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ON THE LIVING ARRANGEMENTS OF ELDERLY WIDOWS*

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Between 1970 and 1990, the share of elderly widows living alone grew by 23.2% in the United States, whereas those living with their children decreased by a similar amount. We pose a variety of models for determining the living arrangements in which living together increases consumption because of economies of scale and may also provide utility directly. We estimate these models using the 1970 data and obtain an excellent fit. The estimated models predict that changes in the incomes of both the widow and her offspring generate three-quarters of the increase in the number of widows living alone.

1. INTRODUCTION

Between 1970 and 1990, the share of elderly widows (which make up more than one-half of the population of women over 65 years) living alone grew by 23.2% in the United States (from 52.1% to 64.2%). Those living with their children decreased by a similar magnitude, whereas other types of living arrangements, such as in institutions or with other adults, remained stationary.

In the same period, there have been large changes in incomes. In 1970, the average annual income for an elderly widow was $2,162, whereas the average annual income for their children's household (henceforth children's income) was $10,556. After correcting for the mismeasurement of inflation in the Consumer Price Index (CPI) (Gottschalk, 1997), average incomes increased by 55.3%: Those of elderly widows increased by 106.8%, whereas those of their children increased by 52.1%. Therefore, not only have all incomes gone up but also those of the elderly have increased much more.[2]

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[2] The important gains in widows' income for this period have been well documented. Hurd (1990) reports that the poverty rate of the nonelderly rose from 11.8% to 14.5% between 1967 and 1984. In contrast, the poverty rate among elderly widows fell from 35.1% to 19.1% between 1961 and 1987. Radner (1995) reports that the ratio between the income of elderly family units and the income of family units with members of 65 years and lower increased from 0.5 in 1967 to 0.63 in 1990.

The purpose of this article is to investigate the role that these changes in incomes may have had in shaping the changes in the choice of living arrangements of elderly widows and their children. We think of the changes in the living arrangements as outcomes of changes in the incentives and actions of both elderly widows and their children and want to understand how each of these groups is affected separately. A purely statistical analysis based on nonlinear extrapolation does not generate an understanding of how the two groups fare and react in the new situation. Consequently, we follow a structural approach that has the nonlinearities built in.[3]

Our first contribution is to pose a novel approach to the modeling of the determination of living arrangements as the outcome of a game between the mother and her child in which both make investments that affect the probability of the specific living arrangement that ensues. Economies of scale in multiperson households, differences in the risk aversion between mother and child, direct preferences about the living arrangement itself (as a stand-in for other issues such as privacy), and, of course, the incomes of mother and child are some of the ingredients that shape the decisions in our model economies. Our approach allows us to have the fraction of mothers and children of the same type with the same living arrangement as a continuous function of parameters (a requirement for estimation) without the need for shocks to preferences. Our approach also accommodates as special cases the Affluence Hypothesis (the rising income of the aged reduced their dependence on children and allowed them finally to achieve their preference for independent living) and the Economic Development Hypothesis (which postulates that intergenerational coresidence in the recent past has been more likely to result from the needs of children than from the needs of their elderly parents), which are the most extended explanations among social theorists to determine the living arrangements of different generations (see Ruggles, 2007).

Our second contribution is to pose and estimate, using data from 1970, versions of the model that accommodate additional features such as altruism. For some of the specifications, we obtain an excellent fit, replicating the joint distribution of living arrangements by income groups of elderly widows and their children. The upshot of the estimation then is to find out what the main determinants of living arrangements are. We have found that mothers prefer living alone, are less risk averse than their children, and face high utility costs of exerting effort. Although children prefer to live alone based solely on the living arrangement, the estimates for the economies of scale imply that mothers are welcome because their income is large relative to their consumption requirements. Our estimates also indicate a lower effort cost for the children as well as a high minimum consumption level that translates into a high risk aversion. All in all, children typically, undertake effort to live together, whereas the opposite is true for mothers.[4]

[3] See Keane and Wolpin (1997) for a standard defense for the use of structural approaches in economics mainly on the basis of the use of counterfactuals.

[4] We have also looked in detail at other features of the families such as the number, the sex, the age, and the marital status of the children. We found that the only feature that really matters is the marital status. We have constructed a model that distinguishes children by marital status, and in this expanded model, the main findings of this article hold. The details are available on request.

Our third contribution is to use counterfactuals with the estimated models to measure the extent to which changes in income account for the changes in living arrangements. Our findings are that income changes play a central role in accounting for the increase in the number of elderly widows that live alone. A simple model that matches the living arrangements in 1970 very well predicts that the changes in incomes of both the widow and her offspring generate 74.4% of the increase in the number of elderly widows who live alone.

When decomposing the changes, we found that the increase in the income of widows accounts for 63.9% of the increase in the number of widows living alone. Interestingly, the model predicts that the increase in the income of the children by itself would have slightly reduced the number of widows living alone, implying a very complex and nonmonotonic relation between income and living arrangements. From a different angle, the model imputes two-thirds of the changes due to income changes to changes in relative income and one-third to changes in the level of income. Finally, we found that changes in income dispersion for mothers and children account only for a very small part of the changes in living arrangements.

A fourth independent contribution of this article is the construction of the data. Although the census provides information about family members who live in the same household, it does not connect those who live apart. The 1993 Asset and Health Dynamics among the Oldest Old (AHEAD), however, does provide this information. We make the assumption that the joint distribution of (relative) income across generations was the same in 1970 and 1990 than in 1993 (the AHEAD year), which allows us to use the census data to construct pairs of mothers and children who do not live together, allowing us to estimate the models. We make this assumption following, among others, the results of Harding et al. (2005), who find that the correlation between parents and children has remained constant over the last 30 years.

The aging of the baby boomers presents considerable challenges to society. The provision of both retirement and health-care benefits to the elderly will require an enormous fiscal effort. The living arrangements of the elderly shape how the benefits translate into the quality of life, and we think that understanding those arrangements is a prerequisite for informed policy making.

The living conditions of the elderly have attracted considerable attention in the literature, since living conditions are considered quite important for determining well-being. This interest has come mainly from demographers and sociologists and, more recently, from economists. Some studies have related the growth of income among the elderly to the increasing share of them who live alone. See McGarry and Schoeni (2001), Costa (1999), and Macunovich et al. (1995) for an extended survey. Although Burr and Mutchler (1992), among others, argue that income of the elderly is an important determinant of living arrangements, Schwartz et al. (1984) and Börsch-Supan et al. (1992) see no role for the increase in income of the elderly in the determination of living arrangements. All these studies have this in common: They see that living arrangements are uniquely determined by the circumstances of the elderly.

Studies that consider incomes and living arrangements of the elderly in relation to characteristics of other individuals (their children mostly) are rare. Kotlikoff

and Morris (1990) use logits and probits in a nonstructural fashion to address some of the same questions. They argue that because incomes of parents and children are correlated, the effects of parents' income on living arrangements may be capturing some influence of children's incomes. For a small and nonrepresentative sample, they find that the probability of living together is negatively but not significantly correlated with children's income. Kotlikoff and Morris (1990) also find that although some characteristics of the children matter, most of the explanatory variations have to come from family-specific preferences about living arrangements. Dunn and Phillips (1998) find that poorer, unmarried, or childless siblings are more likely to live with their parents. Wolf and Soldo (1988) investigate the characteristics of children living with their parents, and Ward et al. (1992) underline the implicit transfers from parents to children when they live together.

From a different point of view, studies that analyze children's decision to leave the parental household find that the higher the children's income is, the higher is the probability that they will leave the parental home and that the higher the parents' income is, the higher is the probability that parents and children will coreside. See, for example, Whittington and Peters (1996). McElroy (1985) and Rosenzweig and Wolpin (1993) pose and estimate structural models of the young children's decision to leave the parental household. Rosenzweig and Wolpin (1993) analyze the relationship between children's human capital investments and parental help (interhousehold transfers when living apart and coresidence with), and McElroy (1985) shows that young children jointly choose their market work and household membership.

Section 2 reports the features of the data that we are interested in: the main facts related with the joint distribution of incomes and living arrangements in 1970 and in 1990. We turn to the theory in Section 3. We pose a general model that is flexible enough to allow for different attitudes toward consumption, different types of economies of scale, and different types of sharing arrangements. In fact, we investigate various alternative specifications of these features (two in this section and the rest in the Appendix, Subsection A). Section 4 describes how we estimate the models using the 1970 data and displays the estimation results. In Section 5, we measure the role of changes in income in shaping changes in living arrangements by computing the equilibria of the models that we estimated with the new values for income. Section 6 decomposes the observed changes in income by isolating the role of the changes in each group (mothers and children), by separating relative and absolute changes, and by isolating changes in income dispersion. Section 7 concludes. This article also includes an Appendix. Subsection A describes how we select and refine the sample in both 1970 and 1990. In Subsection B, we report the income data we use, and in Subsection C, we show alternative specifications of the model and how they perform.

