Geography of the Family: Comment*

Helena Holmlund   Helmut Rainer   Thomas Siedler†

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In a thought-provoking paper published not so long ago in the *American Economic Review*, Kai A. Konrad et al. (2002) (KKLR) coined the notion of the "geography of the family". Their starting point is the observation that in many families, when parents grow old, the problem of taking care of the elderly emerges. Adult children care about the well-being of their parents, but make irreversible location decisions long before the care is needed. The location decisions are determinants of the costs of contributing to parental care. In families with more than one child, the well-being of elderly parents is a public good, and caregiving becomes a contribution game played between siblings. Adult children may therefore take strategic steps to alter their costs as contributors before their parents age and the need for assistance arises. KKLR argue that firstborn siblings may have a first-mover advantage and may choose to raise their costs as contributors by locating in some critical distance from their parents. Second born siblings are thereby forced to stay close to their parents and to provide all the care in the later contribution game. This precommitment strategy adopted by older siblings—akin to the idea of "burning bridges" (Schelling, 1980)—generates a geography of the family whereby firstborn children consistently locate further away from their parents than second born or only children. Empirical evidence based on data drawn from the German Aging Survey shows that adult children's location choices are in line with this prediction.

This paper reexamines these results along theoretical and empirical dimensions. With regard to theory, we argue that the conclusions and empirical predictions of KKLR are not robust enough to withstand two levels of generalization. First, KKLR assume that

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†Holmlund: Centre for Economic Performance, London School of Economics, Houghton Street, London WC2A 2AE, United Kingdom (e-mail: h.holmlund@lse.ac.uk); Rainer: School of Economics and Finance, University of St Andrews, St Salvator's College, St Andrews KY16 9AL, United Kingdom (e-mail: hr11@st-andrews.ac.uk); Siedler: Deutsches Institut für Wirtschaftsforschung (DIW Berlin), Mohrenstraße 58, 10117 Berlin, Germany (e-mail: tsiedler@diw.de).

preferences of adult siblings can be expressed as quasi-linear utility functions. While a quasi-linear utility specification is often useful for reasons of simplicity, it does not always lead to an accurate description of reality. In the present context, it creates a winner-takes-all environment where a slight edge in terms of location means that the child who lives closer to the parents makes all the contributions to parental well-being. In other words, quasi-linearity a priori excludes the possibility of a unique interior equilibrium in the contribution game in which *both* siblings allocate positive amounts of time to their elderly parents. This restrictive assumption is relaxed, allowing for a broader set of caregiving arrangements among siblings. Second, KKLR assume that adult children can move from one location to another without incurring any costs. Since the costs normally associated with relocation are avoided, the critical distance that induces younger siblings to become sole care providers guarantees older siblings an optimal choice that does not involve a trade-off. The key point that we would stress here is the obvious one that this assumption may be too strong. KKLR's model is therefore extended to include a distance-dependent relocation cost.

These two simple but important modifications generate significant changes in the theoretical predictions. In particular, KKLR's main conclusion concerning family location and caregiving patterns does not follow. Focusing on families with one or two children, they argued that the most common family location pattern is for firstborn children to locate further away from their parents than second born or only children. The asymmetric behavior of siblings is driven by a *birth order* effect, i.e., by the ability of older siblings to strategically commit to a location that shifts the burden of providing care for elderly parents to younger siblings. In our model, in contrast, the strategic influence of siblings on one another is more important than the strategic influence of firstborn on second born siblings. Indeed, the location decisions of adult siblings now interact with the contribution game so as to cause an equilibrium in which, irrespective of birth order, children with a sibling consistently locate further away from their parents than only children. In equilibrium, the birth order effect, which tends to generate asymmetric behavior of siblings, becomes negligible relative to a *sibling competition* effect: if one sibling locates away from the parents, a side effect of his or her action is that the other sibling is more likely to become the main care provider in the contribution game. From any sibling's point of view, the best response is to match the location of the other, lest the chances of being severely implicated in parental care increase. Thus, the situation here is not wholly dissimilar from one with a positional externality (Frank, 1991): both siblings strategically choose to locate away from their parents, but each sibling's relative contribution in the caregiving stage remains unchanged. Moreover, due to the inefficiencies associated with ex ante positional competition, the ex post care contributions of children with a sibling are generally lower than those of only children.

Having established this, we investigate new data from the Survey of Health, Ageing and Retirement in Europe (SHARE). This cross-national panel database provides micro data on health, socio-economic status and social and family networks of individuals aged 50 or over. Our estimation sample comprises roughly 9,000 individuals in 9 countries representing various regions in Europe, ranging from Scandinavia (Sweden) through Central Europe (Austria, France, Germany, Belgium, the Netherlands) to the Mediterranean (Spain, Italy, Greece). In a nutshell, the main hypotheses implied by our sibling competition equilibrium are borne out in our data with a striking degree of consistency. Particularly worth mentioning are the following three findings. First, regression results for the individual countries and the pooled cross-country sample suggest that both firstborn and second born siblings are significantly more likely to live further away from their elderly parents than only children. For example, our pooled-country analysis shows that firstborns have a 5 percentage points and second born siblings a 4 percentage points higher probability to live more than 100 kilometres away from their parents than only children. Second, in line with the just described family location pattern, we also find evidence that actual time transfers to elderly parents are significantly lower among siblings than among only children. In contrast, KKLR do not provide evidence concerning actual time transfers to elderly parents. Finally, while children with siblings appear to behave intrinsically differently than only children, there is no significant asymmetry in the behavior of firstborn and second born siblings in terms of their location decisions and time transfers to elderly parents. These results are at odds with the view that older siblings may use their location choices to force younger siblings into staying with the parents and providing the major share of caregiving.

I. Theoretical Considerations

The underlying economic environment is a version of the one considered in KKLR. Therefore the set-up and notation will be kept as close as possible to that in their contribution. All technical details are relegated to the Appendix.

Consider a family comprised of parents P and two children: child A who is born first, and child B who is born second. Parents live and raise their children at some location which is normalized to zero. Our model consists of a two-stage game in which the players are the two children. For simplicity we disregard the possibility of parents ever moving, i.e., we implicitly assume that parents have a prohibitive relocation cost. The results we reassess are therefore those described by Propositions 1 and 3 in KKLR. At stage 1 the children make a non-cooperative choice of location which determines the geographical distance to their parents. We will consider both a sequential and a simultaneous choice format. Let $\delta_i \in [0, \infty)$ $(i = A, B)$ denote the distance to parents P implied by child i's location choice. Unlike KKLR, we assume that children incur a psychic cost if they move,[1] and that the cost is convex in the distance by which they move. For simplicity, suppose that the cost function is quadratic: $c(\delta_i) = \frac{1}{2}\delta_i^2$. At stage 2 the children simultaneously choose the number of visits, g_A and g_B, to make to their parents. Similar to KKLR, the time cost per visit consists of one unit of time spent with the parents, plus travel time which is equal to the actual distance δ_i between child i's residence and the parents' location. Child i's time endowment, which is normalized to unity, is allocated between activities that generate private consumption, x_i, and family visits, g_i, according to:

$$x_i + (1 + \delta_i)g_i = 1 \tag{1}$$

Each child i has preferences defined over private consumption, x_i, and the total number of care visits, $G = g_A + g_B$, that the parents get. Unlike KKLR, we assume that preferences are non-quasilinear. For simplicity, suppose that these preferences can be expressed by Cobb-Douglas utility functions:

$$U^i(x_i, G) = \alpha \ln(x_i) + (1 - \alpha)\ln(G) \tag{2}$$

where the preference parameter α is contained in the open unit interval. It is assumed that the above two-stage game is one with complete information.

Before characterizing the equilibrium of our two-stage game, consider as a benchmark an only child who has no sibling who could contribute to parents' visits. At the second stage, an only child maximizes utility for a given child-parent distance $\delta_S \in [0, \infty)$ by a choice of $g_S = G$ which maximizes (2) subject to (1). Given our assumptions, a unique interior solution exists and is given by $g_S^* = \frac{1-\alpha}{1+\delta_S}$. At the first stage, an only child maximizes expected utility by a choice of δ_S, and it is readily checked that $\delta_S^* = 0$ is the payoff-maximizing location. As in KKLR, an only child therefore has an incentive to locate as close as possible to his or her parents.

Let us now turn to the main case of interest, namely, the game with two adult siblings. The model is solved backwards. We therefore begin by characterizing the unique equilibrium outcome at the second stage for any possible actions chosen at the first stage. We have:

[1] To simplify the model, we ignore the monetary costs of moving.

Lemma. *Fix any pair (δ_A, δ_B) chosen at stage 1. Then, at stage 2, the unique equilibrium value of g_i implied by the contribution game between A and B is*

$$\hat{g}_i(\delta_i, \delta_j) = \begin{cases} 0 & \text{if } \delta_i \geqslant \overline{\mathcal{K}}(\delta_j) \\ \frac{1+\delta_j - \alpha(1+\delta_i)}{(1+\delta_i)(1+\delta_j)(1+\alpha)} & \text{if } \underline{\mathcal{K}}(\delta_j) < \delta_i < \overline{\mathcal{K}}(\delta_j) \\ \frac{1-\alpha}{1+\delta_i} & \text{if } \delta_i \leqslant \underline{\mathcal{K}}(\delta_j) \end{cases}$$

where $i, j = A, B$ with $i \neq j$. The definitions of the dropout values $\underline{\mathcal{K}}(\cdot)$ and $\overline{\mathcal{K}}(\cdot)$ are

$$\underline{\mathcal{K}}(\delta_j) = \max\{0, \alpha(1+\delta_j) - 1\} \quad \text{and} \quad \overline{\mathcal{K}}(\delta_j) = (1 + \delta_j - \alpha)/\alpha.$$

There are two possible equilibrium outcomes. On one side, if adult siblings differ significantly with respect to their geographical distance to their parents, then only the child who lives closest will find it optimal to contribute to parental well-being in equilibrium. Conversely, time transfers to one's elderly parents drop to zero if one has a sibling living significantly closer to the parents. However, if adult siblings differ only moderately distance-wise, then there exists a unique interior equilibrium in pure strategies in which *both* siblings allocate positive amounts of time to their elderly parents.

