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# Bequest Motives and the Social Security Notch <sup>\*</sup>

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## Abstract

Bequests may be a key driver of late life savings behavior and more broadly, a determinant of intergenerational inequality. However, distinguishing bequest motives from precautionary savings is challenging. Using data from the Health and Retirement Study, we exploit an unanticipated change in Social Security benefits, commonly called the Social Security Notch, as an instrument to identify the effect of benefits on bequests. We match data moments generated by the Notch with a model of late life savings behavior that accounts for mortality risk and unobserved expenditure shocks to identify bequest motives. The model is used to decompose the importance of bequest motives as a driver of late life savings by comparing asset profiles with and without utility from bequests. We find that roughly one-third of accumulated assets and bequests are attributable to bequest motives among retirees. Our policy counterfactual features a more progressive Social Security benefits schedule that reduces benefits for the richest retirees. We show that although wealth declines, consumption remains largely unchanged since wealth generated by bequest motives acts as a cushion against benefit reduction.

Key words: bequests, late life savings, assets, social security

JEL codes: D3, D91, H55, J14

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# 1 Introduction

Although standard life-cycle models predict that it is optimal for individuals to run down their assets towards the end of their lives, many elderly still hold on to large amounts of assets. Two major reasons that can explain this phenomenon are precautionary savings and bequest motives. Precautionary savings are driven by various risks to consumption that retirees face, while bequest motives are driven by utility gained from leaving bequests. However, since accumulated assets can serve both purposes, bequest motives are notoriously difficult to distinguish from precautionary savings (De Nardi et al., 2016b; Dynan et al., 2004).

This paper proposes a novel solution by exploiting a plausibly exogenous change in Social Security benefits, known as the Social Security Notch, to identify bequest motives. This change in benefits arose from an error in the calculation of benefits in the 1970s and led to higher benefits for retirees born between 1911-1916 relative to cohorts before and after. To uncover the role of bequests in savings behavior relative to precautionary savings, we construct a dynamic model of post-retirement savings behavior of single retirees that incorporates incentives for precautionary savings and voluntary bequests. We use the policy change as an instrument for benefits to compute instrumental variable (IV) estimates of the effect of benefits on bequests. These IV estimates are then used as data moments to identify the key parameters that govern bequests motives in our dynamic model.

The Social Security Notch has a unique advantage for identifying bequest motives. Social Security benefits are effectively a source of annuity income and serve as insurance against mortality risk. Therefore, a difference in benefits would mean a difference in the incentive to save for precautionary reasons. However, benefit levels are closely tied to lifetime earnings and hence correlated with initial wealth at retirement. Since initial wealth levels are in turn correlated with both bequest motives and precautionary motives, we cannot recover bequest motives. Using the Social Security Notch as an instrument circumvents this problem so that we can estimate the effect of benefits on bequests and identify bequest motives. It is important to note that an alternate instrument that generates a one-time wealth or income change would be insufficient for our purposes. The one-time windfall in wealth can be saved for either precautionary reasons or bequest motives and cannot separate the two.

The dynamic model incorporates warm-glow bequest motives<sup>1</sup> as well as mortality risk and annual expenditure shocks, both of which act as incentives for precautionary savings. Leveraging the Social Security Notch as an instrument, we use the restricted version of the

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<sup>1</sup>Utility from bequests can be modeled in different ways such as warm glow, altruistic motives, or strategic motives. In this paper we deal with warm glow bequest motives as this is the most common way of modeling bequest motives and thus facilitates comparison of our results with the literature.

Health and Retirement Study, Asset and Health Dynamics among the Oldest Old (HRS AHEAD) to estimate the model with rich unobservable heterogeneity in the form of annual expenditure shocks. We use the HRS version that is linked with the Social Security administrative data for more precise information on benefit receipt.