2. THE DATA

In order to understand the determinants of living arrangements, we have to know the characteristics of elderly widows and their children when they live together and when they live apart, both for 1970 and for 1990. However, this

information is not available.[5] We use data from the 1970 and 1990 Integrated Public Use Microdata Series (IPUMS) and the 1993 AHEAD. The IPUMS database is a large (about 2 million individuals in 1970 and 2.5 million in 1990) representative sample of the census and hence of all of the U.S. population, but it is not a panel. Its main disadvantage is the impossibility of establishing links between individuals from different households. So, if an elderly widow is not living with her children, we do not have any information about her. Fortunately, the 1993 AHEAD,[6] which is designed to collect data about elderly people, has this information. Its sample size is 17,718 individuals, of whom 8,222 are elderly people and the rest are relatives. Several sections of the questionnaire are designed to get information about the children on whether they are living in the elder's household or not.

From the IPUMS, we obtain information about the living arrangements of elderly widows and about the marginal income distributions of income both for the elderly widows and for their offspring. The size of the sample is 41,385 elderly widows in 1970 and 61,611 in 1990. Next, we proceed by assuming that certain properties of the joint distribution of the income of the elderly widows and the income of the households where their children live have remained constant throughout the period that we study, which allows us to use just these data sources. Thus, we obtain the distribution of living arrangements for 1970 and 1990 by merging the information from the AHEAD with the information from the IPUMS. We report the details of the assumptions that we make in Section 2.1 and the process to combine the data from different sources in Section 2.2 and describe the properties of the data for 1970 in Section 2.3 and those for 1990 in Section 2.4.

2.1. *The Constant Intergenerational Income Distribution.* A central piece in our analysis is the assumption that an important property of the joint income distribution of elderly widows and their children remained constant between 1970 and 1993. Specifically, we assume that for the members of every quartile of income, the probability that their relatives belong to each of the quartiles of their income distribution remains constant throughout the period. In other words, we assume that the fractions of the population in each of the 16 groups that define the joint quartiles are constant over time. Note that this assumption is consistent with differential changes in the mean and variance of the income of widows and their children. This assumption allows us to construct pairs of mothers and children who are not living together and of their respective incomes from the census samples. The Appendix, Subsection A, describes the sample selection and

[5] Although the Panel Study of Income Dynamics (PSID) allows the possibility of matching different members in a family when they had lived together, its sample size is too small, given that we have to look at the subsample of elderly widows. In 1988, there was a special survey (the 1988 Time and Money Transfer File) that was designed to measure transfers between family members. But even in this case, the sample size was small and there were too many missing values. There were 271 nonmarried women older than 66 years of age, of whom 260 were living alone and the remaining 11 were living with their children.

[6] The 1993 AHEAD is the first wave of the data collection of the study of the AHEAD and is included in the Health and Retirement Study (HRS). The focus of the AHEAD is to understand how older Americans fare in three areas: health, finances, and family.

Section 2.2 describes how we impute the properties of the joint distribution of income to those pairs of mothers and children who live apart.

Numerous papers document a high persistence in the income of parents and their children (see Stokey, 1996, for a survey). However, not much work studies the evolution over time of the intergenerational patterns of income. An exception is Harding et al. (2005), who have reviewed the very disperse literature on this topic and have also homogenized data sources (Occupational Changes in a Generation, the General Social Survey, and the PSID) to obtain information on total household income over a long period of time. The study concludes that the correlation between an adult child's family income and his/her parents' income remained stable from the 1970s through the 1990s. We expect this to be the case also for the subgroup of elderly widows and their children. On the one hand, although between 1970 and 1990 the income of widows improved dramatically, this happened despite the fact that Social Security benefits continued to be their main income source.[7] On the other hand, Gottschalk and Danziger (1997) classify family incomes in quintiles and find that there was low mobility in the United States between these years (in the same line of the work that we mentioned before).[8]

2.2. *The Imputation Process.* As we noted above, the IPUMS data do not allow us to link the widows who are not living with their children. However, the 1993 AHEAD does.[9] We make the assumption that the intertemporal persistence of relative income is the same in 1970 as it was in 1990 and 1993.

According to their living arrangements, elderly widows can be partitioned into four categories: living alone, living with children, living in institutions, and living with others. The fraction of those who either live alone or with children constitutes 85% of the sample both in 1970 and in 1990. Consequently, we have chosen to abstract from those living in institutions or living with other unrelated adults.[10]

Once we restrict the living arrangements to mothers and their children either living together or living alone, we can construct the 1970 and 1990 mother–children pairs with the following detailed steps.

1. **1993 AHEAD.** We analyze only children and widow-mother pairs in the 1993 AHEAD. If the widow is living alone and has more than one child,

[7] The report "Income of the Population 55 or Older, 2000" (Social Security Administration, SSA, 2002) finds that Social Security benefits were between 70% and 80% of the total income of unmarried women for this period. It is around 65% for our sample. For those widows who either did not receive Social Security benefits or had sufficiently low benefits, the Supplemental Security Income program provided a guaranteed source of income.

[8] It could be thought that wealth is better suited than income to represent the options that both mothers and children have. However, Zick and Holden (1999) and Holden and Nicholson (1998), among others, find that when the annuity value of wealth holdings is added to widows' income, the gain is small and does not alter the relative difference in measures of economic well-being across individuals.

[9] The AHEAD data only survey individuals older than 70 years. Fortunately, the samples seem to be consistent (the percentage of widows of 70 years and older living alone in the 1990 IPUMS is very close to that in the 1993 AHEAD, 75.6% and 72.1%, respectively). Since we are using only the intergenerational distribution of income from the AHEAD, we can use the AHEAD.

[10] See the Appendix, Subsection A, and Table A.1 for a detailed discussion of the data.

TABLE 1
JOINT DISTRIBUTION OF INCOMES OF MOTHERS AND CHILDREN

	Mother				
	Poor	Less Poor	Less Rich	Rich	Marginal
Child					
Poor	P_{11}	P_{12}	P_{13}	P_{14}	25.0
Less poor	P_{21}	P_{22}	P_{23}	P_{24}	25.0
Less rich	P_{31}	P_{32}	P_{33}	P_{34}	25.0
Rich	P_{41}	P_{42}	P_{43}	P_{44}	25.0
Marginal	25.0	25.0	25.0	25.0	100.0

we randomize and select one of the children.[11] We define four equal-sized income groups for both widows and children and calculate the joint distribution of incomes of mothers and the household that the children belong to (see Table 1, where $P_{i,j}$ is the proportion of mothers with type-j income with i-type children).

2. **1970 and 1990 IPUMS: subsample of individuals living alone.** From the 1970 and 1990 IPUMS, we select a subsample of children with a mother who is a widow and does not live with them. The children are selected to be in the same age range as the children who live with their widow-mothers.
3. **1970 and 1990 IPUMS: subsample of individuals living together.** We select from the IPUMS the pairs of mothers and children who live together for both 1970 and 1990, respectively.
4. **1970 and 1990 IPUMS: marginal distribution of incomes of mothers and children.** We first merge the subsamples of individuals living alone and living together. Following this, we proceed as in Step 1, sorting all the children and all the widows into four income groups of equal size. Consequently, the 1970 and 1990 marginal distributions of income of mothers and children result in being the same as the 1993 ones. We then match the children with their respective mothers if they are living together (as we did in Step 3). Thus, we identify the pairs of individuals living together for all the children's and mothers' income groups. We obtain the fractions of children who live together among the 16 different combinations of groups of mothers and children. We denote them as $T^t_{i,j}$ for t equal to 1970 and 1990.
5. **1970 and 1990 IPUMS: imputation of the joint distribution of incomes.** We finally obtain the fraction of individuals living alone in each group for the 1970 and 1990 IPUMS. We combine the $T_{i,j}$ from the IPUMS with the $P_{i,j}$ from the AHEAD as follows:

$$A^t_{i,j} = P_{i,j} - T^t_{i,j}\ , \tag{1}$$

[11] We think that if we want to impute characteristics from the AHEAD to the IPUMS, the samples should have a similar nature. Randomizing among the children is a consistent mechanism across the two data sets.