It should be emphasized that the existence of this interior contribution equilibrium is the consequence of relaxing KKLR's assumption of quasi-linear preferences. Quasi-linearity would instead imply that each child's first-order condition in the contribution game can be expressed as a function of one variable only, namely the total provision of the public good. Thus, the first-order conditions would lead to two equations with only one unknown. Consequently, there would be only the following two outcomes in the contribution game: (a) if siblings live at different distances from their parents, then only the child who lives closer contributes to parental well-being, while the other child contributes zero; (b) if both siblings live at the same distance from their parents, then only aggregate contributions can be characterized, while individual contributions are indeterminate.

Continuing the backward induction, the next step is to characterize the siblings' location choices at the first stage. To see that there are distinct theoretical differences between our approach and that of KKLR, consider first the case where the two children *simultaneously* choose their locations. In the KKLR environment, the only pure-strategy equilibria in the simultaneous-move game are asymmetric corner equilibria with one sibling choosing to locate next to the parents and the other sibling choosing to locate in some critical distance. Consequently, only the sibling who lives nearby provides care to the parents. In our setting, in contrast, the only equilibria in pure strategies are symmetric equilibria that induce both siblings to contribute to the public good:

Proposition. *Fix i and j, where $i, j = A, B$ with $i \neq j$.*

(a) For any $\alpha \in (0, 1)$ the location game does not possess an asymmetric pure-strategy equilibrium in which i induces j to stay close to their parents and to assume the whole burden of making care contributions.

(b) There exists $\hat{\alpha}$ with $0 < \frac{1}{2} < \hat{\alpha} < 1$ such that if $\alpha \in (0, \hat{\alpha}]$ the location game possesses a symmetric pure-strategy equilibrium. In this equilibrium, child i sets $\delta_i = \hat{\delta}_i$, where

$$\hat{\delta}_i = \begin{cases} 0 & \text{if } \alpha \in (0, \frac{1}{2}] \\ \frac{-1+\sqrt{4\alpha-1}}{2} & \text{if } \alpha \in (\frac{1}{2}, \hat{\alpha}] \end{cases}$$

(c) If $\alpha \in (\hat{\alpha}, 1)$ the location game does not possess an equilibrium in pure strategies but a mixed-strategy equilibrium exists.

This result provides the basis for understanding why the main conclusion of KKLR about the structure of equilibrium location choices of children does not necessarily withstand careful scrutiny. The following three points should be emphasized in this respect. First, once quasi-linearity is dropped and a relocation cost introduced, there no longer exist pure-strategy equilibria in which siblings make asymmetric location choices [part (a) of the proposition]. As we shall demonstrate below, the absence of asymmetric equilibria in the simultaneous-move game has important implications for the sequential location choice game. In particular, it implies that the strategic effect of distance whereby older siblings can induce younger siblings to stay with the parents and provide all of the care does no longer work.

Second, the only existing pure-strategy equilibria are symmetric [part (b) of the proposition]. More precisely, if the marginal propensity to engage in activities that yield private consumption is large but bounded away from one ($\frac{1}{2} < \alpha \leqslant \hat{\alpha}$), then both siblings have an incentive to lower their costs as caregivers in the contribution game by locating in some distance from their parents. This result forms the basis of what we call the *sibling competition* effect: the attempts of one child to gain an advantage in the contribution game by locating away from the parents puts pressure on the other child to keep up in order to preserve relative contributions. Since each child does not value the extra cost imposed on the other, a "rat race" develops which culminates in both siblings strategically choosing to locate away from their parents. Indeed, the attempts by siblings to alter the outcome of the contribution game through location choices create negative positional externalities and are therefore socially inefficient. Moreover, due to the inefficiencies associated with ex ante positional competition, the ex post care contributions of children with a sibling are generally lower than those of only children. On the other hand, if activities that yield private consumption carry a small preference weight compared to parental well-being ($0 < \alpha \leqslant \frac{1}{2}$), there is no positional competition between siblings. One sibling might try to gain an advantage in the contribution game by locating away from the parents but would quickly discover that the associated reduction in parental well-being outweighs the increase in private consumption. It is therefore optimal for both children to locate as close as possible to their parents.

Finally, if the marginal propensity to engage in activities that yield private consumption is sufficiently close to one ($\hat{\alpha} < \alpha < 1$), then the location game fails to posses an equilibrium in pure strategies [part (c) of the proposition]. The non-existence of pure-strategy equilibrium can be attributed to a violation of quasi-concavity of payoff functions. As a consequence, an equilibrium only exists if players introduce randomness into their location choices. To construct a mixed strategy equilibrium, one could look for increasing probability distributions for each child over some coincident interval $[\underline{\delta}_i, \overline{\delta}_i]$ such that each child is indifferent between choosing any distance in this interval.

We have so far focused on the case in which two siblings simultaneously maximize their payoffs with respect to their own locations, taking the location of the other child as given. We have shown that, while only children have an incentive to locate next to their parents, a choice of zero distance is not necessarily an equilibrium for children with a sibling. Empirically, we would therefore expect that children with a sibling locate on average further away from their parents than only children.

We now consider whether this conclusion also holds if siblings make their location choices sequentially instead of simultaneously. Since it is not possible to obtain closed-form solutions in the sequential game, we report the results of a numerical example. For different values of α, we compute the pure-strategy equilibrium location choices $\tilde{\delta}_A$ and $\tilde{\delta}_B$ under the assumption that child A moves first and child B moves second. We also calculate the corresponding equilibrium number of care visits in the contribution game. For comparative purposes, we also report the location choices and care visits that constitute the equilibrium of the corresponding simultaneous-move game. The results of the numerical example are displayed in Table 1. There are some revealing insights worth mentioning. First, the strategic effect of distance (à la KKLR) whereby older siblings can induce younger siblings to stay with the parents and provide all of the care does not work. To see this, note that every location equilibrium in the sequential-move game is such that both siblings are induced to contribute to the public good ex post. Second, just as in the simultaneous-move game, the choice of zero distance is generally

TABLE 1: SIMULTANEOUS VERSUS SEQUENTIAL LOCATION CHOICE

Preferences	An Only Child		Two Siblings			
			Simultaneous		Sequential	
	δ^*_S	g^*_S	$(\hat{\delta}_A, \hat{\delta}_B)$	$(\hat{g}_A, \hat{g}_B)$	$(\tilde{\delta}_A, \tilde{\delta}_B)$	$(\tilde{g}_A, \tilde{g}_B)$
$\alpha \leq 0.5$	0	$1-\alpha$	(0,0)	$(\frac{1-\alpha}{1+\alpha}, \frac{1-\alpha}{1+\alpha})$	(0,0)	$(\frac{1-\alpha}{1+\alpha}, \frac{1-\alpha}{1+\alpha})$
$\alpha = 0.55$	0	0.45	(0.05,0.05)	(0.28,0.28)	(0.22,0)	(0.17,0.35)
$\alpha = 0.6$	0	0.4	(0.09,0.09)	(0.23,0.23)	(0.23,0.06)	(0.15,0.28)
$\alpha = 0.65$	0	0.35	(0.13,0.13)	(0.19,0.19)	(0.24,0.11)	(0.13,0.23)
$\alpha = 0.7$	0	0.3	(0.17,0.17)	(0.15,0.15)	(0.26,0.15)	(0.11,0.18)
$\alpha = 0.75$	0	0.25	(0.21,0.21)	(0.12,0.12)	(0.28,0.19)	(0.09,0.15)
$\alpha = 0.8$	0	0.2	(0.24,0.24)	(0.09,0.09)	(0.30,0.23)	(0.07,0.11)
$\alpha = 0.85$	0	0.15	(0.27,0.27)	(0.06,0.06)	(0.33,0.27)	(0.04,0.08)

not an equilibrium for siblings in the sequential-move game. Indeed, if α is bounded away from one-half, then both first and second born siblings have an incentive to locate away from their parents, while only children find it optimal to stay as close as possible. Third, while both types of siblings choose to locate away from their parents for a large set of parameter values, our example also illustrates that firstborn siblings may choose to locate in yet a greater distance than second born siblings. Theoretically, the reason is that first born children make their location decisions first, thereby influencing the decisions of second born children. However, this birth order effect becomes small relative to the sibling competition effect as the marginal propensity to engage in activities that yield private consumption increases. Formally, in the sequential location choice game, $|\tilde{\delta}_A - \tilde{\delta}_B|$ decreases while $|\tilde{\delta}_i - \delta^*_S|$ $(i = A, B)$ increases as α gets larger. Overall, our simple numerical example suggests that the strategic influence of siblings on one another (i.e., "sibling competition") may override the strategic influence of firstborn on second born siblings highlighted by KKLR. Put differently, the very presence of a sibling may be more important for family location patterns than birth order. We therefore suggest the following empirical hypothesis:

Prediction. *Independent of their birth order position, children with a sibling differ significantly from only children in their location and caregiving patterns.*

(a) Location-wise, siblings live on average further away from their parents than only children.

(b) Caregiving-wise, siblings consistently allocate less time to their elderly parents than only children.

