Testing Efficiency of Family Decisions; the Case of Adult Children's Caring Decisions

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Abstract

We characterize a generic procedure for testing Pareto inefficiency of decisions of interacting individuals in the field. Observed behavior of single actors (who act in isolation) is used to estimate a payoff function defined over private and (potentially) public goods. We then invoke a maintained assumption in the public goods literature: the utility derived from public goods depends on the total amounts provided, not on the number and identity of providers. This allows for testing whether an observed allocation of interacting individuals is Pareto efficient without making any assumptions on the nature of equilibria. The cost of inefficiency can be estimated without interpersonal comparability or utility cardinalization assumptions. In an application to the decisions of adult children caring for their parents we find a sizeable degree of inefficiency.

Keywords: Pareto efficiency, family decision making, informal care

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1 Introduction

Numerous studies in the lab and in the field have shown that many individuals contribute more to public goods than pure self-interest would predict. At the same time, however, levels of public good provision are often lower than efficient. The failure to achieve socially efficient levels has not only been found when co-players are anonymous. It has also been found when co-players are colleagues (e.g. Haan and Kooreman, 2002), peers (e.g. Stoop et al., 2012), or family members (Peters et al., 2004).

In sharp contrast, in the literature on family decision making the question whether contributions to public goods are socially efficient is at best a side issue. The mainstream approach in the literature on intra-family behavior uses the 'collective framework', which presupposes that allocations *are* Pareto efficient; see e.g. Cherchye et al. (2012) and Browning et al. (2013) for recent contributions. A small fraction of the family economics literature explicitly considers the possibility of Pareto inefficient allocations, with Lechene and Preston (2011), Cherchye *et al.* (2008), and Del Boca and Flinn (2012) being recent examples.

As the cited public goods literature suggests, Pareto optimality is likely to be an exception rather than a rule, even in a family decision context. Moreover, various authors find that individuals act more cooperatively in laboratory settings than they do outside the laboratory; see e.g. List (2006) and Stoop et al. (2012). Therefore, in the analysis of field data on family behavior, universal Pareto optimality is likely to be too bold an assumption. Empirical consumer demand and labor supply studies reveal a large degree of heterogeneity between families in terms of preferences and intra-family distribution of resources. We conjecture that families are also heterogenous in whether their allocations are Pareto efficient or inefficient.

The relative neglect of the efficiency issue in the intra-household literature is most likely related to the difficulty of identifying Pareto optimality empirically. In experimental studies of public good games a player's objective function usually simply equals his earnings by construction, in which case the efficiency of outcomes can be readily verified. In contrast, family members have preferences defined over private and public goods and time allocations. Only when the utility functions of the individual family members are known, verification of Pareto efficiency of observed allocations becomes feasible.

We present a method to test Pareto efficiency in the context of decisions of interacting adult siblings when caring for their parents. We use observed behavior of only children (without siblings) to estimate a utility function that identifies preferences defined over a (potentially) public good (care for parents) and private consumption and leisure. Invoking an assumption central in the public goods literature – preferences for public goods only depend on the total amounts provided, not on the number and identity of providers – Pareto efficiency of caring decisions of interacting siblings can be verified, if the utility function would be known exactly. Since we only have an estimate of the utility function Pareto optimality cannot be verified exactly. However, we can calculate the probability that an observed allocation is Pareto optimal. We reject the hypothesis of Pareto optimality if this probability is smaller than a preset confidence level. Importantly, our approach does not require any assumptions about the nature of equilibria.

We also consider the cost (deadweight loss) of Pareto inefficiency. We define the cost of inefficiency as the minimum sum of compensations that should be given to inefficiently interacting individuals to reach the same utility level as in a Pareto efficient allocation, with the minimum taken over the set of Pareto efficient improvements over the observed allocation, and the sum taken over individuals. The cost can be calculated without interpersonal comparability or utility cardinalization assumptions.

We reject the hypothesis of Pareto optimality for one third of the two child families, half of the three child families and 60% of the three child families. The median worth of the smallest Pareto improvements is about 40 euros per family per week. Moving to Pareto optimal allocations would be worth even 173 euros per family per week (median). We define this to be the costs of inefficiency. The median relative cost of inefficiency is 17% of total consumption (when considering Pareto optimal allocations). The occurrence of inefficiency increases in the number of siblings. We also investigate how the occurrence and cost of inefficiency depend on family characteristics like the genders, age differences and education levels of siblings, and discuss the implications of our findings for long term care policies. We conclude with a discussion of other potential areas of application of this paper's methodology.

The paper proceeds as follows. Section 2 discusses the literature on informal caregiving, focusing on the issue of interactions between caregivers. In section 3 we specify and estimate the structural model for only children. Section 4 explains the test for the efficiency of care-giving decisions in families with more than one child and presents the test results. In section 5 we define and calculate the costs associated with inefficient family outcomes. Section 6 concludes.

2 Family interactions in caregiving

The literature on informal caregiving is extensive, and we do not aim to review it here. For the purpose of this paper we choose to focus on the issue of family interactions in the caregving literature.

Obviously, more children means that more resources are available to care for parents. However, children may shirk their responsibilities if there are other siblings who can do the work, such that the amount of care given by one sibling depends negatively on the care provided by the other(s). In case of a strategic bequest motive (described by Bernheim and Summers, 1985), the amount of care given by a sibling depends positively on the care given by the other siblings. However, more recent studies do not support the bequest motive (Sloan et al., 1997; Perozek, 1998; Callegaro and Pasini, 2008). It has been found that siblings are each other's substitutes. The more siblings a child has, the less often the child visits the parent and the less often he or she gives support to the parent (Kalmijn, 2007; Kalmijn and Saraceno, 2008; Spitze and Logan, 1991). In addition to the number of siblings, the nature of the interactions between siblings plays a role in informal care decisions. Konrad et al. (2002), Holmlund et al. (2009), and Johar and Maruyama (2012) investigated strategic interactions in location choice of children with regard to their parents. Konrad et al. (2002) argue that firstborn children have a first-mover advantage and locate further away from their parents than second-born children. Second-born children therefore experience a higher burden of providing care. Using a structural game-theoretic framework, Johar and Maruyama (2012) also found strategic interactions in location choice between siblings in the U.S., but only a small first-mover advantage.[1]

Some studies that consider caregiving decisions among siblings explicitly assume that decisions are made non-cooperatively (Hiedemann and Stern, 1999; Byrne et al., 2009; Callegaro and Pasini, 2008; Fontaine et al., 2009), while others assume a two-stage decision process in which siblings (1) decide whether to participate in caregiving or not, and (2) those who participate in caregiving make a cooperative care decision (Engers and Stern, 2002).

In sum, the lions share of the literature on siblings interaction related to caregiving is based on reduced form analyses. The small number of papers that uses structural models typically impose either noncooperative or cooperative equilibrium concepts. In contrast, we aim to infer the nature of the interactions from the data.

3 Estimating the utility function for caring, leisure and consumption

The starting point of our empirical procedure is to estimate the utility function for caring, leisure and consumption using data on children without siblings. Section 3.1 deals with the specification of the model. Section 3.2 briefly describes the data and explains the imputation of wage rates and other household income; more elaborate descriptions are provided in Appendix A. Section 3.3 describes the likelihood function and the estimation strategy. Section 3.4 presents the estimation results.

3.1 Model specification

The child derives utility from leisure (t_l), consumption (c), the amount of informal care her parents receive (t_s). Since we cannot observe the household product 'informal care' the number of hours spent on informal care enters the utility function directly.[2] We use the following

[1]Our study focuses on care arrangements, taking living arrangements as given. Some studies model both care and living arrangements, e.g. Hoerger et al. (1996), Pezzin and Schone (1999), and Pezzin et al. (2007).

[2]Note that distinguishing household production parameters and preference parameters hinges on functional form assumptions if the household product cannot be directly observed; see e.g. Pollak and Wachter (*JPE*, 1977), Kerkhofs and Kooreman (*JAE*, 2003). Our utility function below can be interpreted as a reduced form where the household products have been eliminated by substituting the household production function into the utility

quadratic (reduced form) utility function

$$U(t^*) = t^{*\prime} A^* t^* + t^{*\prime} b^*, \tag{1}$$

where $t^* = (t_l, c, t_s + \gamma t_f)'$, $\gamma > 0$, A^* is a lower triangular 3×3 matrix with entries $\alpha_{ll}, \alpha_{cc}, \alpha^*_{ss}, \alpha_{lc}, \alpha^*_{ls}, \alpha^*_{cs}$ and $b^* = (b^*_l, b^*_c, b^*_s)'$.

In our data we do not observe the amount of formal care parents receive, t_f.[3] The following assumption allows us to eliminate t_f. Let

$$t_f = F - \delta t_s \quad 0 \leq \delta < 1 \tag{2}$$

where F is the number of hours of care received when the child does not provide any informal care. If the child provides t_s hours of informal care, formal care is reduced by δt_s with $0 \leq \delta \leq 1$. F and δ will typically depend on the parents' health and their country's institutional arrangements. The parameter γ allows formal and informal care to be less than perfect substitutes in the child's utility function. Our stochastic specification presented below will allow all parameters of the reduced form utility function as well as F, γ, and δ to vary across families.

Substitution of (2) into the utility function (1) and rewriting shows that maximizing (1) is equivalent to maximizing

$$U(t) = t' A t + t' b, \tag{3}$$

where $t = (t_l, c, t_s)'$, A is a lower triangular 3×3 matrix with entries $\alpha_{ll}, \alpha_{cc}, \alpha_{ss}, \alpha_{lc}, \alpha_{ls}, \alpha_{cs}$, $b = (b_l, b_c, b_s)'$, and

$$\alpha_{ss} = \alpha^*_{ss}(1 - \gamma\delta)^2$$

$$\alpha_{ls} = \alpha^*_{ls}(1 - \gamma\delta)$$

function. Differences between children in the effectiveness of providing care will be accounted for by allowing for observed and unobserved heterogeneity in the parameters of the (reduced form) utility function; cf. Byrne et al. (2009).

[3]The amount of formal care that parents receive (t_f) may also include care received from other people, such as neighbors.

$$\alpha_{cs} = \alpha^*_{cs}(1 - \gamma\delta)$$

$$b_l = \alpha^*_{ls}\gamma F + b^*_l$$

$$b_c = \alpha^*_{cs}\gamma F + b^*_c$$

$$b_s = 2\alpha^*_{ss}\gamma F(1 - \gamma\delta) + (1 - \gamma\delta)b^*_s.$$

We will estimate $\alpha_{ll}, \alpha_{cc}, \alpha_{ss}, \alpha_{lc}, \alpha_{ls}, \alpha_{cs}, b_l, b_c$ and b_s, which are consistent with all situations described above.[4][5] The child is assumed to maximize the utility function subject to a time and budget constraint. The time and budget constraints are specified as

$$\begin{aligned} t_l + t_h + t_s + (zd)K &= T \\ c + Kp_d d &= wt_h + \mu \end{aligned} \tag{4}$$

where

t_h = labor time (hours)

K = number of visits (per week)

d = distance to parent (return trip, km)

z = travel time per kilometer (hours)

T = total time (# hours in one week)

p_d = travel costs (per kilometer)

w = wage (per hour)

μ = remaining household income

Remaining household income (μ) includes all income that is not earned by the adult child.