TABLE 2
1970 PERCENTAGES OF INCOME GROUPS (IN PARENTHESES) AND WIDOWS LIVING ALONE (BOLD)

	Mothers			
	0–25	25–50	50–75	75–100
Children				
0–25	**49.4**	**50.1**	**57.6**	**48.8**
	(9.1)	(6.3)	(5.6)	(4.0)
25–50	**56.8**	**64.0**	**68.4**	**67.0**
	(8.1)	(6.7)	(5.9)	(4.3)
50–75	**31.7**	**68.1**	**69.2**	**84.7**
	(3.9)	(7.1)	(5.7)	(8.3)
75–100	**23.2**	**52.7**	**76.7**	**81.3**
	(3.9)	(4.9)	(7.8)	(8.4)

where $A^t_{i,j}$ denotes the fraction of elderly widows with income i and with children with income j who are living alone in year t.

In other words, we randomly choose from the IPUMS a sample of children and mothers living alone and generate the child–mother income pairs according to the 1993 AHEAD joint distribution. This allows us to get the average income for mothers and children in each pair.

2.3. *The Data in 1970.* Of the 85.0% of elderly widows who do not live either in institutions or with unrelated adults, 62.0% live alone, whereas the remaining 38% live with their offspring. In 1970, the average annual income for elderly widows was \$2,162, whereas the average annual household income for their children was \$10,556. Income was more unequally distributed among elderly widows than among their children in the sense that their respective Gini indices were 0.48 and 0.38.

Our analysis of the data can be summarized with the aid of Table 2, in which we have sorted mothers and their children into joint quartiles. From the original 1970 data, we can obtain the number of people living together for each income interval but not what fraction of individuals belong to each income interval. These fractions are needed to define the 16 joint quartiles that we are interested in. Hence, the construction of Table 2 requires the use of our assumption about the joint distribution of income. We report the percentage of mothers living alone within each of the 16 groups (in boldface) and the percentage (in parentheses) of each one of these groups over the total sample, that is, the relative frequencies. Consequently, adding up the frequencies by columns or rows yields 25%.[12] The sample size is large, totaling more than 30,000 observations. Note that the size of the groups along the diagonal is larger than that of the groups away from the diagonal, which is an implication of the intergenerational persistence of income.

[12] The Appendix, Subsection B, reports the individuals' income for the 16 groups.

TABLE 3
FRACTIONS OF WIDOWS LIVING ALONE FOR BOTH 1990 (IN BOLD) AND 1970 (IN ITALICS)

	Mothers			
	0–25	25–50	50–75	75–100
Children				
0–25	**60.7**	**58.8**	**63.1**	**60.5**
	49.4	*50.1*	*57.6*	*48.8*
25–50	**76.5**	**73.4**	**75.6**	**74.0**
	56.8	*64.0*	*68.4*	*67.0*
50–75	**60.4**	**82.5**	**80.9**	**89.0**
	31.7	*68.1*	*69.2*	*84.7*
75–100	**67.1**	**80.1**	**88.9**	**91.5**
	23.2	*52.7*	*76.7*	*81.3*

The main pattern of the data is that more income tends to increase the fraction of widows who live alone. However, this pattern is not universal: For poor mothers, the higher the income of their children, the less likely it is that the widows live alone. The opposite is true for widows in the top half of the income distribution. For mothers in the second quartile of income, there is an inverted *U* relationship. For poor children, the income of the mother does not matter much; it displays a skewed inverted *U* shape. For higher-income children, the higher the income of the mother, the higher the frequency with which they live alone. An important feature of these patterns is their strong nonlinearity, which the estimated models will try to replicate.[13]

2.4. *The Data in 1990.* By 1990, things had changed quite dramatically. Incomes grew by 54.2%, especially that of widows, which went from being 20.5% of that of their children in 1970 to 29.6% in 1990. The Gini indices moved closer to each other, with values midway between those in 1970: They become 0.42 for mothers (0.48 in 1970) and 0.43 for children (0.38 in 1970).

Simultaneously, there was an important change in the distribution of living arrangements.[14] The change was a shift from living with their children to living alone (other arrangements maintained their 1970 share of about 15%). Excluding those other arrangements, the fraction of elderly widows living alone went from 62% in 1970 to 75.3% in 1990.

Table 3 displays the living arrangements for 1990.[15] We have proceeded in the same way as for 1970: From the 1990 IPUMS data set, we get the fraction of people

[13] We have also done the same exercise for the 3×3 case and get an equivalent nonmonotonic pattern. However, it was impossible to deliver the 5×5 case. The reason was that we could not calculate the joint income distribution for this case (we found many empty and low populated cells when we split the AHEAD sample in 25 groups).

[14] The widows that we consider in 1990 are older than the widows in 1970 to account for the increase in life expectancy. See the Appendix, Subsection A, for details.

[15] Because of our assumption, the distribution of income across joint quartiles is the same as in 1970. See Table 2.

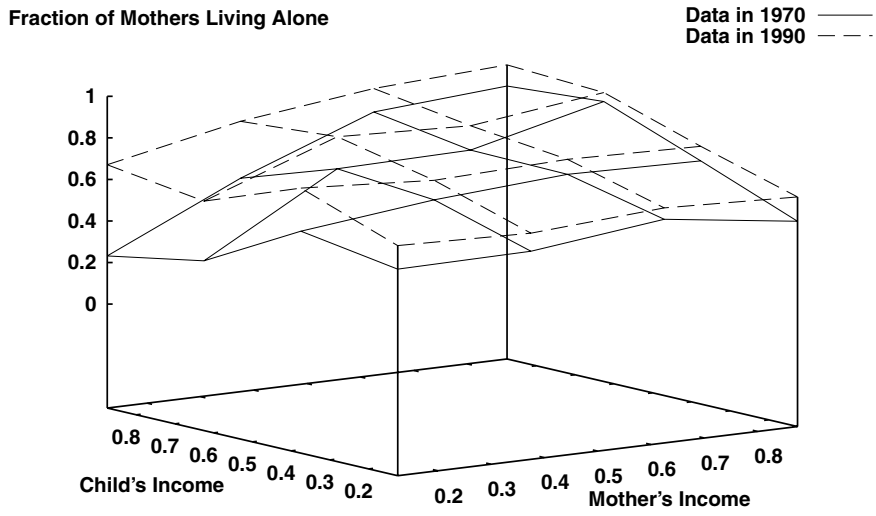

FIGURE 1

FRACTIONS OF WIDOWS LIVING ALONE BY JOINT INCOME QUARTILES, 1970–90

living together for each income group; then, we use our assumption about the joint distribution of income in order to get the fraction of individuals belonging to each income group; and finally, we get the fraction of them living alone. In order to have a more precise idea of the changes, we also report the living arrangements for 1970. The sample size is over 50,000 pairs. There has been an increase in the fraction of elderly widows who live alone in all income groups, albeit not in the same proportion. For the groups with the poorest mothers and the richest children, the fraction of mothers living alone more than doubled. The increase was less dramatic for the groups consisting of mothers with higher income. The shape of the relation is very similar to that of 1970: More income implies more mothers living alone. The differences are as follows: For the group of poorest mothers, the relation between living alone and the income of their children fluctuates between 60.4% and 76.5% (recall that in 1970, it was a decreasing relation). For the second quartile of mothers, there is an increasing relation, whereas in 1970, it displayed an inverted *U* shape. Finally, for the second quartile of children, we can see a flat relation (it was increasing in 1970). Figure 1 shows compactly the properties of the data for 1970 and 1990.

3. THE MODEL

In this section, we present a model of the determination of living arrangements. We start by describing a simple equilibrium model that we denote the baseline and that we later expand in various directions. One of them is reported below (Model 2), and the rest is in the Appendix, Subsection C. The model poses large numbers of two-agent pairs, a mother, which we denote *m*, and her child, which we

denote h, that differ in preferences and income. The agents have preferences about consumption, denoted c; effort, denoted e; and the specific living arrangements—whether they live together, denoted t, or apart, denoted a. The direct preference about living arrangements should be interpreted as a preference for certain attributes associated with the arrangement (privacy, decision-making rights, and so on), instead of for the arrangement itself. We also consider the possibility that agents are altruistic toward each other (by posing as an argument of the utility function the other agent's utility).