In our model estimation via indirect inference, we match important IV moments generated by the Notch, including estimates for the effect of annual benefits on bequests. Our IV estimates show that a \$1,000 increase (1993 dollars) in annual Social Security benefits leads to an \$16,740 increase in bequests and a 5 percentage point increase in the probability of leaving any bequests. The large bequest response of retirees to an increase in benefits suggest that bequest motives are in fact important. We also provide evidence that bequests are a luxury good by looking at heterogeneity in the effect of benefits by wealth levels (as captured at first observation) and find that the effect is larger for higher quantiles of wealth.

Our model estimates of the preference parameters governing bequest motives show that they are influential in determining savings for retirees. As suggested in the heterogeneity of the instrumental variable estimates by asset levels, we find that bequests are a luxury good. We also show that while asset profiles reflect both the bequest motive and precautionary savings, the additional variation from the Notch separately identifies preference parameters that govern the strength of bequest motives. In particular, when the IV estimates are not matched, model estimates indicate that bequest motives are underestimated and their corresponding parameter estimates are statistically much less precise.

To quantify the importance of bequest motives, we simulate asset profiles under the assumption that bequests yield no utility while keeping all other estimated parameters fixed. We find that about 35% of bequests are due to voluntary bequest motives. Not only do asset profiles decline much more sharply without bequest motives, counterfactual bequests, now purely accidental, are roughly 65% of our baseline model simulations. Furthermore, the probability of leaving any bequests decreases by 9 percentage points (from a base probability of 64%).

Given that bequests are an important part of savings behavior, we expect that savings set aside for bequests act as a cushion for cuts in Social Security benefits for the rich. We implement a more progressive benefit schedule which would reduce the cost of Social Security as an insurance program by capping benefits at the 80th percentile. Our counterfactual simulations indicate that median consumption levels are largely unchanged. Instead, the richer retirees elect to draw down on their assets, and by implication, reduce their bequest amounts.

Our findings speak to a long literature on bequests, at least since the debate between [Kotlikoff and Summers \(1981\)](#) and [Modigliani \(1988\)](#) regarding the portion of wealth stem-

ming from intergenerational transfers. [Gale and Scholz \(1994\)](#) argue that intergenerational transfers account for at least 50% of accumulated wealth. If most wealth is not earned but inherited, then understanding why wealth is left behind is important for any kind of policy targeted at reducing intergenerational wealth inequality by changing bequest behavior.

Furthermore, without an understanding of the motives underlying the savings behavior of retirees, it would be difficult to evaluate the distributional and welfare effects of changes to Social Security benefits. With the looming costs of Social Security in the United States and other countries, it is important to understand the consequences of reductions in such benefits. Our results show that although Social Security benefits insure retirees against mortality risk, at the higher end of the benefit distribution, benefits are bequeathed rather than consumed.

Prior papers have attempted to disentangle bequest motives from precautionary savings (see [De Nardi et al. \(2016b\)](#) for a comprehensive review). One approach is to include data that pertains to different sources of risk such as medical costs and long-term care to capture major drivers of precautionary savings ([De Nardi et al., 2010](#); [Lockwood, 2012](#)). The residual is left to bequest motives. Other papers elicit bequest motives from respondents directly ([Ameriks et al., 2011](#)).

Our paper departs from the literature by adopting a new source of variation from the Notch as an instrumental variable. Compared to previous efforts to disentangle bequest motives and precautionary savings, we are less reliant on explicitly modeling multiple sources of expenditure risk by relying on the Notch as an instrument. Instead, our model allows for expenditure risks to be correlated with income in a flexible way and identifies them through the wedge in savings and bequests behavior between the Windfall and non-Windfall cohorts. These unobserved shocks in the model capture the unobserved heterogeneity that may be correlated with Social Security benefits and bequests that the instrument addresses.