We have argued that the symmetry of siblings' location choices is driven by positional competition. Of course, there are other non-strategic reasons that might justify a location pattern whereby, irrespective of birth order, children with a sibling are systematically more mobile than only children. Being an only child may necessitate shorter distances to the parents, since there are no other siblings who could help in case of need. Conversely, having a sibling may allow the responsibility for caregiving to be shared among two people, possibly decreasing individual involvement and allowing for greater mobility. The idea that the existence of an alternative family caregiver allows adult children to better strike a balance between activities that yield private consumption and parental care has been referred to elsewhere as a *resource constraint* effect (Rainer and Siedler, 2009).

II. Empirical Evidence

A. Data

Our main analysis is based on data drawn from the Survey of Health, Ageing and Retirement in Europe (SHARE). This cross-national database provides micro data on health, socio-economic status and social and family networks of individuals aged 50 or over. Our estimation sample is based on data contributed by nine countries. They are a balanced representation of the various regions in Europe, ranging from Scandinavia (Sweden) through Central Europe (Austria, France, Germany, Belgium, the Netherlands) to the Mediterranean (Spain, Italy, Greece).[2] For our purposes, SHARE has three advantages. First, it collects detailed information on child-parent geographic proximity and socioeconomic characteristics for both generations similar to those used by KKLR. Second, it allows us to examine the determinants of geographical distances to parents across countries with large cultural, historical and political differences. Third, it not only helps us understand family location patterns, but also the extent to which time transfers to elderly parents are consistent with those location patterns.

Following KKLR, we restrict our sample to parents with one or two biological children who are still alive at the time of the interview. We also require that all children are 30 years of age or older. On average, adult children are 42 years old, 65 percent are married and slightly more than 70 percent of them have children themselves.[3] The mean age of

[2] This comment uses release 2.0.1 of the SHARE 2004 wave. The original SHARE data covers 12 countries. We decided not to report results for Denmark and Switzerland because of relatively small sample sizes. Moreover, to guarantee a certain degree of homogeneity along economic, social and political dimensions, we excluded Israel from the analysis. Robustness checks indicated that the inclusion of these three countries does not alter our key results. For further information about SHARE see Börsch-Supan et al. (2005) and references therein.

[3] Similar to the data set used by KKLR, children's socioeconomic characteristics and child-parent

parents is 70 years, 60 percent of respondents are female and 15 percent report having severely limited health conditions. Overall, the sample consists of 9,107 adult children, 23 percent of whom are only children.[4]

To examine the location choices of adult children, we distinguish between the following five child-parent geographic distance categories: in the same house or household, less than 1 kilometre away, 1 to 5 kilometres away, 5 to 100 kilometres away, and more than 100 kilometres away. Overall, around 14 percent of adult children live in the same house or household than their elderly parents and 16 percent live more than 100 kilometres away from their parents residence.

To analyze time allocations to elderly parents, we use two outcome variables. The first, *Help to Parents*, is a binary variable which equals one for children who have provided help to their parents in the twelve months prior to the interview.[5] The second, *Frequency of Help*, is a categorial variable which provides information whether a particular child has helped his or her parents almost daily, almost every week, almost every month, or less often.

B. Results

Family Location Patterns.—As noted above, the term "geography of the family" was coined to suggest that the main location pattern in families is characterized by asymmetric behavior of siblings, with firstborn children consistently locating further away from their parents than second born or only children. However, once quasi-linearity is lifted and a distance-dependent relocation cost introduced, then what matters more than birth order is the very presence of a sibling. Indeed, the strategic influence of siblings on one another gives rise to an equilibrium in which, irrespective of birth order, children with a sibling consistently locate further away from their parents than only children.

We now attempt to shed light on these competing views by estimating ordinal logistic regressions for child-parent geographic distance. Results are reported in Table 2. The first column reports estimated coefficients from a pooled regression for all nine countries, and the remaining columns display the results for each country separately. To test for the presence of asymmetry in the location choice of firstborn and second born siblings, we also report p-values from chi-square equality tests at the bottom of the table.

geographic distance are reported by the parent.

[4]A description of all variables used in the analysis as well as summary statistics are provided in the appendix.

[5]Services provided may include personal care (e.g., dressing, bathing, eating), practical household help (e.g., home repairs, gardening, shopping) and help with paperwork (e.g., filling out forms, settling financial matters.

Table 2: Child-Parent Distance Regressions for Three Child Types

	All countries	Germany	Austria	France	Belgium	Nether-lands	Spain	Italy	Greece	Sweden
Child										
Age	0.013**	0.011	0.016	0.018+	0.013	0.023*	0.016+	0.022*	0.016*	-0.007
	(0.003)	(0.009)	(0.010)	(0.010)	(0.008)	(0.010)	(0.010)	(0.011)	(0.008)	(0.009)
Female	-0.006	0.074	0.015	-0.051	-0.022	-0.003	-0.212**	0.146*	-0.073	0.005
	(0.023)	(0.067)	(0.074)	(0.073)	(0.063)	(0.066)	(0.082)	(0.071)	(0.066)	(0.066)
Married	0.283**	0.248**	0.039	0.281**	0.122+	0.200*	0.478**	0.505**	0.688**	0.168*
	(0.028)	(0.079)	(0.087)	(0.088)	(0.073)	(0.083)	(0.150)	(0.101)	(0.109)	(0.068)
Grandchildren	0.040	-0.096	-0.016	-0.081	0.361**	0.131	0.410**	-0.009	-0.133	-0.220*
	(0.031)	(0.086)	(0.093)	(0.107)	(0.086)	(0.088)	(0.139)	(0.094)	(0.113)	(0.098)
Firstborn	0.206**	0.085	0.414**	0.116	0.252**	-0.001	0.261*	0.392**	0.183*	0.115
	(0.030)	(0.083)	(0.094)	(0.094)	(0.080)	(0.106)	(0.112)	(0.097)	(0.092)	(0.093)
Second-born	0.180**	0.161+	0.348**	0.119	0.169*	0.055	0.211+	0.343**	0.199*	0.011
	(0.031)	(0.085)	(0.104)	(0.095)	(0.082)	(0.104)	(0.118)	(0.101)	(0.094)	(0.094)
Parent										
Age	-0.011**	-0.003	-0.020*	-0.019*	-0.018*	-0.014+	-0.020*	-0.014	-0.009	0.002
	(0.003)	(0.008)	(0.009)	(0.009)	(0.007)	(0.008)	(0.009)	(0.009)	(0.007)	(0.007)
Female	-0.097**	-0.160*	-0.250**	-0.064	-0.088	0.000	-0.056	-0.231*	-0.107	-0.050
	(0.027)	(0.075)	(0.093)	(0.089)	(0.075)	(0.080)	(0.107)	(0.091)	(0.085)	(0.072)
Married	-0.003	0.000	-0.088	0.075	-0.214**	0.021	0.243*	-0.114	0.062	-0.046
	(0.029)	(0.084)	(0.092)	(0.086)	(0.081)	(0.087)	(0.107)	(0.092)	(0.084)	(0.077)
Limited activities	0.024	-0.013	0.174+	-0.036	-0.089	0.233**	0.051	-0.139	0.114	-0.003
	(0.027)	(0.076)	(0.089)	(0.092)	(0.076)	(0.085)	(0.097)	(0.089)	(0.078)	(0.077)
Severely limited activities	-0.032	-0.076	0.079	-0.267*	-0.339**	0.143	-0.012	-0.073	0.198+	0.083
	(0.036)	(0.098)	(0.124)	(0.117)	(0.089)	(0.102)	(0.210)	(0.108)	(0.117)	(0.100)
P-value of equality test[a]	0.31	0.32	0.43	0.97	0.29	0.49	0.56	0.56	0.80	0.15
Pseudo R^2	0.05	0.05	0.04	0.04	0.04	0.05	0.06	0.04	0.03	0.01
Observations	9,107	1,114	869	920	1,217	962	735	966	1,173	1,151

Notes: The dependent variable is child-parent geographic distance. The reference categories for non-scaled variables are male, not married, no grandchildren, being an only child, male parent, unmarried parent, and parent has not been limited for the past six month because of a health problem in usual daily activities. Robust standard errors at the family level in parentheses. All regressions also control for a maximum set of highest educational degree variables for adult children and parents. The regression in column 1 also includes a maximum set of country dummy variables. [a] Figures are p-values of the test that the estimated coefficients of being firstborn and second-born are equal and are obtained from χ^2-statistics. + significant at 10 percent, * significant at 5 percent, ** significant at 1 percent level.

The main coefficients of interest are those on being a firstborn and second born sibling, respectively. Overall, having a sibling appears to have a profound impact on adult children's location decisions. There is, however, no evidence to relate birth order to asymmetric location choices of siblings. To see this, consider first the results from our pooled multi-country regression [column (1)]. The estimated coefficients suggest that both firstborn and second born siblings are significantly more likely to live further away from their elderly parents than only children. The estimates are not only statistically significant at the 1 percent level; the corresponding marginal effects lead one to believe that they are also quantitatively important. For example, firstborns have a 5 percentage points and second born siblings a 4 percentage points higher probability to live more than 100 kilometres away from their parents than only children. Finally, there is no significant asymmetry in the location choice of firstborn and second born siblings. Indeed, the *p*-value of 0.31 reported at the bottom of the table indicates that the coefficients for first and second born siblings are not statistically differen from each other.