In our framework, a mother and her child play an investment game in which they undertake a costly effort to shape the probability of the specific living arrangement. The standard approaches to determine the living arrangement (or in general environments in which a pair of agents have to choose whether to stay together or to split) are either to pose transferable utility or to have the agents stay together only if both agents are better off when doing so (Kotlikoff and Morris, 1990). We think that our approach captures better the actual interaction between elderly widows and children because the outcome is continuous in the utility gains from living together of both parties, which is not the case when there is a requirement that both agents are better off when being together. Our approach captures in a new way some of the nice features of transferable utility without having to deal with the thorny issue of what is the nature of the transfers.[16]

Let the utility of a mother who lives with her child be denoted by $u^m(c, e, t)$ and that of a mother who lives alone be denoted by $u^m(c, e, a)$. Likewise, for a child, we have $u^h(c, e, t)$ and $u^h(c, e, a)$. The agents differ in income levels. Consumption equals income when living alone, and it is the same for both agents when living together. In addition, there are economies of scale in consumption. Given their respective incomes, both agents choose their effort, taking into account the other agent's choices and how consumption depends on their living arrangement, and the natural equilibrium concept is Nash. The problem of a mother is

$$\max_{e^m} p(e^m, e^h)u^m[y^m, e^m, a] + [1 - p(e^m, e^h)]u^m[\phi_t(y^m, y^h), e^m, t], \tag{2}$$

where $p(e^m, e^h)$ is the probability of living alone when the effort of the mother is e^m and that of the child is e^h, and $\phi_t(y^m, y^h)$ is the effective consumption of a mother with income y^m when living together with her child who has income y^h. The child solves

$$\max_{e^h} p(e^m, e^h)u^h\big[\phi_a(y^h), e^h, a\big] + [1 - p(e^m, e^h)]u^h\big[\phi_t(y^m, y^h), e^h, t\big], \tag{3}$$

where $\phi_a(y^h)$ shows the possible economies of scale affecting the child's household when the mother lives alone.

For appropriately chosen functions u and p, the problem is strictly concave and its solution is given by the first-order conditions, which are

[16] This point is also raised in Regalia and Ríos-Rull (1998).

(4)
$$0 = \frac{\partial p(e^m, e^h)}{\partial e^m}\left[u^m[y^m, e^m, a] - u^m\left[\phi_t(y^m, y^h), e^m, t\right]\right] + \frac{\partial u^m[y^m, e^m, a]}{\partial e^m} p(e^m, e^h) + \frac{\partial u^m\left[\phi_t(y^m, y^h), e^m, t\right]}{\partial e^m}[1 - p(e^m, e^h)] \quad \text{and}$$

(5)
$$0 = \frac{\partial p(e^m, e^h)}{\partial e^h}\left[u^h\left[\phi_a(y^h), e^h, a\right] - u^h\left[\phi_t(y^m, y^h), e^h, t\right]\right] + \frac{\partial u^h\left[\phi_a(y^h), e^h, a\right]}{\partial e^h} p(e^m, e^h) + \frac{\partial u^h\left[\phi_t(y^m, y^h), e^h, t\right]}{\partial e^h}[1 - p(e^m, e^h)].$$

A Nash equilibrium is just a solution to this system of equations.

Mothers and their children differ in their income, which requires the specification of the joint distribution of income. Equilibrium is a pair of functions $e^m(y^m, y^h)$ and $e^h(y^m, y^h)$ that gives their efforts when the respective incomes are y^m and y^h. The law of large numbers applies, and the fraction of mothers who live alone out of all pairs with income y^m and y^h is given by $p[e^m(y^m, y^h), e^h(y^m, y^h)]$.

We next describe the model in some detail. We look first at the simplest model, which we call the baseline. Then, we briefly describe a slight variation that performs best among a class of models that we have explored and that are described in the Appendix, Subsection C.

Model 1 (Baseline): Mothers care about living arrangements; children do not. The functional form that determines how effort affects the probability of living alone is

$$p(e^m, e^h) = \frac{\exp(e^m + e^h)}{\exp(e^m + e^h) + \rho \exp\{-(e^m + e^h)\}}, \tag{6}$$

which depends on only one parameter, ρ. Note that for any pair of real numbers, we obtain a probability; for example, zero effort of both parties yields a probability of living alone of $1/(1 + \rho)$. Also, note that since efforts have different utility costs, they are not really symmetric.

With respect to the economies of scale, we pose $\phi_a(y^h) = y^h/(\gamma - 0.7)$ and $\phi_t(y^m, y^h) = (y^m + y^h)/\gamma$, which also implies another parameter, γ. We use the Organisation for Economic Co-operation and Development (OECD) estimations of the equivalence scales to take into account the mother's effect on total consumption: Although the first adult in the household amounts to 1, consecutive ones are computed as 0.7. However, we used values from 0.7 to 1 and the results virtually did not change.

We specify the part of the utility function that depends on consumption as the log of consumption minus a constant that can be either positive or negative. This yields two more parameters. Moreover, the direct utility that mothers get from living with their children is η^m, which, of course, may be negative. This is the fifth parameter.

Effort generates a direct disutility and we pose it as $-\alpha^m(e^m)^2$ and $-\alpha^h(e^h)^2$, where the α's are positive parameters. Note that this function is convex, implying that the more effort an agent expends, the higher the marginal disutility it poses. This implies two more parameters, yielding a total of seven.

The utility function of a mother is then given by

$$u^m = -\alpha^m(e^m)^2 + p(e^m, e^h)\log(y^m - \overline{c}^m) + [1 - p(e^m, e^h)]\left[\log\left(\frac{y^m + y^h}{\gamma} - \overline{c}^m\right) + \eta^m\right], \tag{7}$$

whereas that of the child is

$$u^h = -\alpha^h(e^h)^2 + p(e^m, e^h)\log\left(\frac{y^h}{\gamma - 0.7} - \overline{c}^h\right) + \left[1 - p(e^m, e^h)\right]\log\left(\frac{y^m + y^h}{\gamma} - \overline{c}^h\right). \tag{8}$$

Model 2: Both care about living arrangements; mothers also care about their children. We pose a variation of the baseline model in which the living arrangement also enters in the utility of the child and the mother has altruistic feelings toward the child, which we model as having the utility of the child as an argument of the utility of the mother. Now, the utility function for the child is

$$u^h = -\alpha^h(e^h)^2 + p(e^m, e^h)\log\left(\frac{y^h}{\gamma - 0.7} - \overline{c}^h\right) + [1 - p(e^m, e^h)]\left[\log\left(\frac{y^m + y^h}{\gamma} - \overline{c}^h\right) + \eta^h\right], \tag{9}$$

whereas that of the mother is

$$\begin{aligned} u^m = {} & -\alpha^m(e^m)^2 + p(e^m, e^h)\log(y^m - \overline{c}^m) + [1 - p(e^m, e^h)] \\ & \times \left[\log\left(\frac{y^m + y^h}{\gamma} - \overline{c}^m\right) + \eta^m\right] \\ & + \varphi^m\left[-\alpha^h(e^h)^2 + p(e^m, e^h)\log\left(\frac{y^h}{\gamma - 0.7} - \overline{c}^h\right)\right. \\ & \left. + [1 - p(e^m, e^h)]\left[\log\left(\frac{y^m + y^h}{\gamma} - \overline{c}^h\right) + \eta^h\right]\right]. \end{aligned} \tag{10}$$

Note the new term η^h in the child's utility in Equation (9) and the utility of the child in the utility of the mother multiplied by a parameter, φ^m, which measures the strength of the altruism in Equation (10). This model has nine parameters.

4. ESTIMATION

The next step is to parameterize our model using the 1970 data. The way we proceed is to construct various pairs of mothers and children with incomes that match the data. We start by sorting mothers and their children into four equal-sized income levels. Table B.1 in the Appendix reports the average incomes of the mother and the child of each of the 16 groups. We then construct the product pairs of mothers and children according to these criteria, thus obtaining 16 cells. Note that we are using between seven and nine parameters to get 16 targets. This procedure allows us to use our assumption of stability of the joint distribution of relative incomes across mothers and children and, therefore, to define the joint distribution of mothers and children.

4.1. *Estimation Procedure.* The estimation procedure that we use is a minimization of the weighted sum of the squares of the differences between the fraction of single mothers generated by the model and the data within each of the 16 income groups, subject to the requirement that they match the aggregate fraction of single mothers in the data. We have used as weights for all income groups the actual relative size of the groups. Because of the intergenerational persistence of income, the groups in the diagonal (see Table 2) are generally larger. We obtained very similar estimates using equal weights across the groups.

4.2. *Estimation Results.* We now turn to report the estimates of the baseline and Model 2 using the 1970 data. We report the equilibrium living arrangements in the models and compare them with those in the data. We also report a measure of accuracy that is essentially the fraction of the variance of living arrangements accounted for by the model. Formally,

$$\text{Accuracy} = 1 - \frac{\sum_{i,j}^{4} \left(A_{i,j} - p\left(e_i^m, e_j^h\right)\right)^2 P_{i,j}}{\sum_{i,j}^{4} (A_{i,j} - 0.62)^2 P_{i,j}}, \tag{11}$$

where $P_{i,j}$ is the proportion of mothers of income type j with children of income type i, $A_{i,j}$ is the share of elderly widows of type $\{i, j\}$ in the data who live alone, 0.62 is the total share of elderly widows living alone in 1970, and $p(e_i^m, e_j^h)$ is the model's counterpart.