Our paper therefore contributes to the literature by proposing a new identification strategy to estimate bequest motives. Although many papers have analyzed late-life savings behavior, the literature remains divided on the relative importance of bequest motives and precautionary savings. On one hand, some argue that bequests are largely accidental, and assets are driven mainly by precautionary savings. [Hurd \(1987\)](#) is an early paper arguing that bequest motives are weak by comparing the savings behaviors of retirees with children against childless retirees, hypothesizing that childless retirees would have a weak bequest motive. Finding that both groups of retirees dissave at similar rates, he concludes that most retirees have economically insignificant bequest motives. [Hurd \(1989\)](#) complements the earlier finding with a model of savings behavior and estimates a small marginal utility of bequests. [De Nardi et al. \(2010\)](#) estimate a model of late-life savings behavior explicitly

accounting for mortality risk and medical cost and finds that bequest motives are only important for a small fraction of the wealthiest households while most savings are generated for precautionary reasons. [Ameriks et al. \(2011\)](#) relies on survey responses that reveal bequest motives by asking respondents about trade-offs between future consumption and bequests under hypothetical scenarios (see also [Ameriks et al. \(2015a,b\)](#)).

On the other hand, [David and Menchik \(1985\)](#) is an early precursor to our paper finding evidence that bequests matter for explaining the response of retirees to Social Security. [Bernheim \(1991\)](#) shows that most retirees would choose to retain a portion of their wealth in bequeathable form rather than annuitize it as insurance against mortality risk, even if insurance markets were perfect. This suggests the presence of a bequest motive for the majority of households. [Lockwood \(2012\)](#) brings this intuition to a model of annuity choice and provides evidence that annuity markets are priced such that people with bequest motives do not take up annuities at all. Without bequest motives, the low participation in annuity markets would be hard to explain. Another line of research looks at the response of inter vivos gifts to either bequest taxes or estate taxes ([Bernheim et al., 2004](#); [Joulfaian, 2000](#); [Page, 2003](#)). Since the elderly choose to pass more wealth through inter vivos gifts when bequest or estate taxes rise, then bequest motives are likely to be operative. Our paper supports the claim that bequest motives are important.

To our knowledge, our paper is also the first to use the Social Security Notch as a way to identify bequest motives. The Notch has been used by many others as an instrument for income and wealth, starting from [Krueger and Pischke \(1992\)](#) who analyzed retirement decisions in response to changes in post-retirement income.<sup>2</sup> However, prior papers do not capitalize on the nature of benefits as a source of annuity income which leads to a reduction in the incentive to save against mortality risk.

Another related literature examines the propensity to bequeath or save in response to changes in earnings or wealth. A number of papers provide evidence that bequests are luxury goods ([Altonji and Villanueva, 2007](#); [Hurd and Smith, 2002](#); [Menchik and David, 1983](#)). Our estimates for the effect of Social Security wealth on bequests are significantly larger than previous estimates.

Finally, we add to the literature that studies the effects of changes in Social Security benefits on the savings behavior of retirees. Our counterfactual analysis sheds light on the way retirees trade off bequests for consumption when faced with lower benefits. Other studies have examined the potential effects of benefit cuts to retirees but have thus far focused on

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<sup>2</sup>More recent papers include [Moulton and Stevens \(2015\)](#) and [Gelber et al. \(2016\)](#). Other outcomes that have been examined using the Notch include mortality ([Snyder and Evans, 2006](#)), co-residence ([Engelhardt et al., 2005](#)), home-ownership ([Engelhardt, 2008](#)), long-term care utilization ([Goda et al., 2011](#)), healthcare expenditure ([Moran and Simon, 2006](#); [Tsai, 2016](#)), and child's wealth ([Moulton, 2014](#)).

income (Goodman and Liebman, 2008). In particular, the Social Security Administration bases much of its analysis on a simulation model known as Modeling Income in the Near Term (MINT) (Olsen, 2008; Smith and Favreault, 2014). Weinzierl (2014) is a notable exception, providing an analysis of a reduction in benefits with regard to retiree consumption. However, the focus is on the comparison of back-loaded benefits versus front-loaded benefits.

The rest of the paper is as follows. We first lay out the institutional details of our instrument (Section 2). We next propose a model of post-retirement savings behavior (Section 3). We use this model in conjunction with the instrument to estimate and identify underlying preferences for bequests (Section 4). We show our results in Section 5 and decompose the savings of retirees and consider policy counterfactuals where benefit levels are reduced. Section 6 concludes.