[4]The financing of long term care is different between countries and may influence the budget constraint of the parents. In case adult children receive a transfer from the government for providing informal care this will in general be a mere pittance compared to what can be earned in the labor market.

[5]For the model to be economically rational, the marginal utility of consumption must be positive; see e.g. Van Soest (1995). Therefore, in a robustness check we include a penalty for negative marginal utilities of leisure and consumption. The marginal utility of informal care may be negative. Estimates of Byrne et al. (2009) show that adult children care about their parents' health quality, suggesting that altruism may play an important role in the provision of informal care. However, they also show that informal care provision tends to be burdensome, which may explain why few family members provide care for elderly individuals.

It includes capital income, social transfers, and labor income of the partner (if the adult child has a partner). We abstract from the fact that labor market choices of the adult children under consideration and their partners may be determined simultaneously and that children in law may also provide informal care to the parents.[6]

We assume wage rates to be exogenous.[7] We also assume that the geographical distance between adult children and their parents is exogenous. To motivate this assumption, we take a preview to our panel data. In families for which there has been a health shock for at least one of the parents between the two waves of the panel 11.2% of the children moved closer to their parents. In families without a health shock 10.7% of the children moved closer to their parents. The difference is small and insignificant (p-value: 0.774). This is in line with Hiedemann *et al.* (2013), who find that location moves motivated by the need of care provision occur infrequently.
[8]

To take into account preference variation across adult children, the vectors in b are functions of observed and unobserved characteristics of the adult children and their parents. Most families are observed in two waves. From here we use the index τ to indicate waves. We specify

$$\begin{aligned} b_{l\tau} &= X_{l\tau}\beta_l + u_l \\ b_{c\tau} &= X_{c\tau}\beta_c + u_c \qquad (5) \\ b_{s\tau} &= X_{s\tau}\beta_s + u_s. \end{aligned}$$

Note that this implies that F, γ, and δ are allowed to vary across families. $X_{l\tau}$ and $X_{c\tau}$ contain characteristics which are likely to influence the amount of leisure time and consumption that

[6]Kalwij et al. (2014) find that only 16% of all care that is not provided by children is provided by sons-in-law or daughters-in-law.

[7]Bolin et al. (2008b) found no statistically significant wage-rate effects of informal care provision in Europe. Carmichael and Charles (1998) and Heitmueller and Inglis (2007), on the other hand, do find wage-rate effects in the UK (they also include individuals younger than 50). Furthermore, Skira (2013) finds that in the US women who leave work to provide care face lower probabilities of receiving job offers in the future.

[8]Children's place of residence depends on several factors, such as job opportunities, a partner and friends. Charles and Sevak (2005) test whether children's place of residence endogenously responds to parent's health but found no evidence of this. On the other hand, Konrad et al. (2002) and Maruyama and Johar (2013) find that siblings act strategically when making location choices. According to Konrad et al. First-born children shift some of the burden of informal care to the second-born child by locating themselves further away from the parents. Stern (1995) uses lagged geographic distance as an instrument for current geographic distance to handle the endogeneity argument. Hiedemann et al. (2013) find some location moves that seem to be motivated by the need of care provision, but find that such moves occur so infrequently that it would be very difficult to estimate any parameters associated with location choice.

adult children prefer, such as the age, gender, education, number of own children, and marital status of the adult children. $X_{s\tau}$ includes variables influencing the preference for providing informal care to parents, namely the health and education level of the parents, whether both parents are alive and the gender of the parent when the parent is single, the (average) age of the parents, the gender of the child, country specific dummy variables, and the number of children of the adult child. The country specific dummy variables capture social norms and culture.[9] By including variables about the presence of both parents we take into account that partners can (partly) care for each other, which is likely to diminish the children's need to provide care. Also, education is included in the matrix $X_{s\tau}$, because high educated children may have different value orientations (Kalmijn, 2006). Random preferences due to unobserved characteristics are incorporated through the terms u_l, u_c, and u_s. They capture time invariant unobserved heterogeneity. For example, u_s may capture the three motives that are, in addition to observed characteristics, important in explaining social support: reciprocity, altruism, and norms of responsibility.[10] We assume $u = (u_l, u_c, u_s)$ to be distributed jointly normal with mean zero and covariance Σ_u

$$\begin{bmatrix} u_l \\ u_c \\ u_s \end{bmatrix} \sim N \left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_l^2 & \sigma_{l,c} & \sigma_{l,s} \\ \sigma_{l,c} & \sigma_c^2 & \sigma_{c,s} \\ \sigma_{l,s} & \sigma_{c,s} & \sigma_s^2 \end{bmatrix} \right). \tag{6}$$

It is important to note that while we adopt a specific parametric form for the utility function, preferences are identified nonparametrically. In general, preferences are not fully identified in a model that disaggregates nonlabor time use since each nonlabor time use category has the same price, the wage rate (Hicks aggregate commodity theorem). However, in our case the price of informal care exceeds the price of pure leisure because of travel costs. Moreover, the price ratio varies across families as wages and distances to parents vary.

[9]We do not include country-specific government programs that may influence the budget constraint of caregivers.

[10]These three motives are investigated in the sociological literature (e.g. Kohli and Künemund, 2003, and Kalmijn, 2010). Kalmijn (2010) found that altruism is an important motive for parents to support their children, however, for adult children, reciprocity and norms of responsibility appear to be more important.

3.2 Data

To estimate the parameters of the model we use the Survey of Health, Ageing and Retirement in Europe (SHARE). Here we describe the data only briefly. We use data on families observed in the wave 1 (2004/2005), wave 2 (2006/2007), or both. The current study considers the respondents in their role as (potential) *recipients* of informal care. The reason for using this 'parents sample' (cf. Crespo and Mira, 2010) is that it contains information on all siblings within a family, including geographical distance between the children and their parents, employment status of the children, and the amount of informal care they provide to their parents. If we were to consider the respondents as the *providers* of informal care, there would be no information on the amount of informal care the siblings of the respondents give to their parents. We select all respondents with one, two, three or four adult children who are at least 40 years and who do not live in the same household as the respondent. Our final sample has 1679 adult children without siblings, 2146 adult children with one sibling, 857 adult children with two siblings, and 277 adult children with three siblings. Most of the families are observed in two waves (41%), 26% of the families are only observed in the first wave and 33% are only observed in the second wave. Table 1 shows the amount of informal care and the number of observations per country. We find that in general only children are more often involved in informal care giving than siblings and that they also provide more hours of informal care. This suggests that the hours of care provided by a sibling are a substitute for someone's own provision of informal care. A more elaborate data description and motivation of selecting our sample are provided in appendix A.

Table 1: Informal care per country[a]

Country	# Observations				% Informal caregivers				# Hours (if>0)			
# Siblings	0	1	2	3	0	1	2	3	0	1	2	3
Austria	216	430	213	108	15	13	9	15	16	7	5	6
Germany	290	566	351	124	19	15	10	13	17	6	13	4
Sweden	214	664	354	184	11	7	8	5	7	6	4	16
Netherlands	114	442	414	172	8	4	4	5	3	5	3	4
Spain	98	306	162	84	13	10	16	2	17	20	15	5
Italy	167	338	153	56	12	9	12	5	18	13	13	21
France	261	504	429	184	14	10	9	10	10	6	11	7
Denmark	134	508	360	128	11	6	8	6	5	7	4	2
Greece	209	766	258	96	20	20	16	14	17	11	13	11
Belgium	316	522	366	236	20	8	12	11	6	11	7	8
Czechia	163	446	156	40	24	30	30	25	12	11	8	7
Poland	49	206	138	52	16	17	10	12	17	5	14	10
Total (observations/%)	2231	5698	3354	1464	16	12	11	9	12	9	9	8

[a] Percentage of children involved in informal care and the number of hours of informal care, conditional on giving any informal care, per country.

Wage rates (w) and remaining household income (μ) of the adult children are unknown in SHARE. Therefore, we use predictions from a wage equation and an equation for remaining household income. Both equations are estimated using the 'European Union Statistics on Income and Living Conditions' (EU-SILC). In the wage equation we take into account sample selection using the method presented by Heckman (1979). A more elaborate description of the wage equation, the equation for remaining household income, and the EU-SILC data are provided in appendix A.1.

In the structural model, introduced in section 3.1, we take into account that wage rates and remaining household income are predicted with error. Using the estimated variances of the errors in the wage equations and the remaining household income equations (σ_w^2 and σ_μ^2) we integrate the prediction errors out.

3.3 Estimation procedure

We estimate the model in a discrete choice form; cf. Van Soest (1995). In the discrete choice form adult children choose between a finite number of combinations of labor, informal care, amounts of leisure and consumption that satisfy the time and budget constraints. A numerical advantage is that the utility maximizing choice can be found by simply comparing the utility levels for all choice options, without using first-order conditions. Another motivation for the discrete choice approach is that it better aligns with the nature of our data. For example, with regard to labor the data distinguish between full-time employment, part-time employment, and no employment only, which we (initially) categorize as 36, 18, and 0 hours of work, respectively. With regard to informal care, the data contains information about how often parents received help from their children in the last twelve months. From this information we categorize the informal care data as 0 hours, 2 hours per week and 1 visit per week, 6 hours per week and daily visits, and 18 hours per week and daily visits (thus the amount of informal care and the number of visits are thus captured simultaneously and not optimized separately). Thus in total we have a choice set of 12 alternatives (3 labor market categories $\times$ 4 informal care categories). Corner solutions like $(t_s, t_f) = (0, 0)$ are elements of the choice set and thus accommodated for. Of course, discretization comes at the price of introducing rounding errors. We will check the sensitivity of our results to the details of our discretization procedure in Appendix C.

The time endowment T is 168 hours per week. We assume the travel time per kilometer is 0.025 hours (τ) and that the travel cost per kilometer is 0.4 euro (p_d).

We estimate the model parameters using maximum likelihood. The likelihood contribution of an individual i who chooses alternative j, and who is observed in one wave only, is

$$\begin{aligned} &L(\alpha, \beta, \Sigma_u | X_\tau, d_\tau, \beta_w, \sigma_w, \beta_\mu, \sigma_\mu) \\ &= \iiiint\!\!\int_{-\infty}^{+\infty} P(U_{j\tau} > U_{k\tau} \text{ for all } k \neq j | X_\tau, d_\tau, w_\tau, \mu_\tau, u) p(u) p(w_\tau) p(\mu_\tau) du dw_\tau d\mu_\tau. \end{aligned} \tag{7}$$

where $p(u)$ is the density of vector u, and we take into account that wage rates and remaining household income are predicted with error.

