the term associated with $\partial D_n(\varepsilon, P)/\partial P$ because the relevant term is

$$\frac{\partial D_n(\varepsilon, P)}{\partial P}v(\varepsilon, P)f(\varepsilon)$$

which is zero because $v(\varepsilon, P) = 0$ at values of (ε, P) where $D_n(\varepsilon, P)$ changes.

We need to simulate equation (36) in such a way that we "oversample" from that part of the support of ε where $\frac{dv}{dP} \neq 0$. Write equation (36) as

$$E\frac{dv}{dP} = E_k\frac{dv}{dP} = \int \cdots \int_{\widetilde{\varepsilon}_k} \int_{\varepsilon_k} D'_n(\varepsilon, P)\frac{dv}{dP}f(\varepsilon)\,d\varepsilon_k d\widetilde{\varepsilon}_k$$

where $E_k\frac{dv}{dP}$ rearranges the order of integration in equation (36) so that the innermost integral is over the kth element of ε and $\widetilde{\varepsilon}_k = (\varepsilon_1, .., \varepsilon_{k-1}, \varepsilon_{k+1}, .., \varepsilon_m)'$ is the $(m-1)-$vector of ε excluding ε_k. Note that

$$E\frac{dv}{dP} = E_k\frac{dv}{dP} \quad \forall k.$$

Then we can write equation (36) as

$$\begin{aligned}
E\frac{dv}{dP} &= \frac{1}{m}\sum_{k=1}^{m} E_k\frac{dv}{dP} \tag{37}\\
&= \frac{1}{m}\sum_{k=1}^{m} \int \cdots \int_{\widetilde{\varepsilon}_k} \int_{\varepsilon_k} D'_n(\varepsilon, P)\frac{dv}{dP}f(\varepsilon)\,d\varepsilon_k d\widetilde{\varepsilon}_k.
\end{aligned}$$

Let

$$A_k(\widetilde{\varepsilon}_k) = \{\varepsilon_k : v(\varepsilon, P) > 0 \mid \widetilde{\varepsilon}_k\}$$

and

$$B_k(\widetilde{\varepsilon}_k) = \{\varepsilon_k : v(\varepsilon, P) = 0 \mid \widetilde{\varepsilon}_k\}.$$

Then equation (37) can be written as

$$\begin{aligned}
&= \frac{1}{m}\sum_{k=1}^{m} \int \cdots \int \left[\int_{A_k(\widetilde{\varepsilon}_k)} D'_n(\varepsilon, P)\frac{dv}{dP}f(\varepsilon)\,d\varepsilon_k d\widetilde{\varepsilon}_k \right.\\
&\quad \left. + \int_{B_k(\widetilde{\varepsilon}_k)} D'_n(\varepsilon, P)\frac{dv}{dP}f(\varepsilon)\,d\varepsilon_k d\widetilde{\varepsilon}_k \right].
\end{aligned}$$

36

It can be simulated as

$$\frac{1}{mR}\sum_{r=1}^{R}\sum_{k=1}^{m}\left[D_n'\left(\varepsilon_{A_k}^r,P\right)\frac{dv\left(\varepsilon_{A_k}^r,P\right)}{dP}\Pr\left(\varepsilon_k\in A_k\left(\widetilde{\varepsilon}_k^r\right)\mid\widetilde{\varepsilon}_k^r\right)\right. \tag{38}$$

$$\left.+D_n'\left(\varepsilon_{B_k}^r,P\right)\frac{dv\left(\varepsilon_{B_k}^r,P\right)}{dP}\Pr\left(\varepsilon_k\in B_k\left(\widetilde{\varepsilon}_k^r\right)\mid\widetilde{\varepsilon}_k^r\right)\right]$$

where $\varepsilon_{A_k}^r$ is a draw from $f\left(\cdot\right)$ conditional on the kth element $\varepsilon_{A_k k}^r\in A_k\left(\widetilde{\varepsilon}_k^r\right)$ and $\varepsilon_{B_k k}^r$ is a draw from $f\left(\cdot\right)$ conditional on the kth element $\varepsilon_{B_k k}^r\in B_k\left(\widetilde{\varepsilon}_k^r\right)$. In practice, one uses the following algorithm to simulate equation (38):

For each draw $r=1,2,..,R$:

1) Draw ε^r from $f\left(\cdot\right)$.

