On the Living Arrangements of Elderly Widows*

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Abstract

Between 1970 and 1990 the share of elderly widows living alone grew by 23.2% in the U.S. (from 52.1% to 64.2%), the share living with their children decreased by a similar amount, while other types of living arrangements remained stationary. In the same period there was a moderate increase in average income and a big increase in the income of widows. We pose a variety of models for determining the living arrangements between widows and their children where living together provides consumption gains due to economies of scale and may also provide utility directly. We estimate these models using data from 1970. For some of them, we obtain an excellent fit despite the fact that the data display a non-monotonic relation between living arrangements and income. We use the models to measure the contribution of income changes to changes in living arrangements. Our findings are very sharp. The simplest version of the model performs very well, and it predicts that changes in the incomes of both the widow and her offspring generate three-quarters of the increase in the number of elderly widows that live alone.

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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) living alone grew by 23.2% in the U.S. (from 52.1% to 64.2%). Those living with their children decreased by a similar magnitude, while 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, while 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 CPI (Gottschalk (1997)), average incomes increased by 55.3%: those of elderly widows increased by 106.8%, while those of their children increased by 52.1%. Therefore, not only have all incomes gone up, but those of the elderly increased much more.[1]

The purpose of this paper 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 living arrangements as outcomes of changes in the incentives and actions of both elderly widows and their children, and we want to understand how each of these group is affected separately. A purely statistical analysis based on non-linear 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 non-linearities built in. [2]

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 where both make investments that affect the probability of the specific living arrangement that ensues. Economies of scale in multi-person households, differences in the risk aversion between mother and child, direct preferences about the living arrangement itself (as a stand-in for

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

[2] See Keane and Wolpin (19997) for a standard defense for the use of structural approaches in economics mainly on the base of the use of counterfactuals.

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 co-residence 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. While 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, typically children undertake effort to live together while the opposite is true for mothers.[3]

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 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 that live alone.

[3]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 paper hold. Details are available on request.

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 non-monotonic 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 for children account only for a very small part of the changes in living arrangements.

A fourth independent contribution of this paper is the construction of the data. While the census provides information about family members that live in the same household, it does not connect those that 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 census data to construct pairs of mothers and children that do not live together, allowing us to estimate the models. We make this assumption following, among others, the results of Harding, Jencks, Lopoo, and Mayer (2005), who find that the correlation between parents and children has remained constant over the last thirty 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 that live alone. See McGarry and Schoeni (2001), Costa (1999), and Macunovich, Eaterlin, Schaeffer, and Crimmins (1995) for an extended survey. While Burr and Mutchler (1992), among others, argue that income of the elderly is an important determinant of liv-

ing arrangements, Schwartz, Danziger, and Smolensky (1984) and Börsch-Supan, Gokhale, Kotlikoff, and Morris (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) uses logits and probits in a non-structural 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 non-representative 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 while 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 while Ward, Logan, and Spitze (1992) underline the implicit transfers from parents to children when living 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 co-reside. 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 (inter-household transfers when living apart and co-residence with), while McElroy (1985) shows that young children jointly choose their market work and household membership.

Section 2 reports the features of the data 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, for different types of economies of scale and for different

types of sharing arrangements. In fact, we investigate various alternative specifications of these features (two in this Section and the rest in Appendix C). Section 4 describes how we estimate the models using 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. The paper also includes various appendices. Appendix A describes how we select and refine the sample in both 1970 and 1990. In Appendix B we report the income data we use, while in Appendix C we show alternative specifications of the model and how they perform.

2 The Data

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. This information is not available.[4] However in 1993 the AHEAD Survey was conducted and it allows us to determine the joint distribution of income of mothers and their offspring.[5] 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. Its sample size is 17,718 individuals, of whom 8,222 are elderly people and the rest are relatives. We then turn to census data as reported by the IPUMS samples for 1970 and 1990, a very convenient source because of its

[4]While 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 non-married women older than 66, of whom 260 were living alone and the remaining 11 were living with their children.