The integral can be approximated using simulations (simulated maximum likelihood). Using R simulations, the likelihood contribution of equation (7) becomes

$$\begin{aligned} &L_{iR}(\alpha, \beta, \Sigma_u | X_\tau, d_\tau, \beta_w, \sigma_w, \beta_\mu, \sigma_\mu) = \\ &\frac{1}{R} \sum_{r=1}^{R} P(U_{j\tau} > U_{k\tau} \text{ for all } k \neq j | X_\tau, d_\tau, w_\tau^r, \mu_\tau^r, u^r), \end{aligned} \tag{8}$$

where

$$w_\tau^r = \exp(X'_{w\tau}\beta_w + v_w^r) \tag{9}$$

and v_w^r is a draw from the normal distribution with variance σ_w^2. In the same way

$$\mu_\tau^r = \exp(X'_{\mu\tau}\beta_\mu + v_\mu^r), \tag{10}$$

where v_μ^r is a draw from the normal distribution with variance σ_μ^2.

The draws $u^r, v_w^r, v_\mu^r, r = 1 \ldots R$ are from a multivariate normal distribution. A draw can be obtained by taking 5 (pseudo-random) draws from a standard normal distribution (which we call $\theta = (\theta_l, \theta_c, \theta_s, \theta_w, \theta_\mu)$') and then calculating $(u_l^r, u_c^r, u_s^r, v_w^r, v_\mu^r)' = L\theta$. Here, L is the Choleski factor of the covariance matrix of the error terms. Integrals can be approximated with fewer draws (R) when using Halton draws instead of pseudo-random draws. This is because Halton sequences provide more coverage of the density which has to be integrated.[11]

For most countries the estimates of σ_{wp} in the EU-SILC data are not significant, which indicates that selection with regard to unobservables is not very important. We therefore do not take into account correlations between v_w, v_μ and the unobserved characteristics (u_l, u_c, u_s).

Most adult children are observed in two waves. The likelihood contribution of these adults, who choose alternative j in wave 1 and alternative h in wave 2 is

$$\begin{aligned} &L_{iR}(\alpha, \beta, \Sigma_u | X_1, X_2, d_1, d_2, w_1, w_2, \mu_1, \mu_2) = \\ &\frac{1}{R}\sum_{r=1}^{R} P(U_{j1} > U_{k1} \text{ for all } k \neq j | X_1, d_1, w_1^r, \mu_1^r, u^r) \\ &* P(U_{h2} > U_{k2} \text{ for all } k \neq h | X_2, d_2, w_2^r, \mu_2^r, u^r). \end{aligned} \tag{11}$$

To smooth the likelihood function in order to facilitate its numerical maximization we introduce random disturbances to the utilities of the twelve choice opportunities

$$U_{j\tau} = U(t_{j\tau}) + \epsilon_{j\tau} \quad j = 1, ..., 12 \quad \tau = 1, 2 \tag{12}$$

[11]For more information about the derivation of Halton sequences see for example Train (2003), or Drukker and Gates (2006), who discuss the advantages of Halton sequences when using simulations to approximate integrals numerically.

where $\epsilon_{j\tau}$ are independent and identically distributed Gumbel variates with the cumulative distribution function

$$F(\epsilon_{j\tau}) = \exp[-\exp(-\epsilon_{j\tau}/\lambda)], \lambda > 0 \tag{13}$$

leading to choice probabilities

$$\begin{aligned} &P(U_{j\tau} > U_{k\tau} \text{ for all } k \neq j | X_\tau, d_\tau, w_\tau, \mu_\tau, u) = \\ &\exp(U(t_{j\tau})/\lambda) / \sum_{k=1}^{12} \exp(U(t_{k\tau})/\lambda). \end{aligned} \tag{14}$$

The variance of $\epsilon_{j\tau}$ is $V(\epsilon_{j\tau}) = \pi^2\lambda^2/6$ (see Ben-Akiva and Lerman, 1985, p.104). $t_{j\tau}$ represents the combination (t_l, c, t_s) of alternative j chosen in period τ. Substituting the utility function (1) and the time and budget constraint (4) into equation (14) leads to

$$\begin{aligned} &P(U_{j\tau} > U_{k\tau} \text{ for all } k \neq j | X_\tau, d_\tau, w_\tau, \mu_\tau, u) = \\ &\exp((t'_{j\tau} A t_{j\tau} + t'_{j\tau} b)/\lambda) / \sum_{k=1}^{12} \exp((t'_{k\tau} A t_{k\tau} + t'_{k\tau} b)/\lambda), \end{aligned} \tag{15}$$

where the amount of leisure and consumption for alternative j in period τ are defined by

$$\begin{aligned} t_{l\tau} &= T - t_{h\tau} - t_{s\tau} - (zd_\tau)K_\tau \\ c_\tau &= w_\tau t_{h\tau} + \mu_\tau - K_\tau p_d d_\tau. \end{aligned} \tag{16}$$

Equation (15) presents the probability that a certain combination of (t_l, c, t_s) is chosen in period τ, given observed and unobserved characteristics. In the baseline model we choose the scale factor λ to be one (in the same way as in the multinomial logit model). As a robustness check we will lower the value of λ. This increases the scale of the utilities when they enter the logit function. In this way we can approximate the model without random disturbances $\epsilon_{j\tau}$. When λ is too low numerical difficulties occur in the estimation (λ smooths the likelihood function).[12]

[12] Since only the ratio of βs and λ is identified, allowing for heterogeneity in λ is observationally equivalent to allowing for heterogeneity in the βs, as we do; cf. Keane and Wise (2013).

3.4 Estimation results for the one child model

The full estimation results of the structural model for only children are described in appendix B. Here the results are best presented by showing relationships between wage rates, distances and informal care as implied by the estimation results. Figure 1 shows the relation between geographical distance and the amount of informal care given by a reference individual in the model. As a reference individual we consider a married German woman of 55, with an 80 year old father in poor health, no mother, and 2 children of her own. She has a medium education level, a wage rate of 10 euros per hour and her remaining household income is 15,000 euros per year. Unobserved heterogeneity is important regarding the preferences for informal care. Figure 1 therefore shows seven lines. Each line represents the reference individual with a different random effect u_s. These reflect, for example, different levels of family ties, degree of altruism, or feelings of obligation to provide informal care. The line 'p50' shows the relationship between distance and informal care when all random effects u_l, u_c and u_s are equal to zero. This means that the unobserved preferences with regard to leisure, consumption, and informal care are at the median level. For example, with regard to informal care we can interpret this reference individual to have 'median responsibility norms'. The line 'p90' represents the reference individual with high unobserved preferences for informal care, i.e. only 10% of the individuals have a higher random effect u_s. The same explanation holds for the other lines, p10, p25, p60, p70, and p80. For example, for line p25, only 25% of the people have smaller unobserved preferences for informal care. u_l and u_c are zero for all lines, such that the only difference between the lines is the random effect u_s, the unobserved heterogeneity with regard to informal care. Figure 1 shows that the higher the preference of the reference individual to provide care, the longer it takes before informal care decreases with distance (the distance elasticity is lower for those with high preferences for informal care).

Figure 2 shows that for the majority of adult children, who provide almost no informal care, distance to the parent does not influence labor force participation (p10, p25 and p50). Focussing on p70, we see that labor supply increases with distance. Apparently, at least part of the reduction in informal care is replaced by labor.

In line with the literature (e.g. Evers et al., 2008), figure 3 shows a positive wage elasticity of labor supply. According to figure 4 the wage elasticity of informal care supply is small. The wage elasticity for a reference individual with large norms of responsibility (or other reasons that lead to a high unobserved preference for informal care) is almost zero.

4 Testing for Pareto efficiency

To illustrate our approach for testing Pareto efficiency consider a family with two children. The extension to larger families follows analogously. In the case of two siblings we have 144 (12×12) possible allocations, one of which is observed as the siblings' actual choice. For a given draw of the error terms we first compute the utility that siblings obtain for the observed allocation. Next, for the same draw of the error terms, we determine whether there exist allocations with a higher utility level for at least one of the siblings without making the other sibling worse off. We run this for 100 drawings of the error term[13] The fraction of times a Pareto improvement exists is an estimate of the probability that the observed allocation is inefficient.

Below we make explicit the assumptions made in this testing procedure. First of all, we assume that the utility function for leisure, consumption and informal care of siblings has the same *parameter* values as the utility function of only children. Of course this does not imply that the utility functions are equal as the siblings and only children may have different observed as well as unobserved characteristics. Moreover, this assumption only applies to the parameters of the subutility function for care for parents, private leisure and private consumption. Other components of utility, like the possible effect of companionship associated with having siblings, are assumed to be separable from the goods under consideration; cf. Browning *et al.* (2013).

This assumption is the same as generally made in the literature on the provision of public goods. While the number of potential contributors to a public good affects the *level* of public good provision, is does not affect the contributors' *preferences* for it. In the sociological litera-

[13] Although 25 drawings already gives about the same results.

ture on caregiving Polit and Fablo (1987) and Spitze and Logan (1991) report some evidence in line with this assumption. Polit and Fablo (1987) provide a quantitative review of 141 studies that compare personality development of only children and siblings. Overall, this review indicates that only children are comparable in most respects to their siblinged counterparts. No differences are found between only children and others in character, sociability and personal control. Spitze and Logan (1991) found that children's closeness to parents and attitudes towards filial responsibility are unrelated to being an only child or not. Their study shows that differences in support between families with different numbers of siblings are not attributable to different attitudes or feelings of closeness between these families. Instead, to explain differences in support between families of different size, they propose that attention should be paid to how each child adjusts his or her own behavior when more children are potentially available to support parents. Accordingly, in our model the only difference between only children and siblings is that in families with two adult children there is a sibling available who can also provide informal care (the hours of informal care t_s in the utility function becomes the sum of own informal care and informal care provided by the sibling). It could be argued that families with a large number of children are more familiastic or that children in larger families receive less direct attention from parents and are therefore less close to their parents. Given the importance of the assumption about only children and siblings for the empirical analysis, we will test the sensitivity of the main results with regard to this assumption in appendix C.

Secondly, we assume that the sum of informal provided by the child and his/her sibling enters each sibling's utility function, i.e. the child and his/her sibling have the same weight. Again, in appendix C we will relax the assumption of perfect substitutability by introducing a production function for parental care with a constant elasticity of substitution between the informal care time spent of the two siblings:

$$t_s = 2[\mathrm{a}(t_{s1})^{\xi} + (1-\mathrm{a})(t_{s2})^{\xi}]^{\frac{1}{\xi}}, \quad 0 < \mathrm{a} < 1, \quad 0 < \xi \leq 1 \tag{17}$$

and check the sensitivity of our results to deviations from our current assumptions a=1/2 and $\xi = 1$.

Figure 5 shows the share of times (out of 100 draws) that a Pareto improvement exists. For families with two children, we find that for 36% of the families a Pareto improvement exists in more than 95 of the 100 draws. To investigate which families make inefficient decisions, we regress the fraction of times with Pareto inefficiency on several background characteristics. The results in table 2 show that Pareto inefficiency more often exist among sisters than among brothers. Furthermore, Pareto inefficiency is significantly smaller for families where both siblings have a high education level, compared to families where both siblings have a medium education level. Also, Pareto inefficiency is more common among families with low educated parents. The occurrence of conflicts in families is associated with a 5%-points higher fraction of times with the existence of a Pareto improvement.[14] Since only a subsample of families answered questions about conflicts in the family, we also estimate the model without the data about conflicts. These results are in the appendix, table 13. The conclusions are the same.