2) For each $k=1,2,..,m$:

    a) Pull out $\widetilde{\varepsilon}_k^r$ from ε^r;

    b) Find the boundary along ε_k between $A_k\left(\widetilde{\varepsilon}_k^r\right)$ and $B_k\left(\widetilde{\varepsilon}_k^r\right)$ and call it ε_k^*;

    c) Compute $F_k\left(\varepsilon_k\mid\widetilde{\varepsilon}_k^r\right)$ analytically and assign appropriate probabilities to $\Pr\left(\varepsilon_k\in A_k\left(\widetilde{\varepsilon}_k^r\right)\mid\widetilde{\varepsilon}_k^r\right)$ and $\Pr\left(\varepsilon_k\in B_k\left(\widetilde{\varepsilon}_k^r\right)\mid\widetilde{\varepsilon}_k^r\right)$;

    d) Simulate $\varepsilon_{A_k}^r$ and evaluate $dv\left(\varepsilon_{A_k}^r,P\right)/dP$;

    e) Simulate $\varepsilon_{B_k}^r$ and evaluate $dv\left(\varepsilon_{B_k}^r,P\right)/dP$;

    f) Plug the simulated values of $dv\left(\varepsilon_{A_k}^r,P\right)/dP$ and $dv\left(\varepsilon_{B_k}^r,P\right)/dP$ into equation (38) and sum;

3) Divide by mR.

The details for this application are provided at

http://faculty.virginia.edu/stevenstern/resint/ltcstf/welfaresimul.pdf.

13   References

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14 Tables and Figures

Table 1	
Dropped Household Observations	
Total Housholds	6047
More than Five Children	625
Missing Child Variable	1008
Missing Parent Variable	108
Working Respondent	270
Respondents Helping Each Other	25
Small Minority Groups	350
Coding Errors	78
Sample Size	3583

Table 2		
Selected Characteristics of Respondents		
Characteristic	Male	Female
Age	76.73	76.30
Education	11.73	11.80
Black	0.07	0.10
Living Children	2.06	2.02
Married	0.72	0.42
Number of ADL problems	0.38	0.46
At Least 1 ADL problem	0.19	0.24
Number of IADL problems	0.36	0.34

Table 3	
Child Characteristics of Respondents	
Characteristic	Mean
Age	47.01
Male	0.490
Education	13.98
Married	0.698
Number of Children	1.985
Live with Parent	0.94
Live More Than 10 Miles from Parent	0.66
Imputed Weekly Wage	$452

Note: We also observe bracketed time spent helping respondents and labor force participation of the child and spouse of the child.

Table 4			
Ln Wage Estimates			
Variable	Estimate	Variable	Estimate
Constant	0.028 (0.072)	Male	0.099** (0.030)
Years of Schooling, < High School Degree	0.035** (0.006)	Marry	0.028 (0.029)
High School Diploma	0.540** (0.052)	White	0.066** (0.022)
Some college	0.680** (0.053)	Male*Marry	0.090** (0.042)
College Degree	0.978** (0.053)	Male*White	0.022 (0.033)
> College Degree	1.086** (0.054)	Marry*White	-0.035 (0.032)
Age	0.066** (0.002)	Male*Marry*White	0.093** (0.045)
Age^2	-0.001** (0.000)		
$R^2 = 0.34$			

Notes:

1. Dependent variable is ln wage.

2. Numbers in parentheses are standard errors.

3. Double starred items are significant at the 5% level.

4. The education variables refer to highest education level attained. The first variable is a slope conditional on not finishing high school, and the others are dummy variables.