Moving on to individual country results [columns (2) to (10)], the family location pattern observed in the aggregate is borne out with a striking degree of consistency. The estimates for Germany, Austria, Belgium, Greece, Italy and Spain indicate that children with a sibling live on average further away from their parents than only children.[6] While the presence of a sibling appears to play an important role for adult children's location choices, there is a lack of a birth order effect since the coefficients for firstborn and second born siblings are generally not significantly different from each other. Indeed, the only coefficients whose magnitudes are in line with the idea that siblings behave asymmetrically (as suggested by KKLR) are those for Sweden. However, these estimates lack precision and are not statistically significant at conventional levels. Overall, the empirical results so far serve to breath life into the prediction of our model that the presence of a sibling is more important for family location patterns than birth order.

Time Transfers to Elderly Parents.—Our theory also implies that, irrespective of birth order, children with a sibling allocate less time to their parents than only children. We would therefore expect that the presence of both an older sibling or a younger sibling significantly reduces the time a particular child allocates to his or her parents. If, by contrast, older siblings can induce younger siblings to stay close to the parents and become the sole caregivers (à la KKLR), then the presence of a younger sibling would be negatively correlated with time transfers of first born siblings; conversely, the time allocations of second born children would be unaffected by the presence of an older sibling.

[6] Note, however, that the coefficient of being a firstborn sibling in Germany is not precisely estimated.

Table 3: Child-to-Parent Time Regressions for Three Child Types

	All countries	Germany	Austria	France	Belgium	Nether-lands	Spain	Italy	Greece	Sweden
(a) Help to parents[a]										
Firstborn	-1.033**	-0.632*	-1.365**	-1.232**	-0.931*	-1.719**	-2.122**	-2.180**	-0.864**	-1.469**
	(0.119)	(0.121)	(0.375)	(0.457)	(0.366)	(0.541)	(0.623)	(0.606)	(0.327)	(0.362)
Second-born	-0.898**	-0.647*	-0.995**	-1.003+	-0.631	-1.661**	-1.916**	-2.341**	-0.913**	-1.192**
	(0.123)	(0.126)	(0.347)	(0.527)	(0.415)	(0.525)	(0.625)	(0.710)	(0.344)	(0.373)
Pseudo R^2	0.232	0.154	0.268	0.426	0.280	0.315	0.343	0.283	0.200	0.298
P-value of equality test[c]	0.01	0.90	0.02	0.34	0.12	0.82	0.32	0.61	0.71	0.12
(b) Frequency of help[b]										
Firstborn	-1.017**	-0.570*	-1.362**	-1.172*	-0.990**	-2.060**	-2.130**	-2.011**	-0.750*	-1.435**
	(0.120)	(0.269)	(0.357)	(0.467)	(0.359)	(0.610)	(0.619)	(0.622)	(0.325)	(0.346)
Second-born	-0.904**	-0.618*	-1.160**	-1.008+	-0.638	-1.932**	-1.767**	-2.160**	-0.791*	-1.138**
	(0.124)	(0.260)	(0.360)	(0.519)	(0.415)	(0.543)	(0.617)	(0.678)	(0.333)	(0.373)
Pseudo R^2	0.175	0.115	0.204	0.328	0.218	0.303	0.285	0.239	0.144	0.226
P-value of equality test[c]	0.03	0.72	0.22	0.46	0.09	0.62	0.16	0.66	0.76	0.15
Number of observations	6,309	795	597	729	826	731	460	591	693	887

Notes: [a]Estimates from logit regressions. [b]Estimates from ordered logit regressions. The reference categories for non-scaled variables are male, not married, no grandchildren, being an only child, male parent, unmarried parent, and parent has not been limited for the past six month because of a health problem in usual daily activities. Robust standard errors at the family level in parentheses. All regressions also control for a maximum set of highest educational degree variables for adult children and parents. The regressions in column 1 also includes a maximum set of country dummy variables. [c]Figures are p-values of the test that the estimated coefficients of being firstborn and second-born are equal and are obtained from χ^2-statistics. + significant at 10 percent, * significant at 5 percent, ** significant at 1 percent level.

In an effort to understand the role of siblings in caring for elderly parents, we now turn to time transfers in the data. To this end, Table 3 presents estimates of the determinants of child-to-parent time allocations. Panel (a) reports the estimates for whether adult children have provided any kind of help to their parents, and panel (b) displays the results for the frequency of help to elderly parents. Of primary importance are our findings concerning the effects of having a sibling. Overall, we find that time transfers to elderly parents respond negatively to the presence of a sibling. More specifically, the results in panel (a), column 1 indicate that having a sibling reduces the probability that a particular child provides any kind of help to his or her parents. As well as being statistically significant at the 1 percent level, this result is also qualitatively important. The corresponding marginal effects from the pooled regression suggest that being a firstborn or second born sibling reduces the probability to provide help to parents by 4 percentage points, compared to being an only child. In line with our theory, the estimates suggest that the presence of a sibling is considerably more important than a birth order effect.[7] Similarly, moving on to the individual country estimates reveal that both firstborn and second born siblings are less likely to provide help to their parents than only children in all but one country (Belgium). The estimates in panel (b) show that children with a sibling provide less frequent help to their parents than only children. Non-reported marginal effects for the pooled cross-country estimates show, for example, that both types of siblings are 1 to 2 percentage points less likely to help their parent every week, compared to an only child.

It is worthwhile stressing that the results just described hold both for first and second born siblings. In other words, birth order does not have a discernible impact on time transfers to elderly parents. This result resonates with our earlier findings concerning family location patterns. In particular, we have already empirically rejected the idea that first born siblings induce second born siblings to stay close to their parents. In line with this lack of a birth order effect, we have now observed that second born children do not consistently assume the whole burden of making time transfer to parents. These findings are important, for they suggest that there is no systematic asymmetry in the behavior of siblings. Rather, the results provide convincing evidence that the presence of a sibling matters independent of birth order position. Consistent with the theory, children with a sibling not only locate on average further away from their parents than only children, but the also allocate less time to their elderly parents. Particularly persuasive in this respect is the consistency of location and contribution patterns in families with one and

[7] While the p-value for the presence of asymmetry in proving help to parents for firstborn and second born siblings shows a statistically significant difference among siblings, the corresponding marginal effect do not point to important quantitative differences.

two children across a wide range of countries.

III. Conclusion

Kai A. Konrad et al. (2002) made the important observation that strategic interactions between siblings may have a determinate effect on their location choices. In particular, they argued that the strategic influence of older siblings on younger siblings yields a geography of the family whereby firstborn children consistently locate further away from their parents than second born or only children. We show that this conclusion does not necessarily hold when preferences are non-quasi-linear and moving from one location to another is costly. More specifically, in our modified setup positional competition between siblings implies that each child has an incentive to match the location of the other, lest the chances of being severely implicated in caring for elderly parents increase. The core theoretical idea therefore taken to the data is that, regardless of birth order position, children with a sibling choose to locate further away from their parents than only children. In line with the theory, there is robust cross-national evidence that children with a sibling live further away from their parents than only children. Moreover, there is also evidence that time transfers to elderly parents are lower among siblings than among only children. Finally, our analysis suggests that there is no systematic asymmetry in the behavior of siblings, which raises doubts about the robustness of the empirical results presented in Kai A. Konrad et al. (2002).

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Appendix I: Proof of Lemma and Proposition

Proof of Lemma. The game under consideration is a public good game with the possibility of differing contribution costs. Cornes and Hartley (2007) have recently provided a unified analysis of existence and uniqueness properties of such a game without requiring the use of fixed point or other theorems in high-dimensional spaces. Our proof therefore follows their method closely. Fix any distance pair (δ_i, δ_j) at stage 1 ($i, j = A, B$ and $i \neq j$). Then, at stage 2, the value of g_i implied by the contribution game between A and B can be found by solving the maximization problem

$$\max_{x_i, g_i} U^i(x_i, G) = \alpha \ln(x_i) + (1-\alpha)\ln(G)$$
$$\text{s.t.} \quad x_i + c_i g_i = 1$$
$$g_i \geqq 0$$

where $c_i = 1 + \delta_i$ is individual i's contribution cost and $G = g_i + g_j$ is the total provision of the public good. Assuming that individual i treats g_j as a constant, it follows that this maximization problem is equivalent to

$$\max_{x_i, G} U^i(x_i, G) = \alpha \ln(x_i) + (1-\alpha)\ln(G)$$
$$\text{s.t.} \quad x_i + c_i G = 1 + c_i g_j$$
$$G \geqq g_j.$$

Solving this yields a continuous demand function for the public good:

$$G = \max\left\{\frac{(1 + c_i g_j)(1-\alpha)}{c_i}, g_j\right\}.$$

Inverting this and adding $c_i g_i$ to both sides yields individual i's *replacement function* (see Cornes and Hartley, 2007, p. 205):

$$\hat{g}_i = r_i(G, c_i) = \max\left\{\frac{1}{c_i} - \frac{\alpha G}{1-\alpha}, 0\right\}. \tag{RF}$$

Notice that preferences are well-behaved, individual budget constraints are linear, and both the private good and the public good are normal. Moreover, the total supply of the public good is the sum of individual contributions. Under these conditions, there exists a unique Nash equilibrium in the public good game (see Cornes and Hartley, 2007, p. 207). The equilibrium level of total public good provision, $\hat{G}$, must equal the sum of all individual replacement functions associated with the equilibrium allocation. $\hat{G}$ is therefore found by solving

$$\sum_{i=A,B} \max\left\{\frac{1}{c_i} - \frac{\alpha G}{1-\alpha}, 0\right\} = G.$$

Once $\hat{G}$ is known, individual contributions $\hat{g}_i$ and dropout values $\underline{\mathcal{K}}$ and $\overline{\mathcal{K}}$ (as stated in the lemma) can be read off using i's replacement function (RF). □