For families with three adult children, we find that for 49% of the families a Pareto improvement exists in more than 95 of the 100 draws. Figure 6 shows the share of times (out of 100 draws) that a Pareto improvement exists. Table 2 shows that, again, Pareto inefficiency occurs more often in families with sisters than in families with brothers. Education of the children and the parents has the same sign as before, but is not significant anymore. Moreover, Pareto inefficiency appears more often in families where adult children have a partner.

Finally, figure 7 shows the share of times (out of 100 draws) that a Pareto improvement exists for families with four children. For 60% of the families a Pareto improvement exists in more than 95 of the 100 draws. Again, Pareto inefficiency occurs more often in families with sisters than in families with brothers (table 2). We conclude that Pareto inefficiency occurs more often in large families, in families with sisters, in families with low education levels and in families with conflicts.

[14] Data on family conflicts are gathered using a self-administered drop-off questionnaire. In 22% of the families with two siblings there are sometimes or often family conflicts, in the other 78% of the families there are never of rarely family conflicts. Not everyone participated in the drop-off questionnaire.

5 The Cost of Pareto Inefficient Caring Decisions

Consider a pair of siblings who have chosen the Pareto inefficient allocation $(\tilde{t}_h^A, \tilde{t}_s^A)$ and $(\tilde{t}_h^B, \tilde{t}_s^B)$. The implied corresponding values of the optimal amounts of leisure and consumption are given by equation (4), while the optimal number of visits directly follows from $\tilde{t}_s$. To emphasize the dependence of the utility level on remaining household income μ, we define the indirect utility function (suppressing the time subscript τ and sibling superscript m)

$$\begin{aligned} \tilde{\Psi}(\mu) &= U(\tilde{t}_l, \tilde{t}_s, \tilde{c}) \\ &= U(T - \tilde{t}_h - \tilde{t}_s - (zd)\tilde{K}, \tilde{t}_s, w\tilde{t}_h + \mu - \tilde{K}p_d d) \end{aligned} \tag{18}$$

Let $(\hat{t}_h^A, \hat{t}_s^A)$, $(\hat{t}_h^B, \hat{t}_s^B)$ denote a Pareto efficient improvement over the observed allocation, i.e. $\hat{\Psi}(\mu^A) > \tilde{\Psi}(\mu^A)$ and $\hat{\Psi}(\mu^B) \geq \tilde{\Psi}(\mu^B)$ or $\hat{\Psi}(\mu^A) \geq \tilde{\Psi}(\mu^A)$ and $\hat{\Psi}(\mu^B) > \tilde{\Psi}(\mu^B)$. A unique pair (y^A, y^B) exists such that

$$\begin{cases} \tilde{\Psi}(\mu^A + y^A) = \hat{\Psi}(\mu^A) \\ \tilde{\Psi}(\mu^B + y^B) = \hat{\Psi}(\mu^B) \end{cases} \tag{19}$$

Thus y^k is the extra unearned income that sibling k needs in the inefficient allocation in order to be as well of as in the Pareto efficient improved allocation. Given our discretization, we check for each of the 12^2 possible allocations whether it qualifies as a Pareto efficient improvement over the observed allocation. If this is the case we calculate y^A and y^B. If this is not the case, we have $y^A = y^B = 0$ by definition. For specification (1) this is the positive root of a quadratic equation in y^k. The cost of inefficiency is then calculated as the minimum value of $C = y^A + y^B$, with the minimum taken over all Pareto efficient improvements that exist over the observed allocation. Note that the cost of non-cooperation is identified without any interpersonal comparability or utility cardinalization assumptions: any monotonically increasing transformation to (6) will leave the results unaffected. The extension to K siblings ($K > 2$) is straightforward.

Again, the procedure is conditional on a single draw of the error terms. We therefore calculate the occurrence and cost of Pareto inefficiency for 100 draws of the family specific vector of error terms. This yields a point estimate of the cost of inefficiency as well as an estimate of its 95 percent confidence interval.

The estimated median cost of inefficiency per week is 44 euros for two child families, 43 euros for three child families and 34 euros for four child families. Table 3 shows the distribution of the costs and the relative costs (costs divided by total consumption). For two child families we also estimate the cost of inefficiency as the minimum C taken over all Pareto efficient improvements which are also Pareto optimal allocations. Considering the Pareto optimal allocation with the lowest cost of inefficiency, the median cost of inefficiency is 173 euros per week and the median relative cost is 17% of total consumption. For half of the two child families the cost of inefficiency is between 70 and 503 euros per week (in relative terms between 5% and 64% of total consumption). We will also consider Pareto optimal allocations for three and four child families. The computation time for these families, however, is much larger. Not yet ready.

To investigate which families have high cost of inefficiency, we regress the cost on several background characteristics. The results in table 4 show that among older siblings the cost of inefficiency is somewhat higher. The other variables are not significant. When we consider Pareto optimal allocations (in families with two children) we find that sisters have higher costs of inefficiency than brothers. With regard to conflicts we find a positive but insignificant coefficient.

6 Conclusions

We have developed a procedure to test whether the decisions of adult siblings to provide informal care to their parents are efficient. First, we developed a structural model to obtain an estimate of adult children's payoff functions using data on only children (without siblings). Under the maintained assumption that – conditional on observed parental and child characteristics – children with a sibling have the same preference parameters (but different constraints) as only children, we can then test whether observed allocations of siblings in two child families are efficient.

The main advantage of the procedure is that it does not require any *a priori* assumptions about the nature of the interactions between siblings. While the one child model is estimated for a specific flexible functional form, preferences are identified nonparametrically due to the variation in prices across families through variation in distances to parents and wages. Our testing procedure is therefore in principle nonparametric. Our main assumption of preference invariance is the same assumption as generally made in the literature on the provision of public goods: While the number of potential contributors to a public good affects the level of public good provision, it does not affect the contributors' preferences for it. Yet, in the present context one might conjecture, for example, that only children have tighter bonds with their parents and a stronger preference for caring for them than children from two child families. In future work, collecting subjective information on stated preferences is one potential avenue for testing its validity and its effect on the likelihood of inefficiencies in families with more than one child.

In about a third of the two child families, half of the three child families and 60% of the four child families we reject the hypothesis of Pareto efficiency. Pareto inefficiency thus increases with the number of siblings. We find that the likelihood of inefficiencies (inferred from revealed preferences) increases in the presence of reported conflicts (based on subjective statements from the parents). The consistency of the results from these two different types of information indicate the viability of the approach presented here to identify inefficiencies. Moreover, Pareto efficiency is lower in families with sisters compared to brothers, and in lower educated families compared to higher educated families.

Traditional policy perspectives emphasize fiscal measures and reducing the geographical distance between adult children and their parents as instruments to increase informal care. The current analysis suggest that policies supporting families in decision making regarding the provision of informal care to parents could be a highly effective additional policy avenue.

The approach to identify efficiency implemented here suggests potential applications in other contexts of interacting individuals, like schools, workplaces, and households. The plausibility of the assumption of invariance of preferences with respect to the number co-providers to the public good will differ across applications and probably depends on whether the composition of the group of interacting individuals is exogenously given (as in the case of siblings) or the result of individuals' decisions (as in the case of households).

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Figure 1: Estimated relationship between distance and the expected supply of informal care

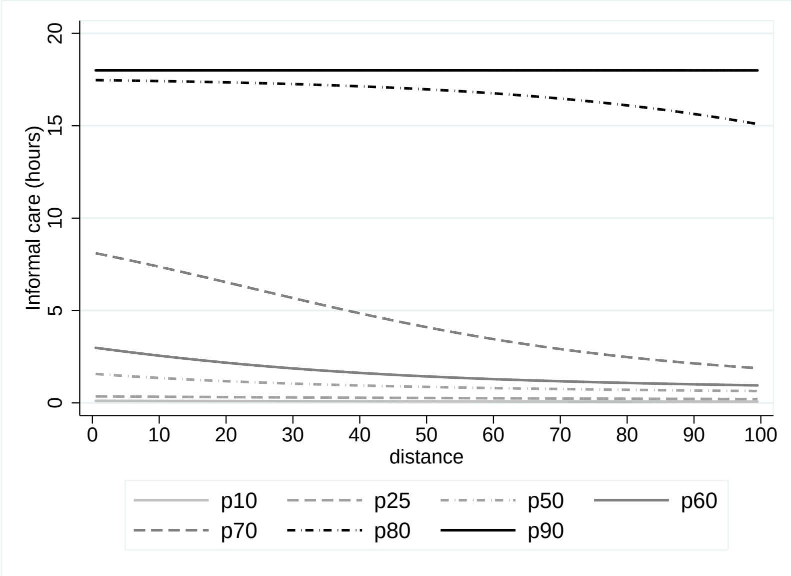

Figure 2: Estimated relationship between distance and the expected labor supply

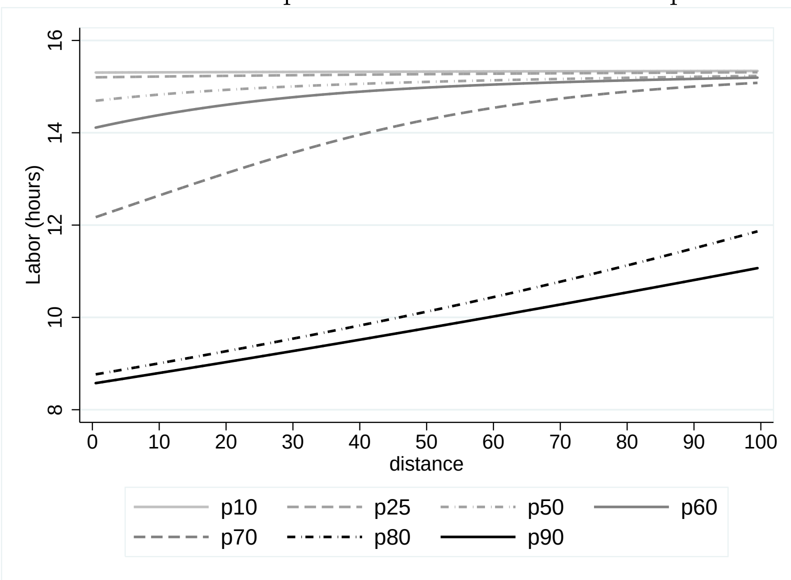

Figure 3: Estimated relationship between wages and the expected labor supply

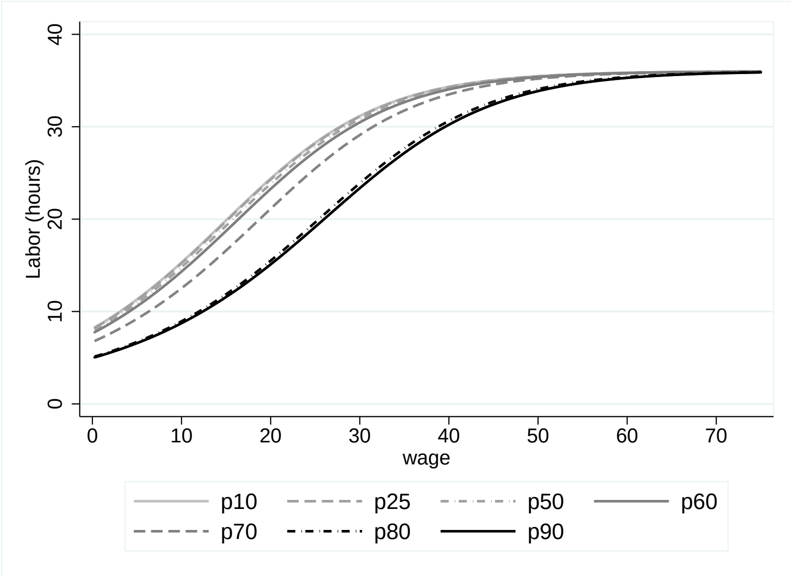

Figure 4: Estimated relationship between wages and the expected supply of informal care