Model 1 (The Baseline). Table 4 shows the predictions of the baseline as well as its accuracy measure. In order to better assess the model, we also include in the table the corresponding values of the data. We see that the model replicates the features of the data despite their strong nonlinearities. Recall that although, in general, more income implies a higher proportion of individuals living alone, this is not the case for the poorest mothers, for whom the income of children increases the fraction living together, or for the poorest children, for whom the behavior is

TABLE 4
PREDICTIONS OF MODEL 1 FOR 1970: PERCENTAGE OF MOTHERS LIVING ALONE
(DATA IN PARENTHESES)

Accuracy **0.8854**	Mother							
	0–25		25–50		50–75		75–100	
Child								
0–25	47.3	**(49.3)**	55.6	**(50.1)**	58.1	**(57.6)**	46.3	**(48.8)**
25–50	48.9	**(56.8)**	67.3	**(64.0)**	72.6	**(68.4)**	78.8	**(67.0)**
50–75	40.4	**(31.7)**	65.9	**(68.1)**	72.6	**(69.2)**	80.6	**(84.7)**
75–100	23.8	**(23.2)**	56.9	**(52.7)**	68.6	**(76.7)**	80.9	**(81.3)**

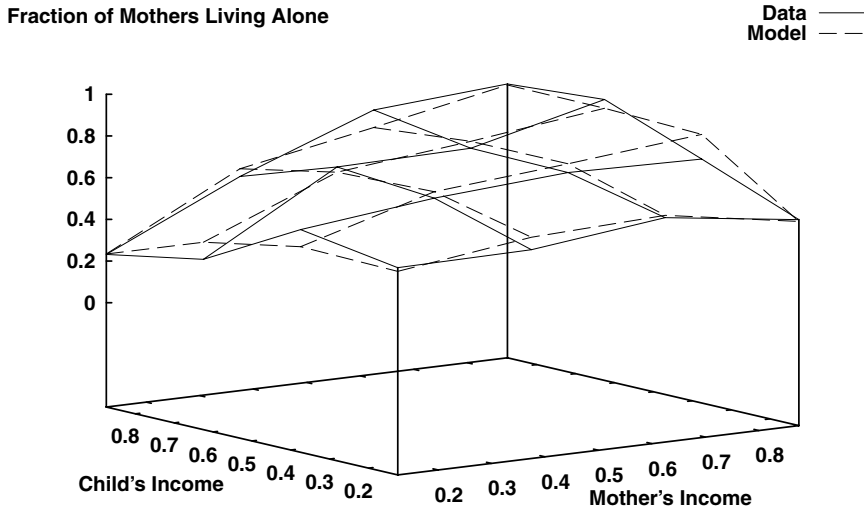

FIGURE 2
FRACTION OF MOTHERS LIVING ALONE IN THE BASELINE MODEL AND IN THE 1970 DATA

more of an inverted *U* shape. The model traces the data very well, with a relatively small number of parameters producing increases of different steepness in different directions. In order to give a graphical sense of the accuracy of the model, Figure 2 shows the distribution of living arrangements both in the baseline model and in the data.

The first column of Table 5 shows the estimated parameter values. They imply that with zero effort, the probability of living alone is 0.2 ($\rho = 3.97$), indicating that typically agents expend costly effort to live alone. Effort is more costly to the mother ($\alpha^m > \alpha^h$). Mothers have an incentive to live alone: Not only do they get a disutility from living with their children ($\eta^m < 0$) but also their consumption is higher when living alone (the parameter that measures the scales of the equivalence, γ, is 33.9; hence, their per capita consumption is $(y^h + y^m)/33.9$ if they live with their children, whereas it is y^m if they live alone). As a result, even

TABLE 5
PARAMETER ESTIMATES

	Model	
	1	2
$\overline{c}^m$	−725.36	−915.11
$\overline{c}^h$	22.49	27.24
ρ	3.97	6.75
α^m	0.14	0.14
α^h	0.11	0.21
η^m	−0.20	0.70
η^h	–	−0.90
φ^m	–	0.51
γ	33.90	31.20
Accuracy	0.8854	0.8867

if they had no direct utility from the living arrangement ($\eta^m = 0$), unless y^h is much larger than y^m, mothers would rather live alone. The estimate is very high; there are around 33 equivalent persons in the child's household. However, what really matters in the decision problem is not the size of the child's household itself but how much additional expenditure is required when living together relative to when living alone to attain the same level of consumption. And, the estimates imply that this amount is very low; that is, accommodating the mother in the child's household with the same level of consumption costs an additional 2%. This estimate is consistent with that obtained in Hong and Ríos-Rull (2004), who found that additional adults in households are essentially costless, whereas children are extremely costly.

Note that mothers are effectively quite risk neutral (because of the large negative value of $\overline{c}^m$). Given all these features, the only thing that precludes mothers from living alone is the cost of effort. Children are different in the sense that they are both quite averse to risk and value consumption more (a positive value for $\overline{c}^h$), implying that children are interested in living together if their mother's income is at least 2.0% of their own income when living alone. So, in most cases, children's effort will be aimed at living together. For example, in the first cell, mothers make a positive effort to live alone and children make a negative effort so that they live with their mothers. Table 6 reports individuals' efforts for the 16 groups.

In the baseline model, mothers always exert effort to live alone (see Table 6): Not only do they get a disutility from living with their children ($\eta < 0$) but also the estimated equivalence scale parameter ($\gamma = 33.9$) and their relative incomes imply that their effective consumption when living alone is almost always larger than when living with their children. Children, on the contrary, want to live together if their mother's income is at least 2.0% of their own income, which is always the case (even if in one case marginally so). This relation is monotonic: The higher the income of one party, the less attractive it is for that party to live together and

TABLE 6
MOTHERS' AND CHILDREN'S EFFORTS TO LIVE ALONE IN THE BASELINE BY INCOME QUARTILES

	Mothers' Effort				Children's Effort			
	Mothers				Mothers			
	0–25	25–50	50–75	75–100	0–25	25–50	50–75	75–100
Children								
0–25	1.04	1.74	2.17	3.52	−0.42	−0.94	−1.31	−2.88
25–50	0.76	1.32	1.57	2.16	−0.11	−0.27	−0.39	−0.81
60–75	0.53	1.19	1.42	1.93	−0.05	−0.17	−0.24	−0.52
75–100	0.10	0.90	1.21	1.71	0.00	−0.08	−0.13	−0.29

NOTE: We divide by 100 to get the efforts supplied by the model.

TABLE 7
PREDICTIONS OF MODEL 2 FOR 1970: PERCENTAGE OF MOTHERS LIVING ALONE
(DATA IN PARENTHESES)

Accuracy	Mother							
0.8867	0–25		25–50		50–75		75–100	
Child								
0–25	46.7	**(49.3)**	53.9	**(50.1)**	56.5	**(57.6)**	48.4	**(48.8)**
25–50	49.0	**(56.8)**	65.9	**(64.0)**	71.2	**(68.4)**	77.9	**(67.0)**
50–75	40.3	**(31.7)**	64.6	**(68.1)**	71.2	**(69.2)**	79.7	**(84.7)**
75–100	20.7	**(23.2)**	55.9	**(52.7)**	67.3	**(76.7)**	79.9	**(81.3)**

the more attractive it is for the other party. The efforts exerted naturally inherit this monotonicity property.

The outcomes of the games depend on the joint effort of both agents. The change in the outcome between any two consecutive income groups depends on the interaction between the efforts of both mothers and children, and both efforts have changed even if only one of the incomes has changed. Consequently, the actual living arrangements are complicated functions of those marginal efforts and they do not generate clear patterns along either rows or columns.

Model 2: Both agents care about living arrangements; mothers also care about their children. Table 7 shows the predictions of this model and Table 5 shows the parameter estimates. In this model, there are nine parameters, and it has the baseline as a special case, but the gains in accuracy are small. The estimates change the mother's attitude with respect to living together; now she is slightly in favor, but the child is not.

The results of the seven alternative models are described in the Appendix, Subsection C. In order to summarize the findings of this section, the baseline model economy does a very good job of matching the data. Moreover, all the variations that we have examined either provided a worse fit or required additional parameters, which increased the measures of accuracy by less than 4%. Model 2,

in which both mother and child care about the arrangement and the mother is also altruistic toward her child, provides more accuracy than the baseline but is a nine-parameter model. We conclude that the baseline model is good enough to study the implications of the changes in incomes up to 1990.