## 2 The Social Security Notch

The Social Security Notch arose from a change in the way Social Security benefits were calculated in the early 1970s.<sup>3</sup> Before 1972, benefits were determined by computing a Principal Insured Amount (PIA) based on Average Monthly Earnings (AME) over the retiree’s career. The PIA was linked to benefit levels via a table. However, in order to account for creeping inflation, Congress would increase benefit levels associated with one’s PIA on an ad hoc basis.

In 1972, Congress passed amendments that were aimed at removing the need to periodically update the benefits table, to be implemented in 1975. However, the new formula double-counted inflation by accounting for inflation in the computation of the PIA based on (nominal) AME, and by allowing for automatic Cost of Living Adjustments (COLA) each year based on prevailing prices. This is commonly referred to as the double-indexation issue. As a result, benefits would become overly generous during periods of high inflation and high wage growth. This windfall affected cohorts born between 1911-1916 retiring at the normal retirement age of 65 or later (henceforth referred to as the Windfall cohort).<sup>4</sup> Earlier cohorts also had high nominal wage growth, but did not benefit from the flawed formula due to retiring before the 1972 change.

However, the Social Security Administration quickly realized that the new formula would

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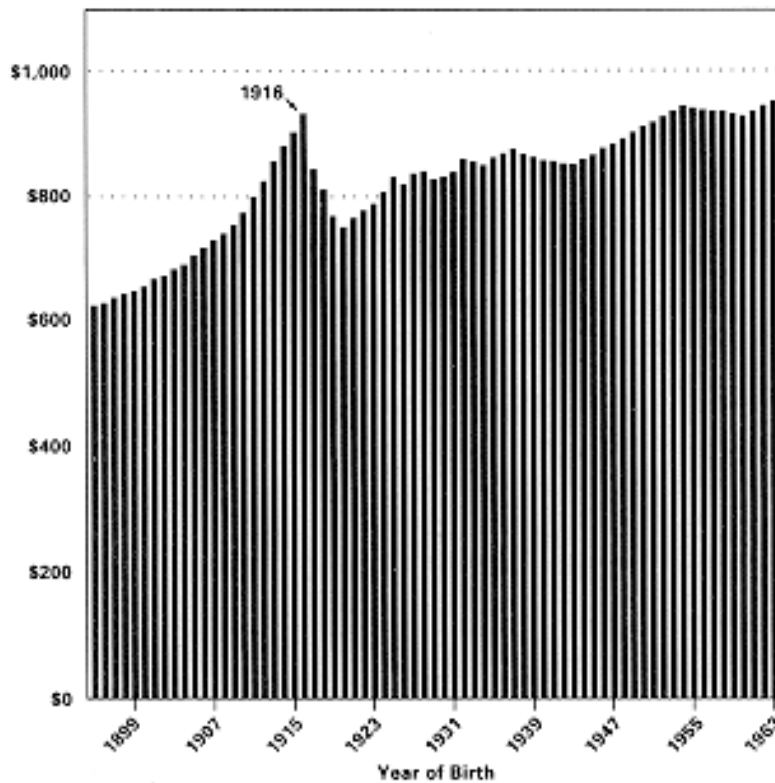
<sup>3</sup>Refer to the Congressional Budget Office report on the Notch issue for a detailed history of the legislation surrounding the Notch (Kollmann, 2003).

<sup>4</sup>We include 1911-1912 cohorts even though retirees who retired before age 65 would not benefit from the windfall. Instead, they benefited from a large ad hoc 20% increase in benefit levels implemented in September 1972 because Congress thought it was necessary to act against rising inflation before the full implementation of the 1972 amendments.

lead to a severe lack of funds by the 1980s. Congress therefore passed the 1977 amendments which provided a corrected formula that separately accounted for inflation over the working life of retirees and COLA. The corrected formula computed the retirees' PIA based on Average Indexed Monthly Earnings (AIME) and was implemented in 1979. Importantly, the correction was only applied to retirees born in 1917 and after, regardless of retirement age. Retirees who were born in the Windfall cohorts retained the PIA computed using the flawed formula and therefore were entitled to higher benefits than subsequent cohorts for the rest of their post-retirement lives. This decrease in benefits due to the correction is commonly referred to as the "Notch". Figure 2.1 shows what a retiree earning average wages throughout her career would receive given her birth year. The Notch is represented by the dip in benefits associated with a retiree from the 1917-1921 cohort retiring at 65.