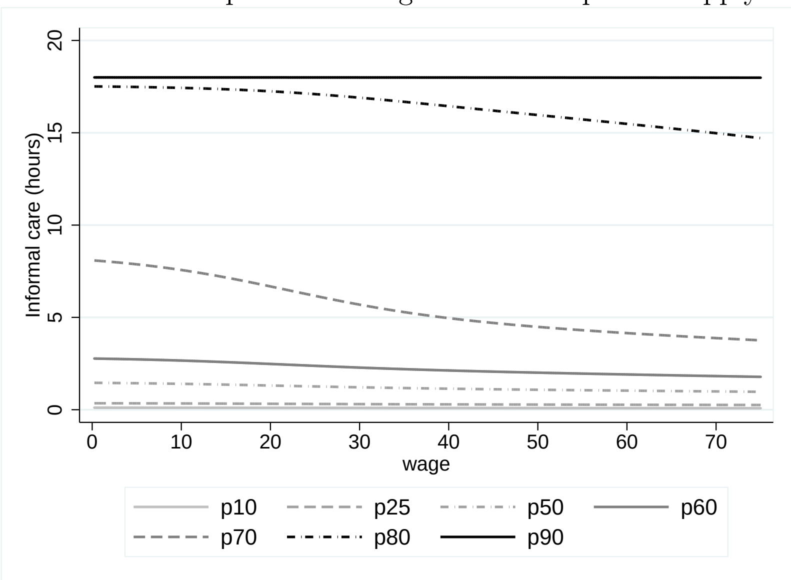

Figure 5: Histogram fraction Pareto inefficiency, two children

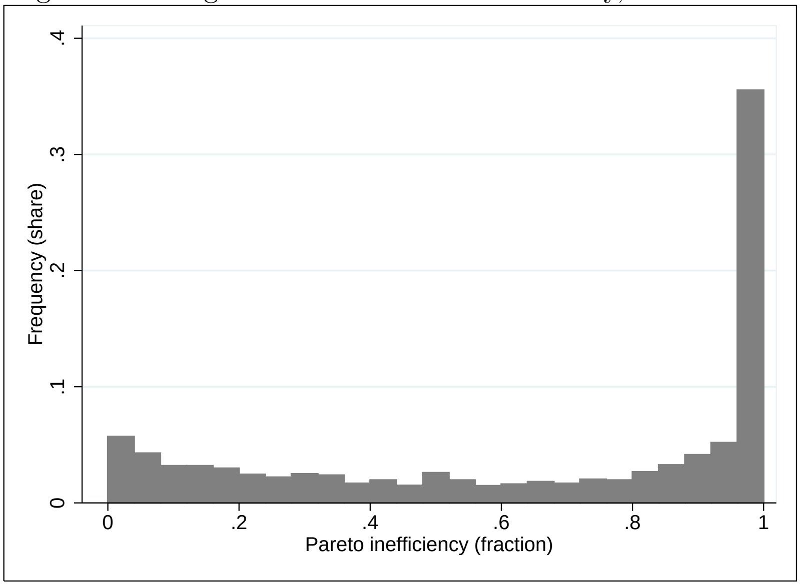

Figure 6: Histogram fraction Pareto inefficiency, three children

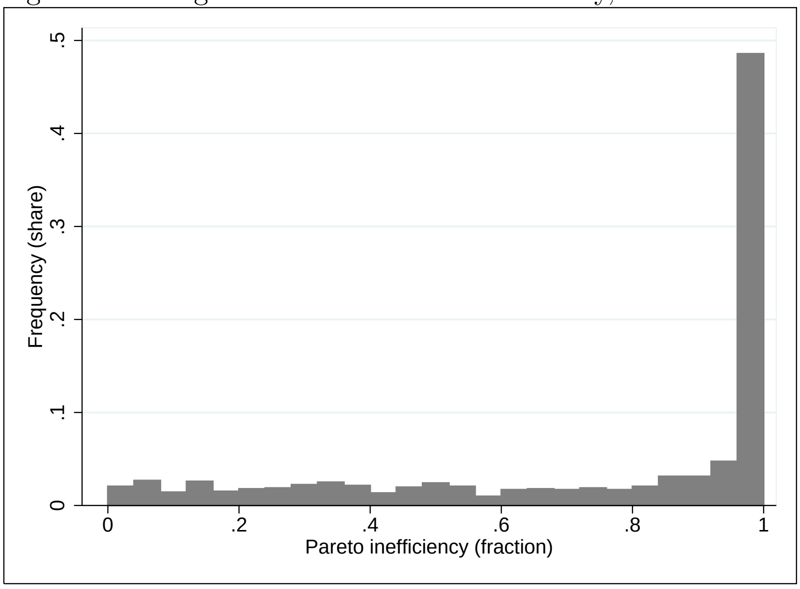

Figure 7: Histogram fraction Pareto inefficiency, four children

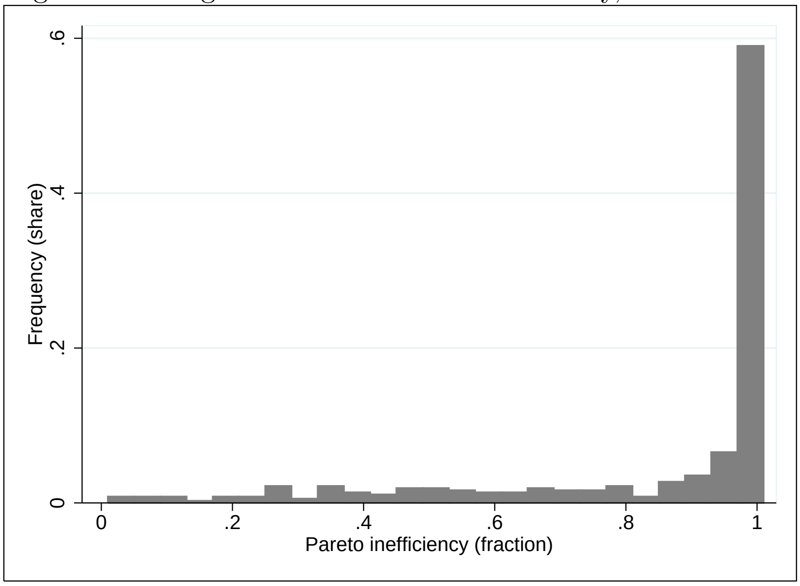

Table 2: Pareto inefficiency

Variables	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
# Siblings	2		3		4	
0 brothers, 2 sisters	0.000	-				
1 brother, 1 sister	-0.105***	0.020				
2 brothers, 0 sisters	-0.425***	0.028				
0 brothers, 3 sisters			0.000	-		
1 brother, 2 sisters			-0.051	0.040		
2 brothers, 1 sister			-0.086**	0.041		
3 brothers, 0 sisters			-0.347***	0.067		
4 siblings: majority sisters					0.048	0.049
2 brothers, 2 sisters					0.000	-
4 siblings: majority brothers					-0.116*	0.062
Age youngest sibling	0.013***	0.002	0.005	0.003	0.002	0.005
Age difference between siblings	0.010***	0.003	0.011**	0.005	-0.003	0.006
# Siblings low education level	0.052**	0.027	0.006	0.017	0.008	0.019
# Siblings medium education level	0.000	-	0.000	-		
# Siblings high education level	-0.047***	0.013	-0.006	0.017	-0.011	0.020
Education parent low	0.044**	0.022	0.030	0.035	-0.040	0.056
Education parent medium	0.000	-	0.000	-	0.000	
Education parent high	0.015	0.034	-0.059	0.061	-0.167**	0.084
Minimum number of children of both siblings	0.028**	0.011	0.027	0.022	-0.046	0.036
Difference in number of children between siblings	-0.002	0.012	-0.003	0.018	-0.019	0.031
No partners	0.000	-	0.000	-	0.000	-
One sibling has a partner	-0.035	0.056	0.269**	0.123		
Two siblings have a partner	-0.036	0.055	0.297***	0.115	-0.106	0.110
Three siblings have a partner			0.332***	0.112	-0.038	0.098
Four siblings have a partner					-0.110	0.109
Minimum distance to parents	0.000*	0.000	0.000	0.000	0.000	0.000
Difference in distance to parents between siblings	0.000	0.000	0.000	0.000	0.000	0.000
Conflicts in the family	0.054**	0.023	-0.014	0.036	-0.001	0.060
Constant	0.340***	0.101	0.380*	0.196	1.106***	0.212
N	1069		381		128	
R^2	0.3851		0.2558		0.305	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Country specific dummy variables are also included. Standard errors are clustered at the family level.

Table 3: Cost of inefficiency (conditional on being inefficient)

Percentile		25	50	75
2 siblings, pareto improvement	euros	16	44	99
	%	1	4	12
2 siblings, pareto optimal allocation	euros	70	173	503
	%	5	17	64
3 siblings, pareto improvement	euros	14	43	103
	%	1	3	7
3 siblings, pareto optimal allocation	euros	99	243	649
	%	5	15	53
4 siblings, pareto improvement	euros	11	34	87
	%	0	2	5

Table 4: Cost of inefficiency

Variables	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
# Siblings	2 (Pareto impr.)		3 (Pareto impr.)		4 (Pareto impr.)		2 (Pareto optimal)	
0 brothers, 2 sisters	0.00	0.00					0.00	-
1 brother, 1 sister	-33.91	30.59					-243.09*	131.47
2 brothers, 0 sisters	-48.01	61.90					-513.60**	199.72
0 brothers, 3 sisters			0.00	0.00				
1 brother, 2 sisters			-25.05	35.83				
2 brothers, 1 sister			-20.52	39.82				
3 brothers, 0 sisters			-27.42	46.71				
4 siblings: majority sisters					-33.18	68.50		
2 brothers, 2 sisters					0.00	-		
4 siblings: majority brothers					-66.10	101.65		
Age youngest sibling	9.14**	3.71	8.22*	4.98	15.89*	8.51	58.97***	12.26
Age difference between siblings	-1.01	3.70	0.53	3.62	14.80	10.34	40.45	26.32
# Siblings low education level	8.99	39.14	-21.61	19.46	-0.81	20.19	80.21	164.17
# Siblings med. education level	0.00	-	0.00	-	0.00	-	0.00	-
# Siblings high education level	-2.86	18.52	-3.11	12.22	-18.81	26.86	-43.98	69.22
Education parent low	-13.48	27.62	25.41	35.91	-112.04	101.29	195.37	138.42
Education parent medium	0.00	-	0.00	-	0.00	-	0.00	-
Education parent high	0.47	34.82	17.01	35.61	-81.94	94.45	-78.99	123.89
Min. # children of both sib.	10.30	17.68	-5.43	14.88	-23.95	37.68	15.18	67.64
Diff in # children between sib.	17.58	13.68	-0.69	14.80	-1.22	26.58	60.24	71.83
At least half of sib. partner	-151.07	157.38	36.15	30.96	-113.21	132.30	-313.48	357.85
Min. distance to parents	-0.06	0.05	-0.01	0.04	-0.07	0.15	-0.65***	0.19
Diff dist. to parents betw sib.	0.01	0.04	0.01	0.04	0.10	0.09	-0.14	0.14
Conflicts in the family	19.67	34.93	11.48	32.93	126.90	138.84	47.33	128.32
Constant	-226.04	177.44	-356.57	243.97	-637.75*	340.37	-2151.52***	628.13
N	706		287		108		705	
R^2	0.076		0.134		0.326		0.124	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Country specific dummy variables are also included. Standard errors are clustered at the family level.