[5]The 1993 AHEAD is the first wave of the data collection of the study of Asset and Health Dynamics among the Oldest Old and it 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.

big size: 41,385 elderly widows in 1970 and 61,611 in 1990.[6]

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. We proceed by assuming that certain properties of the joint distribution of the income of the elderly widows and of the income of the households where their children live have remained constant throughout the period we study, which allows us to use just these data sources. 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, while we describe the properties of the data in 1970 in Section 2.3 and those of 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. Notice 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 that are not living together and of their respective incomes from the census samples. Appendix A describes the sample selection, while Section 2.2 describes how we impute the properties of the joint distribution of income to those pairs of mothers and children that 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, Jencks, Lopoo, and Mayer (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

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

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, while 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 they find that there was low mobility in the U.S., between these years (in the same line of the work 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 that either live alone or with children constitute 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 either mothers and their children living together or living alone, we can construct the 1970 and 1990 mother-children pairs with the

[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 that 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 representing 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 it does not alter the relative difference in measures of economic well-being across individuals.

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

[10]See Appendix A and Table 12 for a detailed discussion of the data.

following detailed steps.

1. **1993 AHEAD**. We analyze only children and widow-mother pairs in 1993 AHEAD. If the widow is living alone and has more than one child, we randomize and select one of the children.[11] We define four equal size income groups for both widows and children, and we calculate the joint distribution of incomes of mothers and the household that the children belong to. That is:

		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

   Where $P_{i,j}$ is the proportion of mothers with type j income with i type children.

2. **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. **Subsample of individuals living together.** We select from the IPUMS the pairs of mothers and children that live together.

4. **Marginal distribution of incomes of mothers and children: 1970 and 1990 IPUMS.** We then sort all the children and all the widows into four income groups of equal size. We obtain the fractions of those that live together and denote them $T^t_{i,j}$ for t equal to 1970 and 1990.

5. **Imputation of the joint distribution of incomes.** Using the $P_{i,j}$ from the AHEAD we obtain

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

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

where $A^t_{i,j}$ are 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 that do not live either in institutions or with unrelated adults, 62.0% live alone while the remaining 38% live with their offspring. In 1970 the average annual income for an elderly widow was \$2,162, while 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 1 where 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 we are interested in. Hence, the construction of Table 1 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 parenthesis) of each one of these groups over the total sample, i.e., the relative frequencies. Consequently, adding up 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 groups away from the diagonal, which is an implication of the intergenerational persistence of income. The main pattern of the data is that more income tends to increase the fraction of widows that 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

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

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 non-linearity, which the estimated models will try to replicate.[13]

Table 1: 1970 Percentages of income groups (in parenthesis) and widows living alone (**bold**).

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

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 move 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 2 displays the living arrangements for 1990.[15] We have proceeded in the same way

[13] We have also done the same exercise for the 3x3 case and we get an equivalent non-monotonic pattern. However, it was impossible to deliver the 5x5 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 we consider in 1990 are older than the widows in 1970 to account for the increase in life expectancy. See Appendix A for details.

[15] Because of our assumption, the distribution of income across joint quartiles is the same as in 1970. See Table 1.

Table 2: Fractions of widows living alone for both 1990 (in **bold**) and 1970 (in *italics*).

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

that for 1970: from the 1990 IPUMS dataset we get the fraction of people 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. 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 that live alone in all income groups, albeit not in the same proportion. For the groups with the poorest mothers and 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: 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, while 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