Table 5 Formal and Informal Care Provision					
Informal Care					
		# Children Helping			
		0	1	2	3
Households Receiving Informal Care	937	555	345	35	2
Single Parents	339	0	305	33	1
Married Parents with no Spouse Care	37	0	35	1	1
Married Parents, Spouse Cares	561	555	5	1	0
Formal Care					
Households Receiving Formal Care					392
Children Help Pay for Care					17

Note: Children and their spouses aggregated into one helper

	Table 6		
	Estimates of Model With No Covariates		
Variable	Estimate	Variable	Estimate
$\log \alpha$	-0.719 (1.596)	γ	-10.390** (1.458)
$\log \mu$	-5.476** (1.567)	$\log(-\beta_0)$	8.222** (0.834)
$\log Z$	-1.084 (1.606)	$\log \sigma_{\eta X}$	0.108** (0.032)
$\log \beta_{10}$	-0.766** (0.057)	$\log \sigma_{\eta L}$	0.225** (0.083)
β_{40}	-1.563** (0.051)	$\log \sigma_{\eta t}$	0.189** (0.023)
$\log \beta_2$	0.000 Restricted	$\log \sigma_u$	8.039** (0.928)
$\log \beta_{1i}$	-0.431** (0.074)	ρ_L	0.900** See note 2
$\log \beta_{3i}$	0.340** (0.053)	ρ_t	0.900** See note 2
β_{4i}	-2.189** (0.078)		

Notes:

1. Numbers in parentheses are standard errors. Single starred items are significant at the 10% level, and double starred items are significant at the 5% level.

2. $\widehat{\rho}_L$ and $\widehat{\rho}_t$ are set equal to

$$\widehat{\rho}_r = 1.8 \frac{\exp\{\lambda_r\}}{1 + \exp\{\lambda_r\}} - .9$$

for $r = L, t$ to insure nice properties of the model. The estimates of λ are $(17.85, 11.84)$ which implies that the standard errors of $\widehat{\rho}_L$ and $\widehat{\rho}_t$ are trivial.

3. The log likelihood value is -15428.1.

Variable	Estimate on $\log \alpha$	Estimate on $\log Z$	Estimate on β_4	Estimate on $\log \beta_1$	Estimate on $\log \beta_3$
Parent Characteristics					
Constant	-5.089** (0.554)	-3.203** (0.361)	-4.186** (0.672)	-0.722** (0.159)	
Age/100	-0.864** (0.074)	-3.121** (0.237)	0.913 (0.834)		
Educ	-0.020** (0.006)				
White	0.115 (0.230)	-0.009 (0.190)	-0.236 (0.296)		
Married		0.331** (0.093)			
# ADLs	-0.165** (0.038)	-0.287** (0.037)	-0.280** (0.109)		
Mother	0.353** (0.156)	0.184 (0.144)	0.116 (0.185)		
Spouse Characteristics					
Age/100	2.599** (0.103)				
# ADLs	-0.095* (0.057)				
Child Characteristics					
Constant	-0.752** (0.347)		-5.333** (1.020)	1.113** (0.125)	0.346** (0.056)
Age/100	-0.918** (0.191)		9.933** (1.393)		
Male	0.389** (0.170)		-1.262 (1.167)		
Biological	0.110 (0.151)		-0.376 (0.633)		
Biological*Male	-0.449** (0.214)		0.851 (1.159)		
Educ	0.002 (0.016)		-0.178** (0.050)		
Married	0.401* (0.210)		-11.539** (2.138)		
# Kids	0.053** (0.023)		-0.317** (0.070)		
Oldest	-0.048 (0.133)		0.245 (0.235)		

Table 7
Estimates with Covariation in $\log \alpha$ and β_4

Table 7 (continued)			
Estimates with Covariation in $\log \alpha$ and β_4			
Variable	Estimate	Variable	Estimate
$\log \mu$	-10.153** (0.472)	$\log \sigma_{\eta t}$	0.890** (0.085)
γ	-5.846** (0.617)	$\log \sigma_u$	11.974** (0.895)
$\log \beta_0$	12.155** (0.785)	ρ_L	0.900
$\log \sigma_{\eta X}$	-0.037 (0.064)	ρ_t	0.900
$\log \sigma_{\eta L}$	0.221** (0.009)		

Notes:

1. Numbers in parentheses are standard errors. Single starred items are significant at the 10% level, and double starred items are significant at the 5% level.

2. $\widehat{\rho}_L$ and $\widehat{\rho}_t$ are set equal to

$$\widehat{\rho}_r = 1.8 \frac{\exp\{\lambda_r\}}{1 + \exp\{\lambda_r\}} - .9$$

for $r = L, t$ to insure nice properties of the model. Estimates without reported standard errors have standard errors that are trivial.