A Data

To estimate the parameters of the model we use the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a multidisciplinary database of microdata on health, socio-economic status and social and family networks of individuals aged 50 and older. Data were collected in 2004/2005 (wave 1) and 2006/2007 (wave 2) by face-to-face computer-aided personal interviews (CAPI), plus a self-completion drop-off part with questions that require more privacy (see www.share-project.org). This study uses 13 countries that have contributed data to SHARE. They represent various regions in Europe, ranging from Scandinavia (Denmark and Sweden) through Central Europe (Austria, France, Germany, Belgium, and the Netherlands) to the Mediterranean (Spain, Italy and Greece). In the second wave two 'new' EU member states have contributed data to SHARE (Czech Republic and Poland). We do not use Israel and Ireland because they are not represented in the EU-SILC data, which we describe in Appendix A.1.

Several papers use SHARE to study informal care giving. Most of these studies use the respondents as providers of informal care (e.g. Bonsang, 2007, 2009, and Bolin et al., 2008a,b). This study considers the respondents in their role as (potential) recipients of informal care. Crespo and Mira (2010) call this the 'parents-sample' as the respondents are the elderly parents. The reason for using the 'parents-sample' is that we need information on all siblings within a family. The respondents (in our case 'the parents') give information about all their children that are still alive (sex, year of birth, geographical distance between the children and their parents, education, marital status, number of children, the employment status of the children, and the amount of informal care they receive from their children). If we were to consider the respondents as the providers of informal care, there would be no information on the amount of care the siblings of the respondents give to their parents. The health situation of the parents provides a measure for the amount of care parents need. SHARE provides many health related variables, such as self-reported health, limitations in activities of daily living (ADL and IADL), mental health, diagnosed chronic conditions, whether people are suffering from several symptoms and limitations in functioning (e.g. measured by grip strength and walking speed). In this study we use self-reported health which has the lowest number of missing data. The parents are asked to rate their health on a five-point scale, ranging from very good to very poor (wave 1) or from excellent to poor (wave 2).[15]

We select all respondents with one, two adult, three or four children. Furthermore, our interest is in children who are 40 years or older, as younger children are hardly involved in personal care for their elderly parents. Following McGarry (1999), Bonsang (2007), and Norton and Van Houtven (2006) we omit households where children are living in the same household as the respondent, because there is no detailed information on informal care giving within households. For the same reason we exclude respondents where grand-children, siblings, and non-relatives are living in the same household as the respondent.[16] Families with self-employed adult children are excluded, because we have no information about the number of hours that self-employed people work. Also, families where one or more children have 'sick' as their daily activity are excluded, as they may not be able to give informal care. After excluding respondents for whom key information is missing, we end up with 1679 adult children without siblings, 2146 adult children with one sibling, 857 adult children with two siblings, and 277 adult children with three siblings.

Most of the families are observed in two waves (41%), 26% of the families are only observed in the first wave and 33% are only observed in the second wave. Informal care is significantly higher for families that are only observed in the first wave, compared to those who are observed in both waves, even after taking into account health and the average age of the parents. The higher level of informal care could reflect bad parental health not controlled for by our parental health variable. Since parents in bad health have a relatively high probability to die between the first and second wave, our results might be subject to attrition bias. In principle, our model

[15]The nonparametric Spearman correlation coefficients show a highly significant association between self reported health, ADL and IADL for both men and women (0.001 significance level). For women the correlation coefficient between self reported health and ADL is 0.5445 and between self reported health and IADL is 0.4271. For men these correlations are 0.5277 and 0.4222, respectively. As a comparison, the correlation between ADL and IADL is 0.6145 for women and 0.5887 for men.

[16]Unfortunately, these households may be a non-random subsample and the choice for adult children and their parents to live in the same household may be correlated with unobservables that influence informal care decisions.

can be extended to control for this by adding an equation describing the attrition probability.

Table 1 shows the amount of informal care and the number of adult children per country. Informal care includes practical household help (e.g. household chores, shopping and home repairs), personal care (e.g. dressing, bathing, eating) and help with paperwork. Adults report whether their children help them on an almost daily basis, weekly, monthly, or less often. Furthermore, they were asked to give an estimate of the number of hours of informal care received on a typical day, week, month or year. We transform these answers to a variable measuring the average amount of informal care that adults receive from their children per week. We define people as involved in informal care when they give one hour or more of informal care per week.

In Germany, Greece, the Czech Republic and Poland, many people are involved in informal care giving (more than 15% of the only children and siblings). Conditional on being involved in informal care, children in Mediterranean countries give relatively many hours of informal care, whereas the children in Denmark, the Netherlands, and Sweden give a relatively small amount of informal care. When we compare only children and siblings, we find that in general only children are more often involved in informal care giving than siblings and that they also provide more hours of informal care. This suggests that the hours of care provided by a sibling are a substitute for someone's own provision of informal care.

Table 5 presents information about informal care giving and the geographical distances between children and their parents. The higher the distance between children and their parents, the higher the traveling time and costs, and the lower the fraction of people involved in informal care. It appears that the distribution of adult children without siblings and with one sibling among the categories is about the same (so that children without siblings do not in general live closer or further away from their parents than children with one sibling). For children with two and three siblings it is less common to live in the same building or within 1 kilometer of their parents.

As expected, the provision of informal care is higher for children with parents in bad health than for children with parents in good health (table 6). In the analysis we distinguish single parents and parents living with a partner, as parents may provide informal care to each other when they are both alive. It appears that when the mother of a child is in poor health and the father is in good health there is somewhat more informal care from adult children than when the father is in poor health and the mother is in good health. The reason may be that men in the observed generations have less household management skills than women.

Table 7 shows the amount of informal care by the daily activity of the child. It is interesting that the amount of informal care does not differ much between children in full-time employment and those in part-time employment. Children who are (early) retired, unemployed or looking after home are most often involved in informal care. However, note that retired persons have relatively older parents, who are more often in bad health. Finally, women are somewhat more often involved in informal care than men and often provide more hours of informal care (table 8).

Table 5: Distance and informal care[a]

Distance	# Observations				% Informal caregivers				# Hours (if>0)			
# Siblings	0	1	2	3	0	1	2	3	0	1	2	3
same building	10	7	4	2	30	31	24	27	16	11	11	10
<= 1 kilometer	17	15	13	12	21	19	20	19	11	12	13	7
1-5 kilometers	19	21	20	21	20	16	13	12	8	8	7	8
5-25 kilometers	26	23	23	24	16	11	12	10	13	6	9	9
25-100 kilometers	13	15	18	17	10	7	6	6	13	6	4	4
100-500 kilometers	10	11	14	15	5	4	4	2	24	7	7	21
> 500 kilometers	3	3	4	5	0	1	1	0	-	4	28	-
> 500 kilometers in another country	3	4	4	4	2	1	0	2	2	1	-	1
Total	100	100	100	100	16	12	11	9	12	9	9	8

[a] Percentage of children involved in informal care and the number of hours of informal care, conditional on giving any informal care, per distance category.

Table 6: Health and informal care[a]

Health	Frequency (%)				% Informal caregivers				# Hours (if>0)			
# Siblings	0	1	2	3	0	1	2	3	0	1	2	3
Father, good / very good	9	8	8	7	6	6	7	9	5	8	5	8
Father, fair	5	6	6	6	20	13	13	7	10	5	9	5
Father, poor	2	2	2	1	34	24	17	10	16	8	9	25
Mother, good / very good	21	23	23	27	17	12	10	9	8	7	11	5
Mother, fair	18	15	17	19	25	20	16	16	10	10	7	12
Mother, poor	9	7	7	5	34	27	24	15	22	11	11	12
Both poor, or poor and fair	5	5	7	7	21	22	16	11	23	15	13	4
Both fair, or fair and good	16	17	15	15	6	6	3	7	7	8	7	4
Father poor, mother good	2	2	3	1	13	11	4	10	3	6	3	4
Father good, mother poor	2	2	2	1	25	18	15	8	12	11	8	6
Both good / very good	13	13	12	11	3	3	2	0	7	4	4	-
Total	100	100	100	100	16	12	11	9	12	9	9	8

[a] Percentage of children involved in informal care and the number of hours of informal care, conditional on giving any informal care, per health status of the elderly parent. In the first three categories the adult child only has a father, in the fourth to the sixth category the adult child only has a mother, and in the last five categories the adult child has a father and a mother.

Table 7: Daily activity and informal care[a]

Health	Frequency (%)				% Informal caregivers				# Hours (if>0)			
# Siblings	0	1	2	3	0	1	2	3	0	1	2	3
full-time	67	74	72	67	14	11	9	6	8	8	8	6
part-time	8	9	8	8	15	11	8	11	8	6	5	4
unemployed	6	3	3	4	17	17	15	24	11	13	13	7
in education	1	0	0	0	7	0	0	0	14	-	-	-
parental leave	0	0	0	0	0	0	0	0	-	-	-	-
(early) retirement	8	5	7	11	32	26	24	17	20	9	9	11
looking after home	9	8	8	9	22	17	18	16	22	19	14	10
other	1	1	1	1	21	0	0	14	25	-	-	42
Total	100	100	100	100	16	12	11	9	12	9	9	8

[a] Percentage of children involved in informal care and the number of hours of informal care, conditional on giving any informal care, per daily activity of the adult child.

Table 8: Gender[a]

Gender	Frequency (%)				% Informal caregivers				# Hours (if>0)			
# Siblings	0	1	2	3	0	1	2	3	0	1	2	3
female	54	52	51	51	18	15	13	12	14	10	10	6
male	46	48	49	49	14	10	8	7	9	8	7	10
Total	100	100	100	100	16	12	11	9	12	9	9	8

[a] Percentage of children involved in informal care and the number of hours of informal care, conditional on giving any informal care, per gender of the adult child.