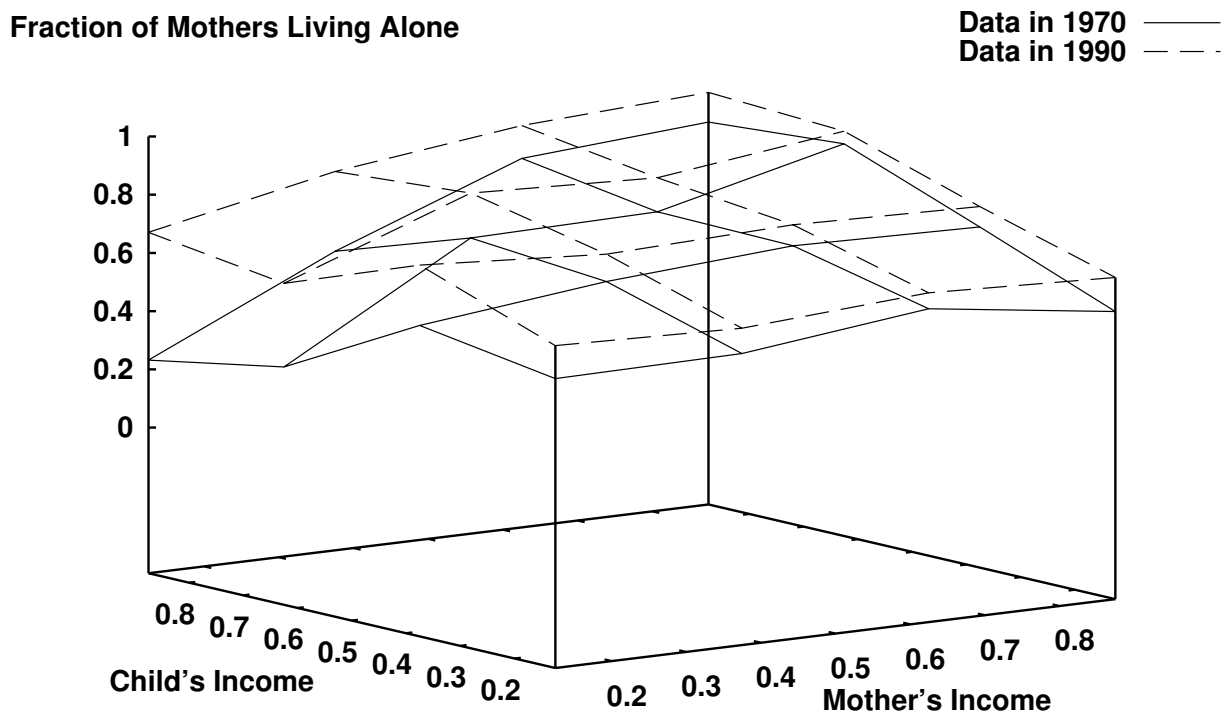

Figure 1: **Fractions of widows living alone by joint income quartiles, 1970-1990.**

in various directions, one of them reported below (Model 2) and the rest in Appendix 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 in 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), rather than 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 where 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 where 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) for example). 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 an new way some of the nice features of transferable utility without having to deal with the thorny issue of what is nature of the transfers.[16]

Let the utility of a mother that lives with her child be denoted by $u^m(c, e, t)$ and that of a mother that lives alone be denoted by $u^m(c, e, a)$. Likewise for a child we have $u^h(c, e, t)$ and $u^h(c, e, a)$. 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

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

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

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

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

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

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

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

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 that 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, that 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 Appendix 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

$$p(e^m, e^h) = \frac{\exp\left(e^m + e^h\right)}{\exp\left(e^m + e^h\right) + \;\; \rho \;\; \exp\left\{-\left(e^m + e^h\right)\right\}}, \quad (6)$$

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 $\frac{1}{1+\rho}$. Also note that since efforts have different utility costs, they are not really symmetric.

With respect to the economies of scale we pose $\phi_a(y^h) = \frac{y^h}{\gamma - 0.7}$ and $\phi_t(y^m, y^h) = \frac{y^m + y^h}{\gamma}$ which also implies another parameter, γ. We use the OECD estimations of the equivalence scales to take into account the mother's effect on total consumption: while 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 a fifth parameter.

Effort generates a direct disutility, and we pose it as $-\alpha^m \; (e^m)^2$, and $-\alpha^h \; \left(e^h\right)^2$, 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

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

while that of the child is

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

Model 2: Both care about living arrangements; mothers also care about their children. We pose a variation of the baseline model where the living arrangement also enters in the utility of the child and where 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:

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

while that of the mother is

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

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 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 13 reports the average incomes of the mother and of the child of each of the 16 groups. We then construct the product pairs of mothers and children according to these criteria, obtaining 16 cells. Note that we are using between seven and nine parameters to get sixteen 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 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 1) are generally larger. We obtained very similar estimates using equal weights across groups.