3. The log likelihood value is -14512.0.

Table 8				
Moments of Behavior				
	Parent or Spouse		Children	
Variable	Mean	Std. Dev	Mean	Std. Dev
$\log \alpha$	-3.859	0.325	-6.337	0.380
$\log \beta_1$	-0.956	0.338	1.886	0.512
$\log \beta_3$	0.080	0.146	0.329	0.077
β_4	-3.787	0.305	-13.852	4.648
Utility	6.348	10.887	6.327	11.070
logHealth	-5.510	0.533		

Table 9			
Relative Effects of Informal Care and ADLs			
	$\alpha \cdot 1000$	$\Delta Q/Q$ (t: 0 to 0.12)	$\Delta Q/Q$ (ADL: 0-1)
Individual 1	22.768	0.023	-0.287
Individual 2	2.027	0.189	-0.287

Notes: "Representative individuals:"

1. Individual 1 is a 76 year old, single, white woman with 11 years of education, 1 ADL problem, and a 47 year old, married, biological daughter. This child, who is not her oldest child, has 14 years of education and 2 children; and

2. Individual 2 is a 76 year old, married, white woman with 11 years of education, and 1 ADL problem, and no children. Her husband is also 76 years old with 1 ADL problem.

	# Obs	All Effects	Just Wage Effect	Just Quality of Care Effect	Just Burden Effect	No Effects
One Child Families						
Single Daughters	165	0.0325	0.0325	0.0325	0.0325	0.0325
Single Sons	110	0.0108	0.0295	0.0406	0.0086	0.0317
Married Daughters	238	0.0073	0.0062	0.0129	0.0047	0.0066
Married Sons	238	0.0075	0.0075	0.0109	0.0067	0.0081
Two Children Families						
Single Daughters	361	0.0153	0.0153	0.0153	0.0153	0.0153
Single Sons	238	0.0055	0.0176	0.0244	0.0043	0.0190
Married Daughters	675	0.0051	0.0044	0.0094	0.0033	0.0048
Married Sons	732	0.0030	0.0031	0.0046	0.0026	0.0033
Three Children Families						
Single Daughters	282	0.0106	0.0106	0.0106	0.0106	0.0106
Single Sons	226	0.0051	0.0163	0.0228	0.0040	0.0176
Married Daughters	631	0.0043	0.0037	0.0081	0.0028	0.0041
Sons w/ Spouse	686	0.0024	0.0024	0.0037	0.0021	0.0026
Four Children Families						
Single Daughters	205	0.0061	0.0061	0.0061	0.0061	0.0061
Single Sons	210	0.0031	0.0114	0.0161	0.0024	0.0123
Married Daughters	457	0.0037	0.0032	0.0069	0.0023	0.0035
Married Sons	432	0.0018	0.0019	0.0029	0.0016	0.0021
Five Children Families						
Single Daughters	99	0.0043	0.0043	0.0043	0.0043	0.0043
Single Sons	93	0.0034	0.0079	0.0104	0.0030	0.0086
Married Daughters	247	0.0020	0.0020	0.0034	0.0015	0.0021
Married Sons	261	0.0011	0.0010	0.0016	0.0010	0.0012

(Table 10: Decomposition of Child Gender Effects on $\Pr[t > 0]$)

Notes:

1. Each element in the table is the $\Pr[t > 0 \mid Gender, Effect]$.

2. The elements corresponding to single children use the Pr[that child provides care], and the elements corresponding to married children use the Pr[that child or the spouse of that child provides care].

<div align="center">

Table 11

Decomposition of Child Gender Effects on $\frac{\Delta^2 \log \Pr[t>0]}{\Delta \text{Effect} \Delta \text{Male}}$

</div>

	All Effects	Just Wage Effect	Just Quality of Care Effect	Just Burden Effect
Single Children				
One Child Families	-1.080	-0.072	0.246	-1.306
Two Children Families	-1.245	-0.077	0.252	-1.474
Three Children Families	-1.244	-0.074	0.262	-1.489
Four Children Families	-1.384	-0.077	0.265	-1.627
Five Children Families	-0.917	-0.081	0.193	-1.051
Married Children				
One Child Families	-0.159	0.009	-0.356	0.170
Two Children Families	-0.157	0.020	-0.334	0.154
Three Children Families	-0.159	0.005	-0.337	0.160
Four Children Families	-0.173	-0.011	-0.324	0.148
Five Children Families	-0.040	-0.027	-0.160	0.173

Notes:

1. Each element in the table is the

$$(\log \Pr\left[t > 0 \mid Male, Effect\right] - \log \Pr\left[t > 0 \mid Female, Effect\right])$$
$$- (\log \Pr\left[t > 0 \mid Male, No\ Effects\right] - \log \Pr\left[t > 0 \mid Female, No\ Effects\right]).$$

   These can be turned into percentage changes by exponentiating and subtracting one.