Proof of Proposition. Continuing the backward induction, the next step is to characterize the siblings' location choices at the first stage. Substituting the equilibrium values from the contribution game into the utility function of each child, and subtracting the distance-dependent relocation cost, we find that the payoff of child i is:

$$U_i(\delta_i,\delta_j) = \begin{cases} (1-\alpha)\ln\left(\frac{1-\alpha}{1+\delta_j}\right) - \frac{\delta_i^2}{2} \equiv \mathbf{V}(\delta_i,\delta_j) & \text{if } \delta_i \geqslant \overline{\mathcal{K}}(\delta_j) \\ \ln\left(\frac{\alpha(2+\delta_i+\delta_j)}{(1+\alpha)(1+\delta_j)}\right) + (1-\alpha)\ln\left(\frac{1-\alpha}{\alpha(1+\delta_i)}\right) - \frac{\delta_i^2}{2} \equiv \mathbf{W}(\delta_i,\delta_j) & \text{if } \underline{\mathcal{K}}(\delta_j) < \delta_i < \overline{\mathcal{K}}(\delta_j) \\ \alpha\ln(\alpha) + (1-\alpha)\ln\left(\frac{1-\alpha}{1+\delta_i}\right) - \frac{\delta_i^2}{2} \equiv \mathbf{Z}(\delta_i) & \text{if } \delta_i \leqslant \underline{\mathcal{K}}(\delta_j) \end{cases}$$

where $i, j = A, B$ with $i \neq j$. Moreover, the definitions of the dropout values $\underline{\mathcal{K}}(\cdot)$ and $\overline{\mathcal{K}}(\cdot)$ are

$$\underline{\mathcal{K}}(\delta_j) = \max\{0, \alpha(1+\delta_j)-1\} \quad \text{and} \quad \overline{\mathcal{K}}(\delta_j) = (1+\delta_j-\alpha)/\alpha.$$

Consider the simultaneous location choice game. In this case the two children maximize the above payoffs with respect to their own locations, taking the location of the other child as given. We now derive player i's best-response function. To begin with, it is useful to note that i's payoff function is only piecewise differentiable. Moreover, note that:

Property 1. *Define* $\mathcal{A}(\alpha) = \frac{1-\alpha}{\alpha}$.

(a) For any $\delta_j \in [0, \mathcal{A}(\alpha)]$*, the interval* $[0, \underline{\mathcal{K}}(\delta_j)]$ *is empty.*

(b) For any $\delta_j \in (\mathcal{A}(\alpha), \infty)$*,* $U_i(\cdot)$ *is a strictly decreasing function of* δ_i *over the interval* $[0, \underline{\mathcal{K}}(\delta_j)]$.

(c) For any $\delta_j \in [0, \infty)$*,* $U_i(\cdot)$ *is a strictly decreasing function of* δ_i *over the interval* $[\overline{\mathcal{K}}(\delta_j), \infty)$.

Property 2. *For any* $\alpha \in (0, \frac{1}{2}]$*, the payoff of child* i *is a strictly decreasing function of* δ_i *over the interval* $(\underline{\mathcal{K}}(\delta_j), \overline{\mathcal{K}}(\delta_j))$.

Property 3. *For any* $\alpha \in (\frac{1}{2}, 1)$ *and* $\delta_j \in [0, \mathcal{A}(\alpha)]$,

$$\lim_{\varepsilon\to 0} \left.\frac{\partial \mathbf{W}(\delta_i,\delta_j)}{\partial \delta_i}\right|_{\delta_i=0+\varepsilon} \gtreqless 0 \quad \textit{if and only if} \quad \delta_j \lesseqgtr \mathcal{B}(\alpha)$$

where

$$\mathcal{B}(\alpha) = \frac{2\alpha-1}{1-\alpha}.$$

Property 4. *For any* $\alpha \in (\frac{1}{2}, 1)$ *and* $\delta_j \in (\mathcal{A}(\alpha), \infty)$,

$$\lim_{\varepsilon\to 0} \left.\frac{\partial \mathbf{W}(\delta_i,\delta_j)}{\partial \delta_i}\right|_{\delta_i=\underline{\mathcal{K}}(\delta_j)+\varepsilon} \gtreqless 0 \quad \textit{if and only if} \quad \delta_j \lesseqgtr \mathcal{C}(\alpha)$$

where

$$\mathcal{C}(\alpha) = \frac{\alpha(\alpha+1)(1-2\alpha) + \sqrt{\alpha^2(\alpha+1)(4\alpha^2+5\alpha-3)}}{2\alpha^2(\alpha+1)}.$$

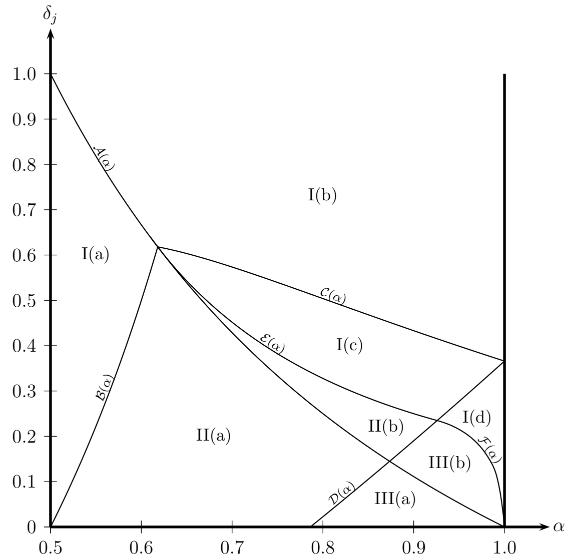

FIGURE 1: Characterization of i's best-response function.

Property 5. *For any* $\alpha \in (\frac{1}{2}, 1)$ *and* $\delta_j \in [0, \infty)$,

$$\lim_{\varepsilon \to 0} \left. \frac{\partial \mathbf{W}(\delta_i, \delta_j)}{\partial \delta_i} \right|_{\delta_i = \overline{\mathcal{K}}(\delta_j) - \varepsilon} \gtreqless 0 \quad \textit{if and only if} \quad \delta_j \lesseqgtr \mathcal{D}(\alpha)$$

where

$$\mathcal{D}(\alpha) = \frac{(\alpha+1)(\alpha-2) + \sqrt{\alpha^2(\alpha+1)(4\alpha^2+\alpha+1)}}{2(\alpha+1)}.$$

For future reference we also note the following definitions:

Definition 1. *Let* $\chi(\delta_j, \alpha) = \underset{\delta_i \in (\underline{\mathcal{K}}, \overline{\mathcal{K}})}{\arg\max} \mathbf{W}(\delta_i, \delta_j)$.[8]

Definition 2. *Let* $\mathcal{E}(\alpha)$ *be that value of* δ_j *which solves* $\mathbf{W}(\chi(\delta_j, \alpha), \delta_j) = \mathbf{Z}(0)$.

Definition 3. *Let* $\mathcal{F}(\alpha)$ *be that value of* δ_j *which solves* $\mathbf{V}(\overline{\mathcal{K}}(\delta_j, \alpha), \delta_j) = \mathbf{Z}(0)$.

With these preliminaries in hand, the derivation of all possible best-response configurations now proceeds in steps (1)-(9):

(1) Suppose first that $\alpha \in (0, \frac{1}{2}]$. Then, by Properties 1 and 2, the payoff of child i is a strictly decreasing function of δ_i over the interval $[0, \infty)$ for all non-negative values of δ_j. Thus, child i has a dominant strategy which is to choose zero distance, $\hat{\delta}_i = 0$, to the parents.

(2) Suppose now that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in [\mathcal{B}(\alpha), \mathcal{A}(\alpha)]$ (see region I(a) in Figure 1). Then, by Property 1(a), $\underline{\mathcal{K}}(\delta_j) = 0$. Moreover, by Properties 1(c), 3 and 5, the payoff of child i

[8]Thus, $\chi_i(\delta_j, \alpha)$ is that value of δ_i which implicitly solves

$$\frac{\alpha(2+\delta_i+\delta_j) - \delta_j(\delta_i+\delta_i^2+1) - \delta_i(1+\delta_i)(2+\delta_i) - 1}{(2+\delta_i+\delta_j)(1+\delta_i)} = 0.$$