4.2 Estimation Results

We now turn to report the estimates of the baseline and of Model 2 using 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,

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

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 3 shows the predictions of the baseline as well as its accuracy measure. To better assess the model, we also include in the table the corresponding

Table 3: Predictions of Model 1 for 1970
Percentage of mothers living alone **(Data in parenthesis)**

Accur. **0.8854**		Mother 0-25		25-50		50-75		75-100	
	0-25	47.3	**(49.3)**	55.6	**(50.1)**	58.1	**(57.6)**	46.3	**(48.8)**
Child	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)**

values of the data. We see that the model replicates the features of the data despite their strong non-linearities. Recall that while 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, nor for the poorest children for whom the behavior is more of an inverted U shape. The model traces the data very well with a relatively small number of parameter,s producing increases of different steepness in different directions. 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.

Table 4: 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
Accur.	0.8854	0.8867

The first column of Table 4 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

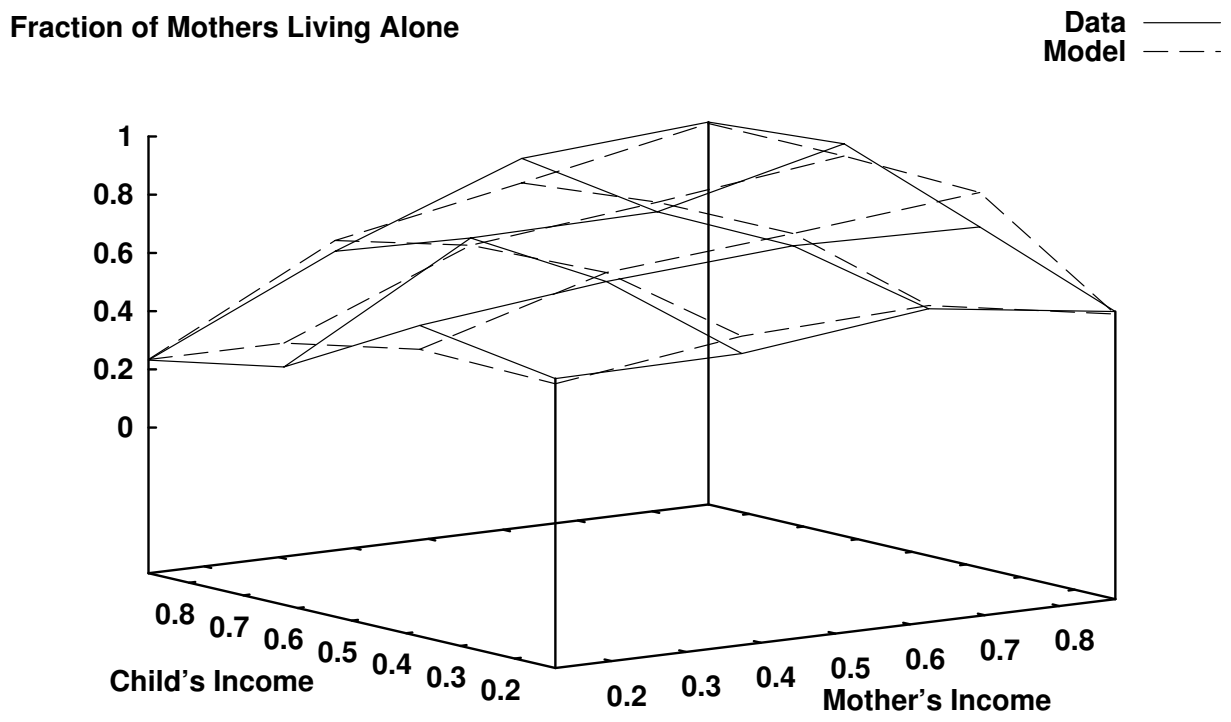

Figure 2: **Fraction of mothers living alone in the baseline model and in 1970 data.**

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 $\frac{y^h+y^m}{33.9}$ if they live with their children, while it is y^m if they live alone). As a result, even 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, this 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) that found that additional adults in households are essentially costless while children are extremely costly. We have clarified the text in this regard.