2. The elements corresponding to single children use the $\log \Pr$[that child provides care], and the elements corresponding to married children use the $\log \Pr$[that child or the spouse of that child provides care].

	All Effects	Just Wage Effect	Just Quality of Care Effect	Just Burden Effect
			Table 12	
	Decomposition of Child Race Effects on $\frac{\Delta^2 \log \Pr[t>0]}{\Delta \text{Effect} \Delta \text{White}}$			
Single Children				
One Child Families	-0.130	-0.043	0.106	-0.189
Two Chilren Families	-0.131	-0.045	0.109	-0.189
Three Children Families	-0.142	-0.048	0.112	-0.202
Four Children Families	-0.157	-0.049	0.114	-0.218
Five Children Families	-0.138	-0.050	0.113	-0.196
Married Children				
One Child Families	0.118	-0.042	0.248	-0.084
Two Chilren Families	0.123	-0.038	0.249	-0.083
Three Children Families	0.122	-0.039	0.251	-0.085
Four Children Families	0.124	-0.037	0.250	-0.086
Five Children Families	0.129	-0.036	0.256	-0.087

Notes:

1. Each element in the table represents

$$(\log \Pr\left[t > 0 \mid White, Effect\right] - \log \Pr\left[t > 0 \mid Black, Effect\right])$$
$$- (\log \Pr\left[t > 0 \mid White, No\ Effects\right] - \log \Pr\left[t > 0 \mid Black, No\ Effects\right]).$$

2. The elements corresponding to single children use the $\log \Pr$[that child provides care], and the elements corresponding to married children use the $\log \Pr$[that child or the spouse of that child provides care].

| | | Table 13 | | | | |
| | | χ^2 Goodness of Fit Tests | | | | |
Family Size	df	Mean Residual	χ^2 Statistic	Censored	# Censored Obs	Normalization
Time Help						
1	155	-0.02	$0.578*10^{18}$	457.70	66	17.19
2	737	0.00	80.81	80.91	0	-17.09
3	994	0.00	139.08	139.08	0	-19.17
4	605	0.01	$0.651*10^{6}$	1678.43	242	30.86
Financial Help						
1	308	1.03	$0.773*10^{6}$	194.17	21	-4.59
2	285	0.75	$0.166*10^{7}$	222.69	28	-2.61
3	350	0.14	$0.336*10^{7}$	176.01	19	-6.58
4	220	0.07	$0.557*10^{6}$	84.25	11	-6.47
Leisure						
2	744	-0.01	197.75	190.16	3	-14.36
3	994	0.07	447.65	447.65	0	-12.25
4	605	0.11	780.03	777.68	2	4.96

Notes:

1. A family of size M has $M - 1$ children.

2. The statistics reported in the column labeled "Normalization" are normalized by subtracting off the mean of the censored χ^2_{df}, $0.978 \cdot df$, and dividing by the standard deviation, $\sqrt{1.722df}$. The relevant general formula is

$$
\begin{aligned}
E\chi^2_{1c} &= F_3(c) + c[1 - F_1(c)]; \\
E\left(\chi^2_{1c}\right)^2 &= 3F_5(c) + c^2[1 - F_1(c)]
\end{aligned}
$$

where χ^2_{1c} is a χ^2 random variable with one degree of freedom censored at c and $F_{df}(c)$ is the χ^2 distribution function with df degrees of freedom evaluated at c.