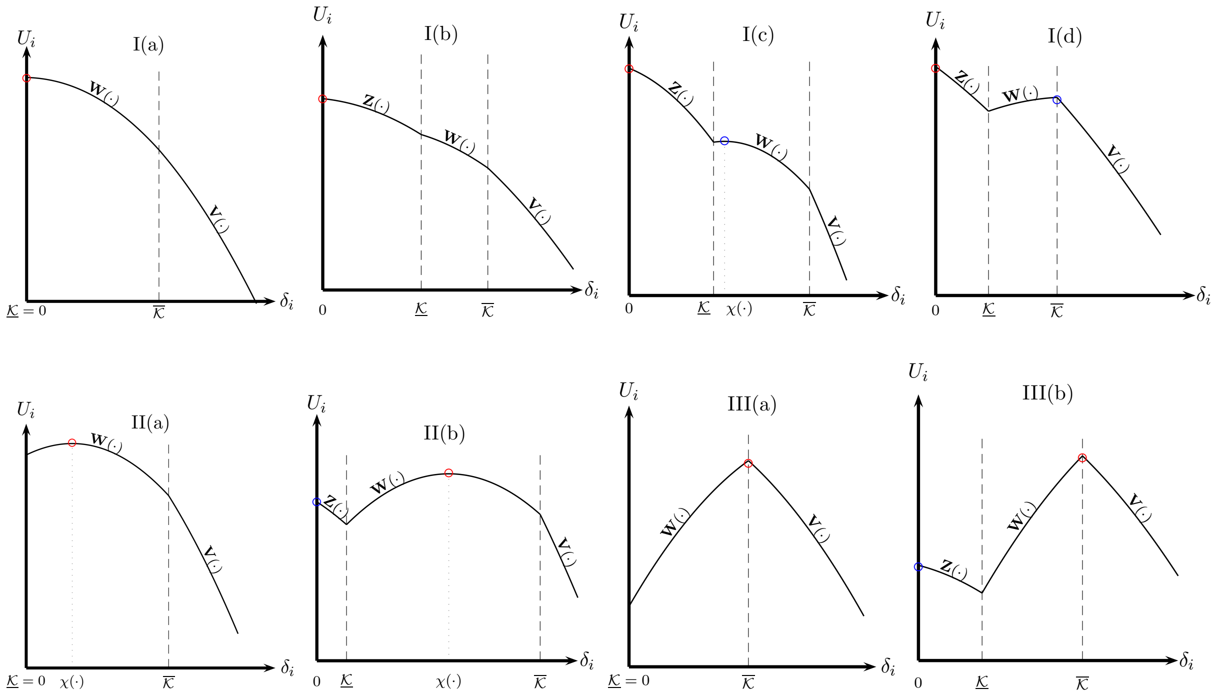

FIGURE 2: Possible payoff configurations.

is a strictly decreasing function of δ_i over the intervals $[0, \overline{\mathcal{K}}(\delta_j))$ and $[\overline{\mathcal{K}}(\delta_j), \infty)$ (see panel I(a) in Figure 2). Thus, for the parameters under consideration, child i's best response is $b_i(\delta_j) = 0$, i.e., to choose zero distance to the parents.

(3) Suppose next that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in (\max\{\mathcal{A}(\alpha), \mathcal{C}(\alpha)\}, \infty)$ (see region I(b) in Figure 1). Then, by Properties 1, 4 and 5, the payoff of child i is a strictly decreasing function of δ_i over the intervals $[0, \underline{\mathcal{K}}(\delta_j)]$, $(\underline{\mathcal{K}}(\delta_j), \overline{\mathcal{K}}(\delta_j))$ and $[\overline{\mathcal{K}}(\delta_j), \infty)$ (see panel I(b) in Figure 2). Thus, for the parameters under consideration, child i's best response is $b_i(\delta_j) = 0$, i.e., to choose zero distance to the parents.

(4) Suppose that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in (\max\{\mathcal{D}(\alpha), \mathcal{E}(\alpha)\}, \mathcal{C}(\alpha)]$ (see region I(c) in Figure 1). Then, by Property 1, the payoff of child i is a strictly decreasing function of δ_i over the intervals $[0, \underline{\mathcal{K}}(\delta_j)]$ and $[\overline{\mathcal{K}}(\delta_j), \infty)$ and therefore has local maximum at $\delta_i = 0$. By Properties 4 and 5 and Definition 1, the payoff of child i is non-monotonic over $(\underline{\mathcal{K}}(\delta_j), \overline{\mathcal{K}}(\delta_j))$ and achieves a local maximum at $\delta_i = \chi(\delta_j, \alpha)$ (see panel I(c) in Figure 2). However, for the parameter values under considerations, $\mathbf{Z}(0) > \mathbf{W}(\chi(\delta_j, \alpha), \delta_j)$, i.e., the utility value associated with the local maximum at $\delta_i = 0$ exceeds the utility value associated with the local maximum at $\delta_i = \chi(\delta_j, \alpha)$. Thus, child i's global best response is $b_i(\delta_j) = 0$, i.e., to choose zero distance to the parents.

(5) Suppose that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in (\mathcal{F}(\alpha), \mathcal{D}(\alpha)]$ (see region I(d) in Figure 1). Then, by Property 1, the payoff of child i is a strictly decreasing function of δ_i over the intervals $[0, \underline{\mathcal{K}}(\delta_j)]$ and $[\overline{\mathcal{K}}(\delta_j), \infty)$ and therefore has local maximum at $\delta_i = 0$. By Properties 4 and 5, the payoff of child i is strictly increasing over the interval $(\underline{\mathcal{K}}(\delta_j), \overline{\mathcal{K}}(\delta_j))$ and therefore achieves a local maximum at $\delta_i = \overline{\mathcal{K}}(\delta_j, \alpha)$ (see panel I(d) in Figure 2). For the parameter values under considerations, $\mathbf{Z}(0) > \mathbf{V}(\overline{\mathcal{K}}(\delta_j, \alpha), \delta_j)$, i.e., the utility value associated with

the local maximum at $\delta_i = 0$ exceeds the utility value associated with the local maximum at $\delta_i = \overline{\mathcal{K}}(\delta_j, \alpha)$. Thus, child i's global best response is $b_i(\delta_j) = 0$, i.e., to choose zero distance to the parents.

(6) Suppose that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in [\mathcal{D}(\alpha), \min\{\mathcal{A}(\alpha), \mathcal{B}(\alpha)\})$ (see region II(a) in Figure 1). Then, by Property 1, $\underline{\mathcal{K}}(\delta_j) = 0$ and U_i is a strictly decreasing function of δ_i over the interval $[\overline{\mathcal{K}}(\delta_j), \infty)$. By Properties 3 and 5 and Definition 1, the payoff of child i is non-monotonic over the interval $[0, \overline{\mathcal{K}}(\delta_j))$ and achieves a global maximum at $\delta_i = \chi(\delta_j, \alpha)$ (see panel II(a) in Figure 2). Thus, child i's best response is $b_i(\delta_j) = \chi(\delta_j, \alpha)$.

(7) Suppose that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in [\max\{\mathcal{A}(\alpha), \mathcal{D}(\alpha)\}, \mathcal{E}(\alpha)]$ (see region II(b) in Figure 1). Then, by Property 1, the payoff of child i is a strictly decreasing function of δ_i over the intervals $[0, \underline{\mathcal{K}}(\delta_j)]$ and $[\overline{\mathcal{K}}(\delta_j), \infty)$ and therefore has local maximum at $\delta_i = 0$. By Properties 4 and 5 and Definition 1, the payoff of child i is non-monotonic over the interval $(\overline{\mathcal{K}}(\delta_j), \overline{\mathcal{K}}(\delta_j))$ and achieves a local maximum at $\delta_i = \chi(\delta_j, \alpha)$ (see panel II(b) in Figure 2). For the parameter values under considerations, $\mathbf{W}(\chi(\delta_j, \alpha), \delta_j) \geqslant \mathbf{Z}(0)$, i.e., the utility value associated with the local maximum at $\delta_i = \chi(\delta_j, \alpha)$ exceeds the utility value associated with the local maximum at $\delta_i = 0$. Thus, child i's global best response is $b_i(\delta_j) = \chi(\delta_j, \alpha)$.

(8) Suppose that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in [0, \min\{\mathcal{A}(\alpha), \mathcal{D}(\alpha)\})$ (see region III(a) in Figure 1). Then, by Property 1, $\underline{\mathcal{K}}(\delta_j) = 0$ and U_i is a strictly decreasing function of δ_i over the interval $[\overline{\mathcal{K}}(\delta_j), \infty)$. Moreover, by Property 3, U_i is strictly increasing in δ_i over $[0, \overline{\mathcal{K}}(\delta_j))$. Hence, U_i achieves a global maximum at $\delta_i = \overline{\mathcal{K}}(\delta_j)$ (see panel III(a) in Figure 2), and so child i's best response is $b_i(\delta_j) = \overline{\mathcal{K}}(\delta_j)$.

(9) Finally, suppose that $\alpha \in (\frac{1}{2}, 1)$ and $\delta_j \in [\mathcal{A}(\alpha), \min\{\mathcal{D}(\alpha), \mathcal{F}(\alpha)\})$ (see region III(b) in Figure 1). Then, by Property 1, the payoff of child i is a strictly decreasing function of δ_i over the intervals $[0, \underline{\mathcal{K}}(\delta_j)]$ and $[\overline{\mathcal{K}}(\delta_j), \infty)$. Moreover, by Property 3, U_i is strictly increasing in δ_i over $(\underline{\mathcal{K}}(\delta_j), \overline{\mathcal{K}}(\delta_j))$. Hence, U_i achieves local maxima at $\delta_i = 0$ and $\delta_i = \overline{\mathcal{K}}(\delta_j)$ (see panel III(b) in Figure 2). However, for the parameter values under consideration, we have that $\mathbf{V}(\overline{\mathcal{K}}(\delta_j, \alpha), \delta_j) > \mathbf{Z}(0)$, and so child i's best response is $b_i(\delta_j) = \overline{\mathcal{K}}(\delta_j)$.