Notice 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 they 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 with their mothers. Table 5 reports individuals' efforts for the 16 groups.

Table 5: 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

*We divide by 100 to get the efforts supplied by the model

In the baseline model mothers always exert effort to live alone (see Table 5): not only 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 monotone: the higher the income of one party the less attractive it is for her to live together and 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 6 shows the predictions of this model, while Table 4 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.

Table 6: Predictions of Model 2 for 1970
Percentage of mothers living alone **(Data in parenthesis)**

Accur.		Mother							
0.8867		0-25		25-50		50-75		75-100	
	0-25	46.7	**(49.3)**	53.9	**(50.1)**	56.5	**(57.6)**	48.4	**(48.8)**
Child	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 results of the seven alternative models are described in Appendix C. 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 that increased the measures of accuracy by less than 4%. Model 2, where 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 we estimated using 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:

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

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, $p^{90}(e_i^m, e_j^h)$ is the equivalent fraction of elderly widows living alone 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. While 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. While 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.

5.1 Predictions for 1990 of Model 1 (Baseline)

Table 7 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), while our model predicts 71.9%, which is 74.4% of the allocational increase between 1970 and 1990. If instead we use the accounting statistic defined above to measure the contribution of income changes to the changes in living arrangements, the model accounts for 77.3% of the

[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 7: Predictions of Model 1 for 1990
Percentage of mothers living alone.
(Data in parenthesis). Total alone predicted 71.9%

Error:		Mother							
0.00584		0-25		25-50		50-75		75-100	
	0-25	61.5	**(60.7)**	64.7	**(58.8)**	64.6	**(63.1)**	52.4	**(60.5)**
Child	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)**

change in the number of widows living alone, a very similar number to the cruder measure. Figure 3 depicts the prediction of the model for the 1990 data.

5.2 Predictions for 1990 of Model 2

Table 8 shows Model 2 predictions with 1990 incomes. They amount to 73.7% of the increase in the data (the more sophisticated measure yields 76.9%).

Table 8: Predictions of Model 2 for 1990
Percentage of mothers living alone.
(Data in parenthesis). Total alone predicted 71.8%

Error:		Mother							
0.00594		0-25		25-50		50-75		75-100	
	0-25	61.0	**(60.7)**	64.1	**(58.8)**	65.2	**(63.1)**	58.5	**(60.5)**
Child	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)**