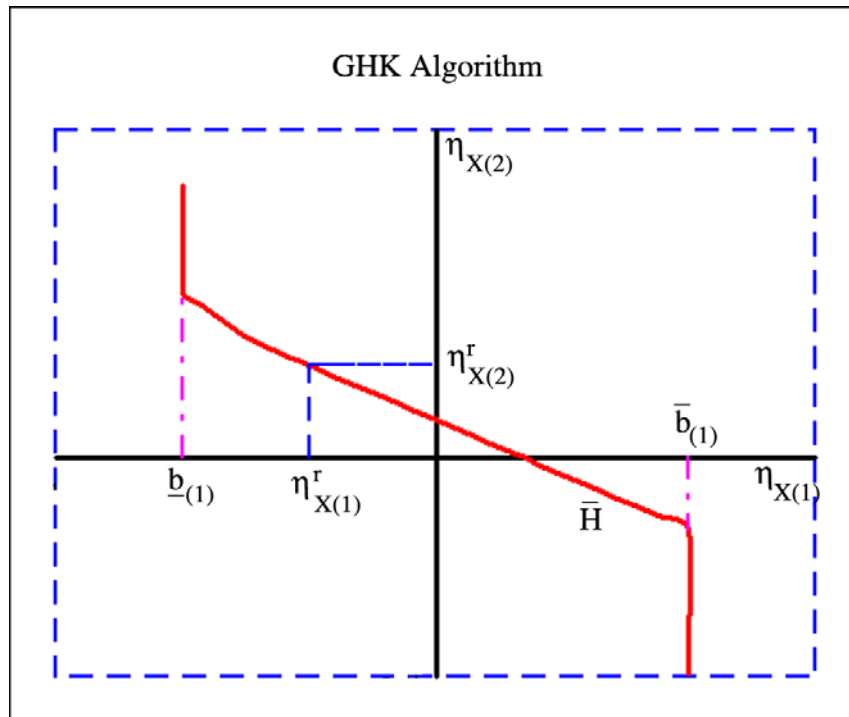|		Number of Children			
Table 14 Policy Experiments					
	Expmnt #	0	1	2	3
Increase in formal care per $q "formal care stamps"	1	0.48	0.35	0.34	0.33
Increase in informal care by children per $ informal care subsidy for children	2	–	0.99	2.09	2.91
Increase in formal care per $ increase in Medicaid Income limit	5	–	0.15	0.23	0.27
Increase in formal care per $q "formal care stamps" conditional on ADLs	6	–	0.43	0.17	0.24

Note: All numbers are measured in hours.
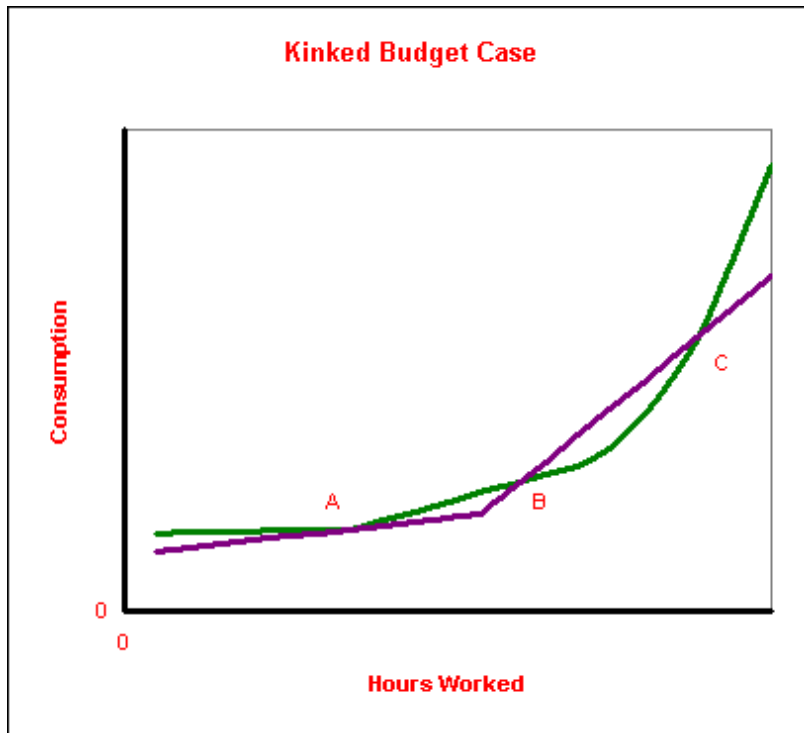
Figure 1:

Figure 1

Figure 2:

Figure 2