5. THE MODEL'S PREDICTIONS FOR 1990

We now use the model to assess the role of changes in income in accounting for the changes in living arrangements that happened between 1970 and 1990. Note that we no longer try to match the data: We use the model to measure the extent to which the changes in income that occurred in that period are behind the changes in living arrangements.

To this end, we construct a measure of the change of the living arrangements between 1970 and 1990. We then compute the equilibrium when the incomes are those of 1990 and the parameter values are those that we estimated using the 1970 data. Next, we compute a measure of the error between the predictions of our model for 1990 and the actual 1990 data. We say that our model accounts for the fraction of the change in living arrangements that results from the difference between 1 and the ratio of the prediction error of our model and the actual allocational change. Formally:

$$\text{Model accounts for} = 1 - \frac{\sum_{i,j}^{4} \left(A_{i,j}^{90} - p^{90}\left(e_i^m, e_j^h\right)\right)^2 P_{i,j}}{\sum_{i,j}^{4} \left(A_{i,j}^{90} - A_{i,j}^{70}\right)^2 P_{i,j}}, \tag{12}$$

where $P_{i,j}$ is defined as before, $A_{i,j}^t$ is the fraction of pairs of type $\{i, j\}$ who lived alone in year $t \in \{70, 90\}$ in the data, and $p^{90}(e_i^m, e_j^h)$ is the equivalent fraction of elderly widows living alone, which is predicted by the model when using the parameter estimates from the 1970 data and the actual incomes of 1990.

An issue that turns out to matter for calculating the predictions of our model is the choice of price deflator to compare incomes between 1970 and 1990. Although the CPI is the most popular price index, there is a relative consensus among economists that it overestimates inflation,[17] so we have corrected this bias.[18] The CPI Advisory Commission calculated a total bias of 1.5 annual percentage points in the CPI for the last decade, with a range extending from 1.0 to 2.7 percentage points per year. Although the unadjusted CPI states that \$1 in 1970 is \$3.37 in 1990, the recommendation of the Advisory Commission implies that \$1 in 1970 equates to \$2.55 in 1990. We used the adjusted CPI.

[17] According to Gottschalk (1997), the CPI fails to capture improvements in the quality of goods and the ability of consumers to substitute away from goods that experience a sudden increase in prices.

[18] The same procedure was followed in Regalia and Ríos-Rull (1998).

TABLE 8
PREDICTIONS OF MODEL 1 FOR 1990: PERCENTAGE OF MOTHERS LIVING ALONE
(DATA IN PARENTHESES)

Error	Mother							
0.00584	0–25		25–50		50–75		75–100	
Child								
0–25	61.5	**(60.7)**	64.7	**(58.8)**	64.6	**(63.1)**	52.4	**(60.5)**
25–50	70.1	**(77.5)**	76.4	**(73.4)**	79.0	**(75.6)**	81.0	**(74.0)**
50–75	65.7	**(60.4)**	75.9	**(83.5)**	79.6	**(80.9)**	83.3	**(89.0)**
75–100	46.1	**(67.1)**	70.0	**(80.1)**	76.9	**(88.0)**	83.4	**(91.5)**

NOTE: Total alone predicted 71.9%.

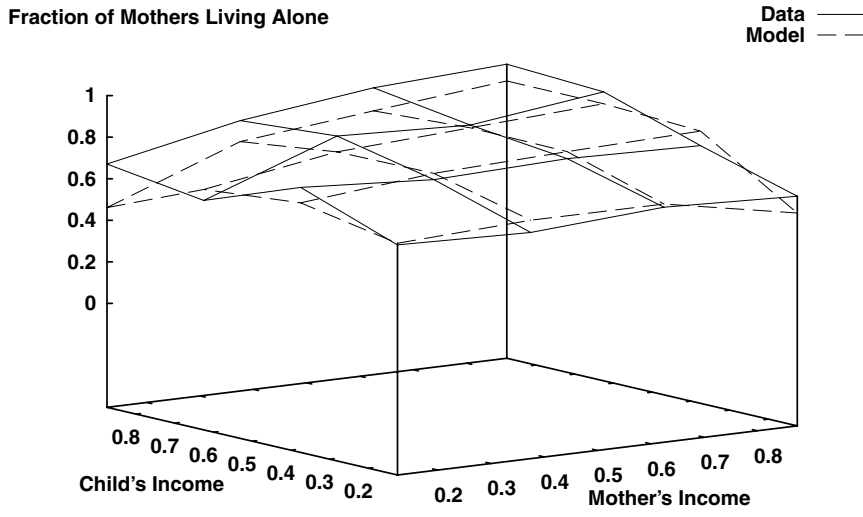

FIGURE 3

FRACTION OF MOTHERS LIVING ALONE IN THE BASELINE MODEL WITH THE 1990 INCOME AND IN THE 1990 DATA

5.1. *Predictions for 1990 of Model 1 (Baseline).* Table 8 reports the predictions of Model 1 when we use the fact that one 1970 dollar equates to 2.55 1990 dollars. In the data in 1990, 75.3% of widows live alone (it was 62.0% in 1970), whereas our model predicts 71.9%, which is 74.4% of the allocational increase between 1970 and 1990.

If instead we use the accounting statistics defined above to measure the contribution of income changes to the changes in living arrangements, the model accounts for 77.3% of the change in the number of widows living alone, a number very similar to the cruder measure. Figure 3 depicts the prediction of the model for the 1990 data.

TABLE 9
PREDICTIONS OF MODEL 2 FOR 1990: PERCENTAGE OF MOTHERS LIVING ALONE
(DATA IN PARENTHESES)

Error	Mother							
0.00594	0–25		25–50		50–75		75–100	
Child								
0–25	61.0	**(60.7)**	64.1	**(58.8)**	65.2	**(63.1)**	58.5	**(60.5)**
25–50	69.4	**(77.5)**	75.6	**(73.4)**	78.5	**(75.6)**	81.0	**(74.0)**
50–75	65.4	**(60.4)**	75.1	**(83.5)**	79.0	**(80.9)**	83.0	**(89.0)**
75–100	46.2	**(67.1)**	69.4	**(80.1)**	76.3	**(88.0)**	83.0	**(91.5)**

NOTE: Total alone predicted 71.8%.

5.2. *Predictions for 1990 of Model 2.* Table 9 shows Model 2 predictions with the 1990 incomes. They amount to 73.7% of the increase in the data (the more sophisticated measure yields 76.9%).

6. DECOMPOSITION OF THE CHANGE

We decompose the changes in income in three different ways. We start by looking separately at a change in the incomes of mothers and children in Section 6.1. We then analyze the change in the level of incomes and relative incomes in Section 6.2. Finally, in Section 6.3, we study separately the changes in the dispersions and averages of incomes.

6.1. *Separate Income Changes by Type of Agent.* The first panel of Table 10 reports the results of setting mothers' incomes to be the same as in 1990 and children's incomes to be the same as in 1970. We see that this change of income alone predicts a large increase in the fraction of mothers living alone, 63.9% of the total change in the data (and 85.9% of the total predicted increase by all income changes in the model). The second panel of Table 10 shows that the model predicts that 1.6% of the widows living alone in 1970 would have now been living with their children when the mothers' incomes are the same as in 1970 and the children's incomes are the same as in 1990, a sharp contrast with the previous case.

Our main finding is that the increase in the income of widows is the most important factor in accounting for the changes in living arrangements. Another important finding is that although the increase in the income of children by itself reduces the fraction of widows living alone, this is not the case when it is combined with an increase in the widows' income. In fact, the marginal contribution of an increase in the children's income after an increase in the widows' income is to further increase the fraction of mothers living alone. This is due to the important nonlinearities present both in the model and in the data.