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

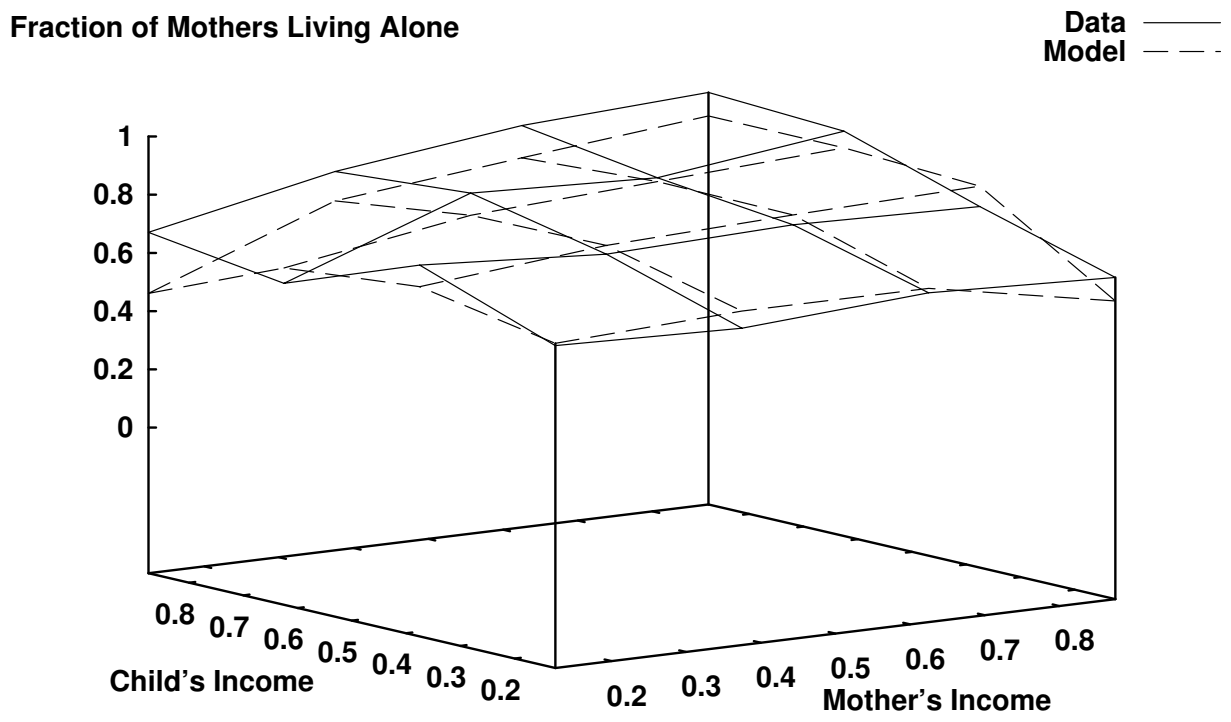

Figure 3: **Fraction of mothers living alone in the baseline model with 1990 income and in the 1990 data.**

change in the level of incomes and in 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 9 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 9 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.

Table 9: Income changes by agent type

Mothers' income change, children's do not. Total alone: 70.5%

Error:		Mothers							
0.00796		0-25		25-50		50-75		75-100	
	0-25	57.5	**(60.7)**	57.6	**(58.8)**	55.3	**(63.1)**	27.1	**(60.5)**
Child	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 do not change, children's do. Total alone: 60.4%

Error:		Mother							
0.04420		0-25		25-50		50-75		75-100	
	0-25	49.3	**(60.7)**	60.2	**(58.8)**	63.8	**(63.1)**	63.2	**(60.5)**
Child	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)**

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 while 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 non-linearities present both in the model and in the data.

6.2 Changes in Relative Income

To look at the effects of relative rather than 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 10. We see an 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 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 10 shows the results.

Table 10: Relative and absolute changes in income

Children's income as in 1970, mothers' relative income as in 1990. Total alone: 68.0%

Error:		Mothers							
0.01110		0-25		25-50		50-75		75-100	
	0-25	56.9	**(60.7)**	57.8	**(58.8)**	56.8	**(63.1)**	33.7	**(60.5)**
Child	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	
	0-25	51.0	**(60.7)**	61.3	**(58.8)**	64.5	**(63.1)**	61.1	**(60.5)**
Child	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)**

To summarize, changes in relative income account for almost two-thirds of the predicted increase, while changes in absolute income accounts for one-third.

6.3 Changes in Income Dispersion

The top panel of Table 11 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 11. 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, while it increased for children's income income from 0.394 to 0.538), the effects of these

changes as described in the top panel of Table 11 are minuscule relative to those implied by the changes in averages reported in the bottom panel.