With the characterization of i's best-response function at hand, we are now ready to proof the proposition. Part (a) states that there does not exist an asymmetric pure-strategy equilibrium in which i induces j to stay close to their parents and to become the sole contributor to the public good. Clearly, the only candidate for such an asymmetric pure-strategy equilibrium is one child locating at $\delta_i^{as} = 0$ and the other locating at $\delta_j^{as} = \overline{\mathcal{K}}(0) \equiv \frac{1-\alpha}{\alpha}$. To see that 0 and $\overline{\mathcal{K}}(0)$ do not constitute a pure-strategy equilibrium, fix $\delta_j^{as} = \overline{\mathcal{K}}(0)$. Then, for child i, $\underline{\mathcal{K}}(\overline{\mathcal{K}}(0)) = 0$, and

$$\lim_{\varepsilon \to 0} \left. \frac{\partial \mathbf{W}(\delta_i, \overline{\mathcal{K}}(0))}{\partial \delta_i} \right|_{\delta_i = 0 + \varepsilon} \gtreqless 0 \text{ if and only if } \alpha \gtreqless 0.618.$$

Thus, $\delta_i^{as} = 0$ is a best-response to $\delta_j^{as} = \overline{\mathcal{K}}(0)$ for all $\alpha \leqslant 0.618$. Next, fix $\delta_i^{as} = 0$. Then, for child j, $\underline{\mathcal{K}}(0) = 0$, and

$$\lim_{\varepsilon \to 0} \left. \frac{\partial \mathbf{W}(0, \delta_j)}{\partial \delta_j} \right|_{\delta_j = \overline{\mathcal{K}}(0) - \varepsilon} \gtreqless 0 \text{ if and only if } \alpha \gtreqless 0.786.$$

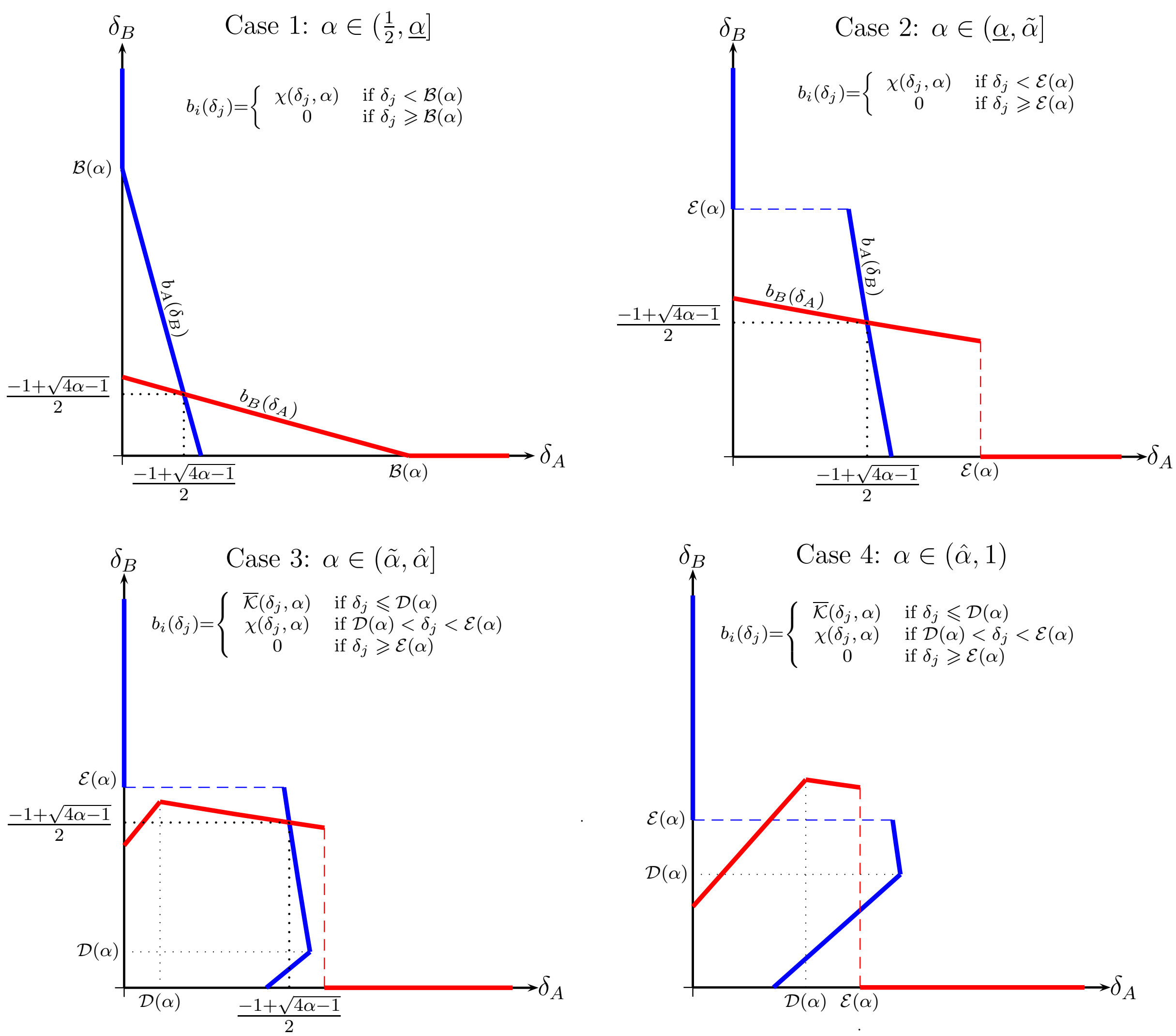

FIGURE 3: Equilibrium in the location game.

Thus, $\delta_j^{as} = \overline{\mathcal{K}}(0)$ is a best-response to $\delta_i^{as} = 0$ for all $\alpha \geqslant 0.786$. Overall, there exists therefore no value of $\alpha \in (0,1)$ for which $\delta_i^{as} = 0$ and $\delta_j^{as} = \overline{\mathcal{K}}(0)$ are mutually best-responses. This completes the proof of part (a) of the proposition.

Consider next parts (b) and (c) of the proposition. We have already shown that when $\alpha \in (0, \frac{1}{2}]$, then the payoff of child i is a strictly decreasing function of δ_i over the interval $[0, \infty)$ for all non-negative values of δ_j. Thus, each child has a dominant pure-strategy which is to choose zero distance to the parents, i.e., $\hat{\delta}_A = \hat{\delta}_B = 0$ constitutes a dominant-strategy equilibrium. Now suppose that $\alpha \in (\frac{1}{2}, 1)$. Then four types of scenarios may arise (see Figure 3). To see this, let $\underline{\alpha}$ be that value of α for which $\mathcal{A}(\alpha) = \mathcal{B}(\alpha)$, and let $\tilde{\alpha}$ be the solution to $\mathcal{D}(\alpha) = 0$.[9] Now, if $\alpha \in (\frac{1}{2}, \underline{\alpha}]$, then i's best-response function is (see

[9]Given our earlier definitions, it is readily checked that $\underline{\alpha} \simeq 0.618$ and $\tilde{\alpha} \cong 0.786$ (see also Figure 2).

Figure 3, Case 1):

$$b_i(\delta_j) = \begin{cases} \chi(\delta_j, \alpha) & \text{if } \delta_j < \mathcal{B}(\alpha) \\ 0 & \text{if } \delta_j \geqslant \mathcal{B}(\alpha) \end{cases},$$

and a symmetric pure-strategy equilibrium is located at the point where $\chi(\delta_A, \alpha)$ and $\chi(\delta_B, \alpha)$ intersect. Given that $\chi(\delta_j, \alpha)$ is that value of δ_i which solves

$$\frac{\alpha(2 + \delta_i + \delta_j) - \delta_j(\delta_i + \delta_i^2 + 1) - \delta_i(1 + \delta_i)(2 + \delta_i) - 1}{(2 + \delta_i + \delta_j)(1 + \delta_i)} = 0,$$

it is readily checked that a symmetric pure-strategy equilibrium occurs where $\hat{\delta}_A = \hat{\delta}_B = \frac{-1+\sqrt{4\alpha-1}}{2}$. Next, if $\alpha \in (\underline{\alpha}, \tilde{\alpha}]$, then i's best-response function is (see Figure 3, Case 2):

$$b_i(\delta_j) = \begin{cases} \chi(\delta_j, \alpha) & \text{if } \delta_j < \mathcal{E}(\alpha) \\ 0 & \text{if } \delta_j \geqslant \mathcal{E}(\alpha) \end{cases}$$

While i's best-response function now has a point of discontinuity at $\mathcal{E}(\alpha)$, a symmetric pure-strategy equilibrium occurs again where $\chi(\delta_A, \alpha)$ and $\chi(\delta_B, \alpha)$ intersect. Finally, for any $\alpha \in (\tilde{\alpha}, 1)$, there are two sub-cases to consider. Let $\hat{\alpha}$ be the solution to $\mathcal{E}(\alpha) = \frac{-1+\sqrt{4\alpha-1}}{2}$.[10] If $\alpha \in (\tilde{\alpha}, \hat{\alpha}]$, then i's best-response function is (see Figure 3, Case 3):

$$b_i(\delta_j) = \begin{cases} \overline{\mathcal{K}}(\delta_j, \alpha) & \text{if } \delta_j \leqslant \mathcal{D}(\alpha) \\ \chi(\delta_j, \alpha) & \text{if } \mathcal{D}(\alpha) < \delta_j < \mathcal{E}(\alpha) \\ 0 & \text{if } \delta_j \geqslant \mathcal{E}(\alpha) \end{cases}.$$

As before, i's best-response function has a point of discontinuity at $\mathcal{E}(\alpha)$. However, a symmetric pure-strategy equilibrium exists and occurs at the point of intersection between $\chi(\delta_A, \alpha)$ and $\chi(\delta_B, \alpha)$. A final possibility is that there is no pure-strategy equilibrium. This case arises when $\alpha \in (\hat{\alpha}, 1)$ (see Figure 3, Case 4). Given child j's candidate equilibrium strategy $\delta_j = \frac{-1+\sqrt{4\alpha-1}}{2}$, it now pays off for child i to deviate from the candidate equilibrium strategy $\delta_i = \frac{-1+\sqrt{4\alpha-1}}{2}$ by setting $\delta_i = 0$. As consequence, the two best-response functions do not intersect. Despite non-existence of pure-strategy equilibrium, a mixed-strategy equilibrium exists since i's payoff function is continuous and the strategy space is non-empty and compact (Glicksberg, 1952). This completes the proof of parts (b) and (c) of the proposition. □

[10]Given j's candidate equilibrium strategy $\delta_j = \frac{-1+\sqrt{4\alpha-1}}{2}$, $\hat{\alpha}$ is therefore that value of α at which i is indifferent between the candidate equilibrium strategy $\delta_i = \frac{-1+\sqrt{4\alpha-1}}{2}$ and a deviation from that strategy to $\delta_i = 0$. Given our earlier definitions, it is a fairly straightforward, though rather tedious, exercise to show that $\hat{\alpha} \cong 0.857$.