A.1 Modeling wage rates and remaining household income

Wage rates (w) and remaining household income (μ) of the adult children in SHARE are unknown. This appendix shows the wage equation and the equation for remaining household income that we use to predict wage rates and remaining household income.

We can only observe wages for workers. However, the working population is probably not a random subsample from the population as people with comparatively high wages (conditional on, for example, their education level) are more likely to work. There may be unobservables that influence the decision to participate, as well as the wage rate. A commonly used method to deal with this sample selection is the method presented by Heckman (1979). Heckman takes selection bias into account by adding an equation which models the participation decision, and allowing for nonzero correlation between the wage and the participation equation. We estimate the following Heckman model, for each country separately

$$\begin{aligned}
\ln(w_i^*) &= X_{wi}\beta_w + v_{wi} \\
p_i^* &= X_{pi}\beta_p + v_{pi} \\
w_i &= w_i^* \quad \text{if } p_i^* > 0 \\
w_i &= 0 \quad \text{if } p_i^* \leq 0
\end{aligned}$$

where (20) is the wage equation and (20) is the (probit type) participation equation. X_{wi} and X_{pi} contain personal characteristics such as age, gender, and education level. Generally an exclusion restriction is required to generate credible estimates from the Heckman selection model. A commonly used instrument is the presence or number of children (Puhani, 2000), therefore, we include dummy variables for having children in the participation equation, but exclude these from the wage equation. We assume that v_p and v_w are bivariate normal distributed

$$\begin{bmatrix} v_p \\ v_w \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \sigma_{wp} \\ \sigma_{wp} & \sigma_w^2 \end{bmatrix} \right) \tag{21}$$

and we estimate the parameters using FIML. As for a probit model, the normalization $\sigma_p^2 = 1$ is used since only the sign of p_i^* is observed. For remaining household income (μ) we estimate an equation using a standard OLS regression, for each country and for men and women separately

$$\ln(\mu_i) = X_{\mu i}\beta_\mu + v_{\mu i}, \tag{21}$$

where $X_{\mu i}$ contains personal characteristics such as age, marital status, and education level.

The wage equation and the equation for remaining household income are estimated using EU-SILC 2005. EU-SILC contains microdata on income, poverty, social exclusion, and living conditions in Europe. It comprises information from surveys and registers from the EU member states, that are collated by Eurostat. We select people up to age 76 and omit households who receive income from self-employment or who are permanently sick or disabled (just as in SHARE). Furthermore, we exclude observations which have missing data for one or more of the variables in the model. We end up with 55,100 observations, which are described in table 9.

Table 9: Descriptives EU-SILC

	AT	BE	CZ	DE	DK	ES	FR
Male (%)	49	48	47	46	49	47	48
Age (mean)	45	43	46	47	45	43	43
Primary education (%)	1	14	0	2	0	33	12
Lower secondary education (%)	24	18	19	16	29	22	13
(Upper) secondary education (%)	53	34	69	46	43	21	47
Post secondary non-tertiary education (%)	9	2	1	6	0	1	2
Tertiary education (%)	13	31	12	30	28	23	26
Man with partner (%)	35	32	32	32	38	31	34
Woman with partner (%)	34	35	32	31	37	33	32
Man with child (%)	22	24	17	21	23	24	25
Woman with child (%)	23	26	19	25	25	24	26
Net wage rate (mean)	10	11	2	10	14	8	11
Nonlabor income (mean)	27413	24240	5990	24718	28575	18717	24010
N	1488	1346	1095	6028	1422	7171	3221
	GR	**IT**	**NL**	**PL**	**SE**		**Total**
Male (%)	44	47	51	46	50		47
Age (mean)	43	46	45	42	43		44
Primary education (%)	28	27	9	17	9		18
Lower secondary education (%)	13	29	24	7	16		20
(Upper) secondary education (%)	36	32	37	60	42		41
Post secondary non-tertiary education (%)	5	5	3	3	5		4
Tertiary education (%)	19	7	27	13	28		18
Man with partner (%)	28	30	40	30	38		32
Woman with partner (%)	32	32	35	33	37		33
Man with child (%)	22	21	25	27	27		23
Woman with child (%)	25	22	21	31	26		25
Net wage rate (mean)	7	9	12	2	10		9
Nonlabor income (mean)	15475	22161	22036	4835	23742		18709
N	1345	14155	6007	10464	1358		55100

Wage equations are estimated for each country separately. Table 10 describes the wage equation for Sweden. The wage equations for all other countries are estimated in a similar way and are available on request. Although not significantly, table 10 shows that wage rates increase with age and are significantly higher for people with a high education level. σ_{wp} is not significantly different from zero, indicating that sample selection is not a significant issue. This also holds for most of the other countries.[17]

Table 10: Estimation results wage equation Sweden, sample selection model[a]

Equation 1: ln(wage rate)	Coefficient	St. error
Man	0.157	0.105
Age	0.019	0.017
$Age^2/100$	-0.010	0.020
Primary education	-0.070	0.109
Lower secondary education	-0.057	0.083
(Upper) secondary education	0.000	-
Post secondary non-tertiary education	0.051	0.089
Tertiary education	0.109	0.046
Man with partner	0.073	0.088
Woman with partner	-0.092	0.082
Intercept	1.458	0.368
Equation 2: participation decision		
Man	-0.069	0.196
Age 15-29	0.000	-
Age 30-39	1.045	0.157
Age 40-49	1.010	0.143
Age 50-59	1.147	0.166
Age $\geq$ 60	-1.193	0.155
Primary education	-0.351	0.163
Lower secondary education	-0.962	0.130
(Upper) secondary education	0.000	-
Post secondary non-tertiary education	-0.355	0.194
Tertiary education	0.090	0.117
Man with partner	0.612	0.152
Woman with partner	0.574	0.145
Man with child	-0.022	0.144
Woman with child	-0.514	0.151
Intercept	0.206	0.169
ρ	0.016	0.157
σ_w	0.615	0.014
$\sigma_{wp} = \rho\sigma_w$	0.010	0.097
N	1358	
Censored observations	422	
Uncensored observations	936	
Log likelihood	-1374.725	

[a] The reference individual is a woman with (upper) secondary education in the age category 15-29. She has no partner and no children.

Table 11 shows the estimation results of remaining household income for Sweden. Again, the equations for the other countries are estimated in a similar way and are available on request.

[17]Due to measurement errors in the wage rates, the standard deviation of the errors in the wage equation may be overestimated. A sensitivity analysis, in which we for example multiply σ_w by 0.8 for all countries, indicates that this does not influence the structural estimation results very much.

Remaining household income increases with age. Furthermore, in Sweden remaining household income is not significantly different for different education categories. Next, we will use the wage equations and the equations for remaining household income from EU-SILC to estimate the parameters of the structural model.

Table 11: Estimation results remaining household income, Sweden[a]

ln(remaining household income)	Men		Women	
	Coefficient	St. error	Coefficient	St. error
Age	-0.097	0.023	-0.040	0.023
Age^2	0.001	0.000	0.001	0.000
Primary education	-0.115	0.227	0.051	0.232
Lower secondary education	0.326	0.186	0.185	0.189
(Upper) secondary education	0.000	-	0.000	-
Post secondary non-tertiary education	0.109	0.248	-0.156	0.300
Tertiary education	0.203	0.149	0.028	0.136
Married	0.440	0.163	0.421	0.167
Widowed	0.054	0.453	-0.442	0.341
Divorced	-0.658	0.292	-0.676	0.231
Never married	0.000	-	0.000	-
Having a child	0.724	0.138	0.845	0.141
Intercept	10.524	0.454	9.766	0.468
N	655		638	
R-squared	0.115		0.116	
Adj R-squared	0.101		0.102	
σ_μ	1.466		1.434	

[a] The reference individual is a man (left) or woman (right) who has never been married, with (upper) secondary education and no children.

B Estimation results of the one child model

Table 12 presents the estimation results of the structural model.[18] This appendix first describes the parameter estimates related to the preferences for informal care (t_s), then the parameter estimates related to leisure (t_l), and finally the parameter estimates related to consumption (c). With regard to informal care the results show significant decreasing marginal utility (α_{ss} is significantly negative). Furthermore, the interaction term α_{ls} is significantly positive, meaning that when the amount of informal care is already high, the utility of an extra hour of leisure increases. When parents are in bad health they need more attention and the estimates show

[18] Our estimation procedure uses 25 drawings. The estimation is computer intensive. Other studies with this kind of models have used for example 5 or 10 drawings which produce qualitatively similar results (Van Soest, 1995) or 10 drawings (Van Soest and Stancanelli, 2010).

that this increases the preference for informal care.[19] The preference for informal care is highest when a single living father or mother has poor health, when both parents are in poor health, or when the mother has poor health and the father is in good health. On the other hand, when the father is in poor health and the mother is in good health, the preference for informal care giving is lower. Presumably, mothers are better able to give informal care to their spouses than fathers are able to give informal care to the mothers of the adult children. Maybe, fathers in the observed generation have lower household management skills. Several studies find that mothers receive more care than fathers (Bonsang 2007; Klein Ikkink et al. 1999; Attias-Donfut et al. 2005). We also find that mothers in good health receive more informal care than fathers in good health, but when the parent is in fair or poor health this no longer holds. In addition to poor health, the preference for informal care increases with the age of the parent(s). This is in accordance with the literature, indicating that even after extensively controlling for disability, age remains an important driver of long term care use (De Meijer et al., 2009).

The country specific dummy variables comprise institutional as well as cultural differences between countries. Cultural differences include differences in social norms with regard to informal care and the degree to which family ties are considered to be important. It has been found that southern European countries have stronger family ties than northern European countries (Reher, 1998). The estimation results show that preferences with regard to informal care are relatively high in Greece, Germany, Belgium, Austria, and the Czech Republic.[20,21]

High educated children have significantly lower preferences for informal care than low educated children. One argument in the literature is that high educated children provide less care than low educated children because high educated children live farther away from their parents due to geographical labor market restrictions. However, also after taking into account distance (via the budget constraint) we find a significant effect of education on the preference

[19]In the model we assume that (self reported) health is not a function of the amount or quality of informal care received by the parent. Of course, this does not preclude that the amount or quality of informal care affects the parent's well-being.

[20]It is notable that southern European countries like Italy and Spain do not show significantly positive coefficients. Probably this has to do with living arrangements. In Italy and Spain many adult caregivers co-reside with their parents and these households are not included in this analysis.

[21]While country specific dummy variables could also be included in b_l and b_c, we limit our inclusion of country dummies to b_s to keep the estimation manageable. In principle they could be included.

for informal care, which may be explained by different value orientations of the higher educated (Kalmijn, 2006)[22] and/or competing interests (Waite and Harrison, 1992). Finally, we find that women have significantly higher preferences for providing informal care than men.

Secondly, we describe the parameter estimates related to leisure (t_l). The preference for leisure increases with age. Children increase women's preferences for leisure significantly, probably because more children often mean more responsibilities for adult daughters inside their own households (the care for a child also belongs to 'leisure time' in this model). Marital status does not affect adult children's preferences for leisure.[23] Finally, compared to medium educated children, low educated children have significantly higher preferences for leisure. It is possible that less favorable labor conditions among the lower educated bring about higher preferences for leisure time rather than labor time.