The new formula was implemented in 1975, affecting cohorts born between 1911-1916 and retiring at 65. Earlier cohorts (1905-1910) and later cohorts (1917-1921) did not receive the windfall from double-indexation that the flawed formula in combination with high

**Figure 2.1:** Monthly Social Security Payouts for An Average Worker by Birth Year



*Notes:* Monthly Social Security payout in 1994 dollars for workers who claimed benefits at age 65 and had average earnings every year of their working life. Source: [Kollmann \(2003\)](#).



wage growth and inflation provided. Our identification strategy is to compare retirees who were affected by different benefit rules based on birth year. As seen in Figure 2.1, benefits were exceptionally high for the Windfall cohort (born between 1911-1916), deviating from the general trend of benefits over time.<sup>5</sup> These changes provide the variation we need for identifying bequest motives as they generate significant increases in social security payouts that serve as a form of insurance against longevity (i.e., an annuity). This lowers the precautionary savings incentive such that increases in savings and bequests are likely generated by bequest motives instead.

## 2.1 Validity of the Social Security Notch as an Instrument

The key assumption required for the instrument to be valid is that any observed differences in bequests across the Windfall and non-Windfall cohorts are driven by the institutional changes determining benefit levels. If the windfall were anticipated by retirees from the Windfall cohort, they may have saved less pre-retirement<sup>6</sup>, which would yield an underestimate of the effect of benefits on bequests. However, the windfall was unanticipated even by Congress and the Social Security Administration, who did not expect to exhaust the program’s funds. It is therefore plausible that retirees from the Windfall cohort did not act in anticipation of the windfall by saving less pre-retirement.

A related concern is that the later cohorts (1917-1921) may have anticipated benefit formulas received by the Windfall cohort and thus planned to retire at earlier ages or dissaved at faster rates. Since early retirement lowers benefits as well as reduces assets, this would violate the assumption that the instrument is uncorrelated with bequests except through benefits. This would upward-bias our estimates since a portion of our “control group” would have started off retirement with lower assets relative to the Windfall cohort, and hence have lower bequest amounts.

However, if retirees from the Notch cohort in fact anticipated benefit levels that were as high as the Windfall cohort’s received benefits, we would see a nearly immediate reaction against the 1977 amendments from them the moment they began collecting benefits that were significantly smaller. However, the Notch remained unnoticed by the media until September 1983, when a column from Dear Abby<sup>7</sup> coined the term “Notch babies” for the retirees in the later cohort. She was a Notch baby herself and the first to raise the issue to public attention, urging retirees to take political action. Subsequently, the Social Security Administration

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<sup>5</sup>Although the birth years chosen to designate as the Windfall cohort vary across studies, the deviation from the general trend is clear. In our instrumental variable estimates, we check that alternate specifications of the Windfall cohort do not affect our results. These results are presented in Table A.5 of Appendix A.2.

<sup>6</sup>Throughout this paper, “retirement” refers to the first year of receiving Social Security benefits.

<sup>7</sup>A well-known columnist.

**Table 2.1:** Balancing Tests on Retiree Characteristics

	Coefficient	Std. Err.	p-value
Years of education	0.091	(0.203)	0.654
Number of kids	-0.082	(0.125)	0.508
Female	-0.023	(0.033)	0.477
Pension benefits	-0.011	(0.380)	0.977
Retirement age	0.110	(0.370)	0.766
Imputed bequests	0.041	(0.029)	0.158

*Notes:* This table reports regressions of various retiree characteristics on an indicator for belonging to the Windfall cohort (controlling for linear cohort trends and gender). Sample consists of single, white, male and female retirees in the HRS AHEAD data. “Retirement” refers to the first year of receiving Social Security benefits. “Imputed bequests” is an indicator for whether the bequest amounts are unknown and thus imputed as the assets in the year prior to death.