Appendix II: Summary Statistics of Outcome Variables

	All countries	Germany	Austria	France	Belgium	Nether-lands	Spain	Italy	Greece	Sweden
Child-parent geographic distance										
Same house or household	0.144	0.151	0.165	0.059	0.081	0.027	0.240	0.331	0.261	0.015
Less than 1 kilometre away	0.154	0.120	0.130	0.109	0.172	0.162	0.284	0.135	0.183	0.115
1-5 kilometres away	0.193	0.176	0.177	0.153	0.234	0.269	0.181	0.177	0.159	0.201
5-100 kilometres away	0.347	0.346	0.357	0.404	0.446	0.415	0.191	0.265	0.239	0.411
More than 100 kilometres away	0.162	0.207	0.172	0.275	0.067	0.127	0.105	0.092	0.159	0.255
Number of observations	9,107	1,114	869	920	1,217	962	735	966	1,173	1,151
Time transfers to parents										
Help to parents	0.091	0.158	0.122	0.080	0.081	0.041	0.057	0.032	0.144	0.083
	(0.287)	(0.365)	(0.328)	(0.271)	(0.273)	(0.233)	(0.231)	(0.177)	(0.352)	(0.277)
Frequency of help										
No help received	0.909	0.842	0.878	0.920	0.919	0.959	0.944	0.968	0.856	0.917
Less often than every month	0.018	0.031	0.022	0.010	0.012	0.020	0.004	0.000	0.025	0.029
Almost every month	0.020	0.035	0.027	0.015	0.012	0.006	0.009	0.012	0.035	0.024
Almost every week	0.037	0.070	0.055	0.032	0.040	0.011	0.015	0.012	0.059	0.026
Almost daily	0.016	0.021	0.018	0.023	0.017	0.004	0.028	0.009	0.026	0.005
Number of observations	6,309	795	597	729	826	731	460	591	693	887

Notes: Figures are means with standard deviations in parentheses.

Appendix III: Summary Statistics of Explanatory Variables

	All countries	Germany	Austria	France	Belgium	Nether-lands	Spain	Italy	Greece	Sweden
Main explanatory variables										
Child										
Age	41.88	41.99	42.25	42.39	41.89	39.79	42.39	40.16	42.98	42.82
	(8.27)	(8.28)	(8.01)	(8.55)	(8.42)	(7.48)	(8.38)	(7.45)	(8.24)	(8.76)
Female	0.501	0.505	0.524	0.505	0.500	0.490	0.488	0.502	0.480	0.517
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)
Married	0.647	0.630	0.613	0.635	0.646	0.647	0.737	0.654	0.765	0.517
	(0.478)	(0.483)	(0.487)	(0.482)	(0.478)	(0.478)	(0.440)	(0.476)	(0.424)	(0.499)
Grandchildren	0.715	0.694	0.694	0.767	0.745	0.664	0.728	0.588	0.757	0.778
	(0.451)	(0.461)	(0.461)	(0.423)	(0.436)	(0.473)	(0.445)	(0.492)	(0.429)	(0.416)
Firstborn	0.385	0.359	0.364	0.360	0.355	0.425	0.389	0.383	0.415	0.414
	(0.487)	(0.480)	(0.481)	(0.480)	(0.479)	(0.495)	(0.488)	(0.486)	(0.493)	(0.493)
Second-born	0.385	0.359	0.364	0.360	0.355	0.425	0.389	0.383	0.415	0.414
	(0.487)	(0.480)	(0.481)	(0.480)	(0.479)	(0.495)	(0.488)	(0.486)	(0.493)	(0.493)
Only child	0.230	0.282	0.273	0.280	0.290	0.150	0.222	0.234	0.170	0.171
	(0.421)	(0.450)	(0.446)	(0.449)	(0.455)	(0.357)	(0.416)	(0.424)	(0.375)	(0.377)
Parent										
Age	69.58	68.77	69.11	69.43	68.99	67.66	71.91	68.52	71.68	70.34
	(8.95)	(8.67)	(8.55)	(9.21)	(9.11)	(8.92)	(8.90)	(7.85)	(8.94)	(9.29)
Female	0.591	0.591	0.612	0.622	0.500	0.536	0.641	0.611	0.646	0.586
	(0.492)	(0.492)	(0.488)	(0.485)	(0.500)	(0.499)	(0.480)	(0.488)	(0.478)	(0.493)
Married	0.606	0.676	0.486	0.528	0.592	0.719	0.635	0.710	0.460	0.656
	(0.489)	(0.468)	(0.500)	(0.499)	(0.492)	(0.450)	(0.482)	(0.454)	(0.499)	(0.475)
Limited because of a health problem										
Not limited	0.529	0.431	0.489	0.577	0.556	0.554	0.503	0.555	0.549	0.540
	(0.499)	(0.495)	(0.500)	(0.494)	(0.497)	(0.497)	(0.500)	(0.497)	(0.498)	(0.499)
Limited, but not severely	0.320	0.364	0.360	0.259	0.271	0.266	0.435	0.302	0.336	0.317
	(0.466)	(0.481)	(0.480)	(0.438)	(0.445)	(0.442)	(0.496)	(0.459)	(0.473)	(0.466)
Severely limited	0.151	0.205	0.151	0.164	0.173	0.180	0.061	0.143	0.115	0.143
	(0.358)	(0.404)	(0.358)	(0.371)	(0.378)	(0.384)	(0.240)	(0.350)	(0.319)	(0.351)
Number of observations	9,107	1,114	869	920	1,217	962	735	966	1,173	1,151

Notes: Figures are means with standard deviations in parentheses.

Appendix IV: Description of Variables

Variable	Question in SHARE reads:	Variable in SHARE	Definition of variable
Outcome Variables			
Child-parent geographic distance	"Please look at card 5. Where does [*child name*] live?"	Card 5: (1) In the same household; (2) In the same building; (3) Less than 1 kilometre away; (4) Between 1 and 5 km away; (5) Between 5 and 25 km away; (6) Between 25 and 100 km away; (7) Between 100 and 500 km away; (8) More than 500 km away; (9) More than 500 km away in another country.	Variable has the following five distance categories: (1) In the same building or household; (2) Less than 1 km away; (3) 1 to 5 km away; (4) 5-100 km away; (5) More than 100 kilometres away.
Help to parents	"Now please think of the last twelve months. Has any family member from outside the household, any friend or neighbor given you [or] [your] [husband/wife/partner] any kind of help?"	(1) Yes; (5) No.	Variable equals one if a respondent indicates (1) for a child, and zero otherwise.
Frequency of help	"In the last twelve months, how often altogether have you or [or] [your] [husband/wife/partner] received such help from this person? Was it..."	(1) Almost daily; (2) Almost every week; (3) Almost every month; (4) Less often.	Variable has the following four help categories for a particular child: (1) Almost daily; (2) Almost every week; (3) Almost every month; (4) Less often or no help received.
Explanatory Variables			
Child			
Age	"In which year was [child name] born?"		Age of child (in years).
Female	"Is [child name] male or female?"	(1) Male; (2) Female.	Variable equals one if a

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Variables	Question in SHARE reads:	Variables in SHARE	Definition of variable
			respondent indicates (2) for a child, and zero otherwise.
Married	"Please look at card 4. What is the marital status of [child name]?"	(1) Married and living together with spouse; (2) Registered partnership; (3) Married, living separated from spouse; (4) Never married; (5) Divorced; (6) Widowed.	Variable equals one if a respondent indicates (1) for a child, and zero otherwise.
Grandchildren	"How many children − if any − does [child name] have?"		Variable equals one if a respondent indicates that child has any children, and zero otherwise.
Highest school leaving certificate	Please look at card 2. What is the highest school leaving certificate or school degree [child name] has obtained?	Card 2: (1) Comprehensive school; (2) Grammar school; (3) Fee-paying grammar school; (4) Sixth form College/ Tertiary College (5) Public or other private school (6) Elementary school (7) Secondary modern/ secondary school (8) Technical school (not college) (95) No degree yet/still in school (96) None (97) Other type (also abroad).	Information is used to generate a maximum set of educational dummy variables for each child.
Parent			
Age	"In which month and year were you born?"		Age of respondent (in years).

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Variables	Question in SHARE reads:	Variables in SHARE	Definition of variable
Female	"What is your sex?"	(1) Male; (2) Female.	Variable equals one if respondent indicates (2), and zero otherwise.
Married	"What is your marital status?"	(1) Married and living together with spouse; (2) Registered partnership; (3) Married, living separated from spouse; (4) Never married; (5) Divorced; (6) Widowed.	Variable equals one if a respondent indicates (1), and zero otherwise.
Limited activities	"For the past six months at least, to what extent have you been limited because of a health problem in activities people usually do?"	(1) Severely limited; (2) Limited, but not severely; (3) Not limited.	Information is used to generate three dummy variables.
Highest school leaving certificate	Please look at card 2. What is the highest school leaving certificate or school degree that you have obtained?	See card 2 above.	Information is used to generate a maximum set of educational dummy variables.