6.2. *Changes in Relative Income.* In order to look at the effects of relative instead of absolute income changes, we pose a change in the mother's income so that it achieves the same relative income of 1990 but without changing the children's income. The results are shown in the first panel of Table 11. We see an

TABLE 10
INCOME CHANGES BY AGENT TYPE

Mothers' Income Changes, Children's Does Not. Total Alone: 70.5%								
Error	Mother							
0.00796	0–25		25–50		50–75		75–100	
Child								
0–25	57.5	**(60.7)**	57.6	**(58.8)**	55.3	**(63.1)**	27.1	**(60.5)**
25–50	70.2	**(77.5)**	75.8	**(73.4)**	78.1	**(75.6)**	79.2	**(74.0)**
50–75	68.7	**(60.4)**	76.5	**(83.5)**	79.5	**(80.9)**	82.1	**(89.0)**
75–100	61.6	**(67.1)**	74.7	**(80.1)**	79.1	**(88.0)**	83.6	**(91.5)**
Mothers' Income Does Not Change, Children's Does. Total Alone: 60.4%								
Error	Mother							
0.04420	0–25		25–50		50–75		75–100	
Child								
0–25	49.3	**(60.7)**	60.2	**(58.8)**	63.8	**(63.1)**	63.2	**(60.5)**
25–50	45.4	**(77.5)**	66.8	**(73.4)**	72.9	**(75.6)**	79.9	**(74.0)**
50–75	30.4	**(60.4)**	62.0	**(83.5)**	70.9	**(80.9)**	82.0	**(89.0)**
75–100	16.0	**(67.1)**	38.4	**(80.1)**	59.9	**(88.0)**	79.3	**(91.5)**

TABLE 11
RELATIVE AND ABSOLUTE CHANGES IN INCOME

Children's Income as in 1970, Mothers' Relative Income as in 1990. Total Alone: 68.0%								
Error	Mother							
0.01110	0–25		25–50		50–75		75–100	
Child								
0–25	56.9	**(60.7)**	57.8	**(58.8)**	56.8	**(63.1)**	33.7	**(60.5)**
25–50	67.0	**(77.5)**	74.0	**(73.4)**	77.0	**(75.6)**	79.4	**(74.0)**
50–75	61.5	**(60.4)**	72.8	**(83.5)**	77.2	**(80.9)**	81.6	**(89.0)**
75–100	43.0	**(67.1)**	66.4	**(80.1)**	74.2	**(88.0)**	81.8	**(91.5)**
Children's Income as in 1990, Mothers' Relative Income as in 1970. Total Alone: 65.6%								
Error	Mother							
0.02174	0–25		25–50		50–75		75–100	
Child								
0–25	51.0	**(60.7)**	61.3	**(58.8)**	64.5	**(63.1)**	61.1	**(60.5)**
25–50	52.2	**(77.5)**	70.2	**(73.4)**	75.1	**(75.6)**	80.5	**(74.0)**
50–75	43.1	**(60.4)**	69.7	**(83.5)**	75.7	**(80.9)**	82.5	**(89.0)**
75–100	22.1	**(67.1)**	61.0	**(80.1)**	72.0	**(88.0)**	82.7	**(91.5)**

increase of 45.1% of the total increase in the data (60.6% of the total increase predicted by the model). This shows that an increase in the relative income of the mothers is very important. Alternatively, we look at the effects of absolute but not relative changes in income by looking at the increase in income for all parties but only in the same proportion as the increase in the children's income. Now, the

TABLE 12
CHANGES IN THE DISPERSION OF INCOMES

1970's Incomes, 1990's Coefficients of Variation. Total Alone: 60.3%								
Error	Mother							
0.03111	0–25		25–50		50–75		75–100	
Child								
0–25	40.2	**(60.7)**	41.6	**(58.8)**	41.4	**(63.1)**	27.7	**(60.5)**
25–50	58.2	**(77.5)**	68.0	**(73.4)**	72.7	**(75.6)**	77.3	**(74.0)**
50–75	51.6	**(60.4)**	67.3	**(83.5)**	73.5	**(80.9)**	80.2	**(89.0)**
75–100	29.2	**(67.1)**	57.1	**(80.1)**	69.1	**(88.0)**	80.1	**(91.5)**
1970's Coefficients of Variation, 1990's Incomes. Total Alone: 71.8%								
Error	Mother							
0.01065	0–25		25–50		50–75		75–100	
Child								
0–25	63.3	**(60.7)**	70.1	**(58.8)**	71.5	**(63.1)**	63.5	**(60.5)**
25–50	63.2	**(77.5)**	75.9	**(73.4)**	79.0	**(75.6)**	82.0	**(74.0)**
50–75	56.5	**(60.4)**	75.0	**(83.5)**	79.0	**(80.9)**	83.5	**(89.0)**
75–100	33.4	**(67.1)**	69.8	**(80.1)**	76.6	**(88.0)**	83.9	**(91.5)**

increase is 27.1% of the increase in the data (which is 36.4% of the total increase predicted by the model). The second panel of Table 11 shows the results.

In order to summarize, changes in relative income account for almost two-thirds of the predicted increase, whereas changes in absolute income account for one-third.

6.3. *Changes in Income Dispersion.* The top panel of Table 12 reports the predictions of the model if the averages of incomes are set to their 1970 values and the coefficients of variation are set to their 1990 values. The alternative exercise (1990 averages and 1970 dispersions) is reported in the bottom panel of Table 12. Note that even though there were relatively significant changes in the dispersion of incomes (the coefficient of variation for the mothers' income decreased from 0.706 to 0.536, whereas it increased for children's income from 0.394 to 0.538), the effects of these changes, as described in the top panel of Table 12, are minuscule relative to those implied by the changes in the averages reported in the bottom panel.

7. CONCLUSION

In this article, we have documented the increase in the fraction of elderly widows who live alone and its relation both to their income and to their children's income. We have used different data sets and assumed the stability of the intertemporal persistence of incomes across generations in order to be able to link mothers and children who live apart.

We have posed various versions of an equilibrium model of determining living arrangements based on both parties exerting effort to control the outcome and in which the two incomes play a central role. We have estimated those models using the 1970 data, obtaining quite a good fit and replicating the strongly nonmonotonic patterns of the data.

We then used the models to make predictions about the prevailing living arrangements of 1990 based only on the incomes of mothers and children and found that the changes in the income account for three-quarters of the changes in the living arrangements of elderly widows between 1970 and 1990.

We have explored how different types of income changes have affected the living arrangements and found that the increase in the income of widows accounts for two-thirds of the total increase in the fraction of widows living alone; the increase in the income of children by itself reduces the fraction of widows living alone, and the combined effect is what accounts for the rest, up to three-quarters, as predicted by the model, reflecting the highly nonlinear relation between incomes and living arrangements. From a different point of view, we have found that the change in relative income between mothers and children accounts for about one-half of the changes in the living arrangements in the data, whereas the increase in the levels of income accounts for about one-quarter of the changes. From yet another type of decomposition of the changes in incomes, we have found that the change in the average levels of income accounts for almost all of the increase in the fraction of widows living alone, whereas the change in the dispersion of incomes by itself reduces the fraction of widows living alone. Again, the combination of changes in the averages and in the dispersions of income is larger than the sum of their individual effects.

All this leads us to conclude that the increase in mothers' income, compounded by the general increase in income for the whole population, has been the most important factor in shaping changes in living arrangements.

This article has shown that by affecting the way of life of the elderly, the increase in the income of the elderly of the last few years (due to increased Social Security benefits) has strong implications that go beyond the standard of living of the elderly. The next step in our research is to integrate the study of living arrangements with that of access to health care to get a better picture of how policies that support the elderly translate into higher standards of living. Preliminary explorations on the role of other characteristics of families such as marital status, age, sex, and the number of the children seem to play a small role in helping us understand the changes in the living arrangements since the 1970s.

APPENDIX

A. *Data Analysis.* We use the census data as reported by the IPUMS samples for 1970 and 1990, a very convenient source because of its big size.[19] From the

[19] Unfortunately, the IPUMS sample for 2000 and subsequent years did not include the variable that allows us to find out if a woman is also a mother; the newest available sample with this information that we have is from 1990.

IPUMS, we obtain the information about elderly widows and their children if they live together. However, it is impossible to match the mothers with their children if they live apart. In 1993, the AHEAD Survey was conducted and collected data in this regard. The AHEAD collects information by directly interviewing the targeted population: individuals who are 70 years old or older and not living in institutions. Because one main focus of the AHEAD is to analyze elderly people's family structures and relationships, Section D of the survey collects detailed data about the subjects' relatives, whether they are living in the same household or not. Then, we construct tables of the joint distribution of income of the widows, their offspring, and their living arrangements by merging the information from the AHEAD with the information from the IPUMS. We explained in detail how we do it in Section 2.2. We start by describing how we choose our sample of elderly widows.

A.1. *Age.* Between 1970 and 1990, the life expectancy of 65-year-old women went from 17 to 19 years.[20] This was accompanied by a reduction in the disability rates among elderly people.[21] In order to account for the increase in life span, we pose a slight difference in the definitions of elderly widows for the two periods. In 1970, we select widows from 65 to 82 years of age; in 1990, we choose those widows from 67 to 84 years of age. The change in the age group that we look at has the additional advantage of keeping nearly constant the fraction of widows (49.1% and 47.8% in 1970 and 1990, respectively), since the increase in life expectancy also affects men.