Table 11: Changes in the dispersion of incomes

1970's incomes, 1990's coefficients of variation Total alone: 60.3%

Error: **0.03111**		Mothers 0-25		25-50		50-75		75-100	
	0-25	40.2	**(60.7)**	41.6	**(58.8)**	41.4	**(63.1)**	27.7	**(60.5)**
Child	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: **0.01065**		Mother 0-25		25-50		50-75		75-100	
	0-25	63.3	**(60.7)**	70.1	**(58.8)**	71.5	**(63.1)**	63.5	**(60.5)**
Child	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)**

7 Conclusion

In this paper we have documented the increase in the fraction of elderly widows that live alone and its relation both to their income and to their children's income. We have used different data sets, and we assumed the stability of the intertemporal persistence of incomes across generations in order to be able to link mothers and children that 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 where the two incomes play a central role. We have estimated those models using 1970 data, obtaining quite a good fit and replicating the strongly non-monotonic 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 we found that changes in 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 living arrangements and we have 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 the three-quarters predicted by the model, reflecting the highly non-linear 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 living arrangements in the data, while 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 average levels of income accounts for almost all of the increase in the fraction of widows living alone, while 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 paper 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 number of the children seem to play a small role in helping us understand the changes in the living arrangements since the 1970's.

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Appendices

A Data Analysis

We use data from the 1970 and 1990 IPUMS and from the 1993 AHEAD. The IPUMS database is a large (about two million individuals in 1970 and two and one-half 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 (Asset and Health Dynamics Among the Oldest Old), which is designed to collect data about elderly people, has this information. Several sections of the questionnaire are designed to get information about the children whether they are living in the elder's household or not. 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 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.

Age: Between 1970 and 1990 life expectancy of 65-year-old women went from 17 to 19 years.[19] This was accompanied by a reduction in the disability rates among elderly people[20] 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; in 1990 we choose those widows from 67 to 84 years of age. The change in the age group 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.

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 we abstract from family size in our model.

[19] See The Berkeley Mortality Database webpage: `http://www.demog.berkeley.edu/wilmoth/mortality`.
[20] See Manton, Corder, and Stallard (1997).

Living arrangements: There are four types of living arrangements that 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 12: 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

Table 12 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 we consider only the options of living alone or living with children. In 1970 62% of the widows that were not living with others or in institutions lived alone, while in 1990 this fraction was 75.3%. The set of women that we look at constitute 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 13: Total income for widows and their children by income quartiles

		Mothers' Income				**Children's Income**			
		Mothers				Mothers			
1970:		0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
	0-25	495.61	1157.20	1794.47	5199.60	2843.59	2799.52	2825.58	2682.10
Children	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*:									
	0-25	3690.84	6668.67	10426.57	25320.47	8147.27	8273.85	8460.34	8468.56
Children	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 with the baseline. We also report the estimation results and comment on the main points. Table 15 shows the predictions of most of these models, while Table 14 shows the parameter estimates.

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 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

$$p(e^m, e^h) = \frac{\exp\left(e^m + \rho_1 e^h\right)}{\exp\left(e^m + \rho_1 e^h\right) + \exp - \left(e^m + \rho_1 e^h\right)} \tag{13}$$

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 $\frac{1}{1+\rho}$ and for differential effects of the mother and her child. The effort function is

$$p(e^m, e^h) = \frac{\exp\left(e^m + \rho_1 e^h\right)}{\exp\left(e^m + \rho_1 e^h\right) + \rho \exp - \left(e^m + \rho_1 e^h\right)} \tag{14}$$

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.

Table 14: Parameter Estimates

	Model						
	3	4	5	6	7	8	9
$\overline{c}^m$	-559.68	-725.36	-915.02	-920.84	-920.84	-1669.75	-725.36
$\overline{c}^h$	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
Accur.	0.8751	0.8854	0.8854	0.8854	0.8854	0.8468	0.8854

Table 15: Predictions of All Models for the % of Mothers Living alone

		Mothers				Mothers			
		0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
		Model 3, Acc. 0.8751				**Model 4, Acc. 0.8854**			
	0-25	45.0	51.5	55.4	49.4	46.9	55.5	58.1	47.1
Child	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, Acc. 0.8854				**Model 6, Acc. 0.8854**			
	0-25	45.9	53.6	56.5	48.5	45.9	53.5	56.5	48.5
Child	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, Acc. 0.8854				**Model 8, Acc. 0.8468**			
	0-25	45.9	53.5	56.5	48.5	47.0	52.4	55.0	46.1
Child	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