The parameter estimates related to consumption (c) show that older adult children have significantly lower preferences for consumption. In addition, high educated individuals have a relatively high preference for consumption. As mentioned before, for the model to be economically rational, the marginal utility of consumption must be positive.

The final part of table 12 shows the estimates of the covariance matrix of the unobserved heterogeneity terms (equation 6).

[22]Kalmijn (2006) found that face-to-face contact between high educated children and their parents is relatively low, even after controlling for distance.

[23]Married persons are likely to spend leisure time with each other, but on the other hand household production is more efficient for couples than for singles, which saves time. Waite and Harrison (1992) found that the presence of a husband decreases the number of visits a woman has with friends, but does not reduce a woman's social contacts with kin.

Table 12: Estimation results structural model[a]

		Coef.	Std. err.	z-value
α_{ll}	(t_l^2)	0.00028	0.00001	48.05
α_{cc}	(c^2)	0.00000	0.00000	2.30
α_{ss}	(t_s^2)	-0.01884	0.00437	-4.32
α_{lc}	$(t_l \times c)$	0.00000	0.00000	-0.18
α_{ls}	$(t_s \times t_l)$	0.00210	0.00011	18.34
α_{cs}	$(t_s \times c)$	-0.00004	0.00002	-2.08
β_{l0}	(t_l)	-0.12490	0.00161	-77.79
β_{l1}	($t_l\times$ child is man)	-0.00090	0.00131	-0.69
β_{l2}	($t_l\times$ number children)	0.00964	0.00079	12.25
β_{l3}	($t_l\times$ man$\times$number children)	-0.01037	0.00070	-14.82
β_{l4}	($t_l\times$ age child)	0.00127	0.00003	42.89
β_{l5}	($t_l\times$ child is married)	0.00102	0.00143	0.71
β_{l6}	($t_l\times$ child is divorced)	-0.00119	0.00270	-0.44
β_{l7}	($t_l\times$ child is widowed)	0.01992	0.01652	1.21
β_{l8}	($t_l\times$ child has low education level)	0.02806	0.01242	2.26
β_{l9}	($t_l\times$ child has high education level)	0.00045	0.00077	0.59
β_{l10}	($t_l\times$ parent has low education level)	0.00008	0.00149	0.05
β_{l11}	($t_l\times$ parent has high education level)	0.00520	0.00070	7.39
β_{c0}	(c)	0.01869	0.00171	10.95
β_{c1}	($t_c\times$ child is man)	0.00402	0.00090	4.47
β_{c2}	($t_c\times$ number children)	-0.00039	0.00026	-1.50
β_{c3}	($t_c\times$ man$\times$number children)	0.00030	0.00045	0.66
β_{c4}	($t_c\times$ age child)	-0.00026	0.00003	-8.82
β_{c5}	($t_c\times$ child is married)	0.00004	0.00073	0.05
β_{c6}	($t_c\times$ child is divorced)	0.00140	0.00093	1.51
β_{c7}	($t_c\times$ child is widowed)	0.00166	0.00171	0.97
β_{c8}	($t_c\times$ child has low education level)	0.00049	0.00143	0.35
β_{c9}	($t_c\times$ child has high education level)	0.00119	0.00045	2.63
β_{c9}	($t_c\times$ parent has low education level)	0.00059	0.00046	1.27
β_{c10}	($t_c\times$ parent has high education level)	-0.00060	0.00068	-0.88

[a] Table continues on the next page.

Table 12: Estimation results structural model, continued[a]

		Coef.	Std. err.	z-value
β_{s0}	(t_s)	-3.17486	0.28930	-10.97
β_{s1}	$(t_s\times$ child is man)	-0.38636	0.12114	-3.19
β_{s2}	$(t_s\times$ number children)	-0.05331	0.04191	-1.27
β_{s3}	$(t_s\times$ man$\times$number children)	-0.01718	0.06062	-0.28
β_{s4}	$(t_s\times$ single father good / very good health)	0.18285	0.16400	1.11
β_{s5}	$(t_s\times$ single father fair health)	0.79559	0.15829	5.03
β_{s6}	$(t_s\times$ single father poor health)	1.28847	0.20848	6.18
β_{s7}	$(t_s\times$ single mother good / very good health)	0.77916	0.13613	5.72
β_{s8}	$(t_s\times$ single mother fair health)	0.83340	0.13119	6.35
β_{s9}	$(t_s\times$ single mother poor health)	1.15668	0.17781	6.51
β_{s10}	$(t_s\times$ father and mother poor, or poor and fair health)	1.06273	0.16470	6.45
β_{s11}	$(t_s\times$ father and mother fair, or fair and good health)	0.40327	0.15300	2.64
β_{s12}	$(t_s\times$ father poor, mother good health)	0.80666	0.27110	2.98
β_{s13}	$(t_s\times$ father good, mother poor health)	1.43250	0.21584	6.64
β_{s14}	$(t_s\times$ Germany)	0.76112	0.14886	5.11
β_{s15}	$(t_s\times$ Italy)	-0.04692	0.15184	-0.31
β_{s16}	$(t_s\times$ Greece)	0.30587	0.12897	2.37
β_{s17}	$(t_s\times$ Spain)	-0.01115	0.16294	-0.07
β_{s18}	$(t_s\times$ France)	0.15719	0.16841	0.93
β_{s19}	$(t_s\times$ Netherlands)	-0.26669	0.20373	-1.31
β_{s20}	$(t_s\times$ Denmark)	0.17068	0.15325	1.11
β_{s21}	$(t_s\times$ Belgium)	0.49965	0.13935	3.59
β_{s22}	$(t_s\times$ Austria)	0.45049	0.15532	2.90
β_{s23}	$(t_s\times$ Poland)	0.34778	0.20801	1.67
β_{s24}	$(t_s\times$ Czech Republic)	0.82504	0.15540	5.31
β_{s25}	$(t_s\times$ (average) age parent - 55)	0.03575	0.00499	7.16
β_{s26}	$(t_s\times$ child has low education level)	0.25735	0.13107	1.96
β_{s27}	$(t_s\times$ child has high education level)	-0.09784	0.06897	-1.42
β_{s28}	$(t_s\times$ parent has low education level)	0.50267	0.10176	4.94
β_{s29}	$(t_s\times$ parent has high education level)	-0.35413	0.12108	-2.92
σ_l^2		4.81e-11	3.27e-09	0.01
σ_c^2		3.87e-06	1.44e-06	2.68
σ_s^2		1.07526	0.20550	5.23
σ_{lc}		-2.79e-09	9.52e-08	-0.03
σ_{ls}		-3.97e-07	0.00001	-0.03
σ_{cs}		0.00052	0.00014	3.76
Log likelihood		-3136		
N		2231		

[a] The reference individual is a female adult child who has never been married, of whom both parents are alive, have a good / very good health position, and are living in Sweden.

C Robustness checks

C.1 Robustness checks one child model

C.1.1 Scale parameter

As a robustness check we lower the value of the smoothing parameter λ. This increases the scale of the utilities when they enter the logit function. In this way we approximate the model without random disturbances.

P.M.

C.1.2 Discretization

To estimate the model we discretized the choices available to each adult child. Adult children can choose between different combinations of labor and informal care (which also lead to different levels of leisure and consumption). With regard to labor we distinguish full-time employment, part-time employment and no employment (these are also the three categories available in the data). With regard to informal care we distinguished '<1 hour informal care per week', '1-4 hours of informal care', '4-8 hours of informal care' and '>8 hours of informal care'. This gave us a choice set of 12 alternatives (3 labor market categories x 4 informal care categories). As a robustness check we increased the choice set to 15 alternatives, where we distinguish '<1 hour informal care per week', '1-2.5 hours of informal care', '2.5-4 hours of informal care', '4-8 hours of informal care' and '>8 hours of informal care' (3 labor market categories x 5 informal care categories).

P.M.

C.2 Robustness checks Pareto efficiency test

C.2.1 Pareto inefficiency without data on conflicts

Table 13: Pareto inefficiency, without data on conflicts

Variables	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
# Siblings	2		3		4	
0 brothers, 2 sisters	0.000	-				
1 brother, 1 sister	-0.102***	0.014				
2 brothers, 0 sisters	-0.420***	0.018				
0 brothers, 3 sisters			0.000	-		
1 brother, 2 sisters			-0.050*	0.027		
2 brothers, 1 sister			-0.137***	0.028		
3 brothers, 0 sisters			-0.390***	0.042		
majority sisters					0.040	0.029
2 brothers, 2 sisters					0.000	-
majority brothers					-0.094***	0.034
Age youngest sibling	0.012***	0.001	0.008***	0.002	0.001	0.003
Age difference between siblings	0.007***	0.002	0.010***	0.003	0.002	0.003
# Siblings low education level	0.028*	0.017	-0.002	0.014	0.021*	0.011
# Siblings medium education level	0.000	-	0.000	-	0.000	-
# Siblings high education level	-0.061***	0.009	-0.018*	0.011	-0.013	0.012
Education parent low	0.036**	0.016	0.020	0.025	-0.027	0.036
Education parent medium	0.000	-	0.000	-	0.000	-
Education parent high	0.011	0.023	-0.015	0.034	-0.059	0.057
Minimum number of children of both siblings	0.022***	0.008	0.019	0.014	0.020	0.017
Difference in number of children between siblings	0.004	0.007	0.000	0.011	0.011	0.010
No partners	0.000	-	0.000	-	0.000	-
One sibling has a partner	-0.015	0.038	0.223**	0.092	0.855***	0.082
Two siblings have a partner	-0.016	0.037	0.198**	0.089	0.758***	0.076
Three siblings have a partner			0.240***	0.089	0.788***	0.064
Four siblings have a partner					0.757***	0.070
Minimum distance to parents	0.000***	0.000	0.000*	0.000	0.000	0.000
Difference in distance to parents between siblings	0.000	0.000	0.000	0.000	0.000	0.000
Constant	0.390***	0.070	0.331**	0.137	0.094	0.132
N	2851		1118		366.000	
R^2	0.351		0.2735		0.210	

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Country specific dummy variables are also included. Standard errors are clustered at the family level.

C.2.2 Preference parameters

As explained in section 4 we assume that – conditional on observed parental and child characteristics – siblings have the same preferences for leisure, consumption and informal care as only children. However, as mentioned before, it could be argued that families with a large number of children are more familiastic or that children in larger families receive less direct attention from parents and are therefore less close to their parents. Therefore, we test the robustness of the results with regard to the coefficients related to the preferences for informal care. First, we multiply β_{s0} to β_{s29} by 0.8 and repeat the analysis.

Second, we multiply β_{s0} to β_{s29} by 1.2 and repeat the analysis. P.M.

C.2.3 Production function parental care

In this robustness check we relax the assumption of perfect substitutability of informal care between siblings. In section 4 we introduced a production function for parental care (equation 17). We check the sensitivity of our results to deviations of a and ξ.

P.M.