A.2. *Number of children.* We select elderly widows who gave birth to at least two children. In the IPUMS samples, the average number of children for elderly widows was 3.84 in 1970 and 3.64 in 1990. For the restricted sample of those elderly widows who gave birth to two or more children, the average is 4.41 in 1970 and 4.14 in 1990, a difference of less than 10%. This small change in family size and the fact that there seems to be a weak relation between family size and living arrangement are the reasons that we abstract from family size in our model.

A.3. *Living arrangements.* Four types of living arrangements can be used to characterize the data: living alone, with children, with others, and in an institution. An elderly widow is defined as living in an institution (or group quarters) if she lives with five or more individuals who are unrelated to the household head. This is the strategy suggested by Ruggles and Sobek (1995) in order to make definitions consistent over the 1970 and the 1990 census.

Table A.1 shows the distribution of living arrangements of widows. Living with others and living in an institution are infrequent events, and they have remained relatively constant. Hence, we abstract from those two living arrangements and consider only the options of living alone or living with children. In 1970, 62% of

[20] See the Berkeley Mortality Database Web page: http://www.demog.berkeley.edu/wilmoth/mortality.

[21] See Manton et al. (1997).

TABLE A.1
DISTRIBUTION OF WIDOWS BY LIVING ARRANGEMENTS IN PERCENTAGES

Living Arrangement	1970	1990	Difference
Alone	52.1	64.2	12.1
With children	32.0	21.0	−11.0
With others	10.6	10.3	−0.3
In an institution	5.3	4.5	−0.8

the widows who were not living with others or in institutions lived alone, whereas in 1990, this fraction was 75.3%. The set of women that we look at constitutes 66.6% of the unmarried women of age 65+ and 80% of the unmarried women for the age range defined previously.

B. *Original Income Data by Quartiles*

TABLE B.1
TOTAL INCOME FOR WIDOWS AND THEIR CHILDREN BY INCOME QUARTILES

	Mothers' Income Mothers				**Children's Income** Mothers			
	0–25	25–50	50–75	75–100	0–25	25–50	50–75	75–100
				1970				
Children								
0–25	495.61	1157.20	1794.47	5199.60	2843.59	2799.52	2825.58	2682.10
25–50	481.49	1162.02	1800.76	5082.54	7349.71	7399.34	7383.02	7412.85
60–75	468.13	1168.03	1806.63	5157.74	11190.24	11238.30	11271.29	11252.24
75–100	455.01	1165.64	1806.59	5299.34	20471.54	20741.16	20734.92	21042.20
				1990*				
Children								
0–25	3690.84	6668.67	10426.57	25320.47	8147.27	8273.85	8460.34	8468.56
25–50	3676.78	6677.98	10409.57	25332.64	23635.31	23639.91	23612.95	23595.38
60–75	3487.81	6696.51	10386.17	25754.10	41102.07	40965.84	41136.31	41021.86
75–100	3415.08	6701.01	10442.49	26041.83	85049.80	85338.85	85229.26	88191.93

*In 1970 dollars (deflator is 2.55).

C. *Alternative Specifications of the Model and Estimations Results.* We present seven more alternative specifications to the baseline and Model 2. We describe briefly how the alternatives differ among them and compared them with the baseline. We also report the estimation results and comment on the main points. Table C.1 shows the parameter estimates and Table C.2 shows the predictions of most of these models.

Model 3: Children care about living arrangements; mothers do not. The term η^m disappears from Equation (7), and η^h is added to the child's utility in

TABLE C.1
PARAMETER ESTIMATES

	Model						
	3	4	5	6	7	8	9
$\bar{c}^m$	−559.68	−725.36	−915.02	−920.84	−920.84	−1669.75	−725.36
$\bar{c}^h$	64.19	20.14	20.71	26.46	26.46	−4.25	20.01
ρ	2.91	3.94	4.31	4.27	4.27	–	3.94
ρ_1	–	–	–	–	–	4.38	−0.00
α^m	0.18	0.15	190.97	189.77	189.77	0.08	0.15
α^h	0.21	0.11	0.11	0.11	0.11	1.33	0.11
η^m	–	−0.20	−0.23	−0.23	−0.23	0.06	−0.20
η^h	−0.18	0.00	0.00	–	–	–	–
φ^m	–	–	–	–	0.0	–	–
φ^h	–	–	0.85	0.85	0.85	–	–
γ	32.17	32.95	31.22	31.22	31.22	26.22	33.06
Accuracy	0.8751	0.8854	0.8854	0.8854	0.8854	0.8468	0.8854

TABLE C.2
PREDICTIONS OF ALL MODELS FOR THE PERCENTAGE OF MOTHERS LIVING ALONE

	Mother				Mother			
	0–25	25–50	50–75	75–100	0–25	25–50	50–75	75–100
	Model 3, Accuracy 0.8751				**Model 4, Accuracy 0.8854**			
Child								
0–25	45.0	51.5	55.4	49.4	46.9	55.5	58.1	47.1
25–50	49.8	68.5	73.9	80.4	47.6	66.4	71.9	72.2
50–75	40.3	66.0	72.9	81.1	39.1	64.8	71.8	80.0
75–100	24.8	55.0	67.4	80.3	23.3	55.3	67.5	80.3
	Model 5, Accuracy 0.8854				**Model 6, Accuracy 0.8854**			
0–25	45.9	53.6	56.5	48.5	45.9	53.5	56.5	48.5
25–50	48.1	66.4	72.1	79.0	48.1	66.3	72.0	79.0
50–75	39.7	65.0	71.1	80.7	39.7	64.9	71.8	80.7
75–100	23.1	55.6	67.9	81.0	23.2	55.6	67.9	81.0
	Model 7, Accuracy 0.8854				**Model 8, Accuracy 0.8468**			
0–25	45.9	53.5	56.5	48.5	47.0	52.4	55.0	46.1
25–50	48.1	66.3	72.0	79.0	49.3	69.0	75.9	83.8
50–75	39.7	64.9	71.8	80.7	42.1	67.9	76.5	85.8
75–100	23.2	55.6	67.9	81.0	28.3	56.0	72.2	86.6

Equation (8). **Performance:** This model yields similar but slightly worse (lower accuracy) results than the baseline. The parameter estimates change a little, especially the minimal consumption of the child, which is now larger. The estimates also show that the child would rather live alone than with the mother.

Model 4: Both care about living arrangements. Performance: This model is richer than the previous one and the baseline in the sense that it has one more parameter and, hence, more possibilities of matching the data. However, there is no increase

in accuracy with respect to the baseline (in fact, the estimate of the extra parameter is zero, the value implicitly assumed in the baseline). We conclude that the simultaneous inclusion of the mother and the child caring directly for the living arrangement is not a useful modeling strategy.

Model 5: Both care about living arrangements; children also care about their mothers. The child's utility function has a term with the utility of the mother weighted by φ^h. **Performance:** This is another nine-parameter model like Model 2, and its accuracy is lower than this one (it is about the same as the baseline despite having more parameters). The altruism parameter is positive, and the effort is very costly for the mother. We think this model is not a good one.

Model 6: Mothers care about living arrangements; children also care about their mothers. Performance: This is an eight-parameter model, yet it gives almost the same predictions as Model 5. The reason for this is that η^h, the additional parameter in Model 5, had an estimate of 0.0, the assumed value in Model 6.

Model 7: Mothers care about living arrangements; both agents are altruistic. Performance: This is identical to Model 6, since the point estimate of the extra parameter used in this model, φ^m, is zero.

Model 8: Baseline with a new effort function. The function is also a one-parameter function that is centered on one-half (zero effort of all parties yields a 0.5 probability of living alone). In this case, we discriminate among abilities to affect the odds of living alone for both agents. The new effort function is

$$p(e^m, e^h) = \frac{\exp\left(e^m + \rho_1 e^h\right)}{\exp\left(e^m + \rho_1 e^h\right) + \exp -\left(e^m + \rho_1 e^h\right)}. \tag{C.1}$$

Performance: This model does not improve over the baseline; in fact, it does quite worse. Moreover, the estimates change. For example, now the minimum consumption of the child is a lot smaller (even negative). We do not think that this model provides a good estimation.

Model 9: Baseline with a two-parameter effort function. The twist is now that the effort function is a two-parameter function that allows for centering at $1/(1 + \rho)$ and for differential effects of the mother and her child. The effort function is

$$p(e^m, e^h) = \frac{\exp\left(e^m + \rho_1 e^h\right)}{\exp\left(e^m + \rho_1 e^h\right) + \rho \exp -\left(e^m + \rho_1 e^h\right)}. \tag{C.2}$$

Performance: This model shows no improvement over the baseline despite the baseline being nested in it. The estimate of the additional parameter (ρ_1) is zero, which is the implicit value in the baseline.

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