responded both in newspapers and by commissioning a study to examine the costs and benefits of compensating the Notch babies.<sup>8</sup>

We argue that the circumstances surrounding the change in benefits were such that retirees from all three cohorts (pre-Windfall, Windfall, and Notch) were unaware of the changes in benefits pre-retirement until they received their first month’s benefit. Therefore, differences in assets post-retirement across the cohorts can be attributed to the disparities in benefits, conditional on general cohort trends. Unfortunately, we do not directly observe pre-retirement assets and are unable to directly test for differences. Instead, we first check for comparability of pre-retirement characteristics across the Windfall and non-Windfall cohorts. Table 2.1 shows regressions of pre-retirement characteristics on an indicator for belonging to the Windfall cohort (conditional on linear cohort trends and gender). Pre-retirement characteristics include education, number of children, gender, pension benefits, and retirement age.

The results are reassuring, suggesting that retirees across the cohorts are similar.<sup>9</sup> For example, we find little difference in age of retirement, a major endogenous choice that one may expect would be affected by a change in benefits. This result is in line with prior works such as Krueger and Pischke (1992) but differs from works such as Gelber et al. (2016). In particular, Gelber et al. (2016) employs a regression discontinuity design by exploiting variation in retiree date of birth and finds that the Notch resulted in a 0.16 year delay in labor force exit among elderly individuals. One can expect that such an effect should dampen

<sup>8</sup>See U.S. General Accounting Office (1988) for more detail.

<sup>9</sup>Refer to Appendix A and Table D.9 for a discussion of the estimated effect of the Notch on other late-life outcomes in the literature.

the effect of the Notch on bequests.

A number of caveats in relation to our analysis are worth mentioning. First, similar to Krueger and Pischke (1992), Gelber et al. (2016) also finds no evidence of the Notch on retirement age when they use variation in *year* of birth instead of *date* of birth and thus argues that the contrasting results are primarily due to differences in the level of the variation used. Unfortunately, we do not have information on exact date of births, so we are unable to verify whether this is also the case for our data and acknowledge this limitation.

Second, the sample in Gelber et al. (2016) is the full population as they are using administrative data, whereas our sample is based on the HRS AHEAD data and is selected on survival to 1992, which is the first survey year of the data. It is likely that our sample had higher wealth and income than the general population. As Gelber et al. (2016) finds that the point estimate for below-median income retirees is substantially larger than for above-median income retirees, it is likely that our estimates are driven by wealthier retirees whereas their findings seem to be driven by lower income retirees.

Finally, as described in Section 4, the primary estimation method of this paper is to use the IV estimates as moments to identify a dynamic structural model via indirect inference. In the estimation process, we control for initial conditions by using the first year of observation of each individual in our HRS AHEAD sample as state variables (including assets) and simulate forward. If potential adjustments in retirement age due to the Notch are reflected in the level of assets in the first year of observation, the IV estimates using the simulated data would align with the IV estimates computed from our observed data (despite not explicitly controlling for retirement age).

### 3 Model

In this section, we propose a model of savings behavior that captures the role of bequests, mortality risks, and other unobserved expenditure shocks that may be correlated to income. Compared to reduced-form specifications, the model allows us to perform a quantitative decomposition of the role of bequests in explaining the savings behavior of retirees. Furthermore, our interest in exploring the response of savings behavior to changes in Social Security benefits are only partially addressed by the reduced-form specification since we would want to consider the savings behavior of retirees across ages over time.

Retirees begin with initial assets and known Social Security benefits. They maximize their expected lifetime utility at age  $t$ ,  $t = t_1, \dots, T$ , by choosing their consumption each period (year) and saving the rest for future periods.

*Preferences* – The flow utility from consumption ( $c$ ) is specified with constant relative risk aversion:

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1 - \sigma} \quad (3.1)$$

where  $\sigma$  refers to risk aversion with regard to inter-temporal consumption subject to mortality risk and shocks to the budget constraint. Utility from bequests ( $b$ ) also follows a constant relative risk aversion form:

$$v(b) = \left( \frac{\phi}{1 - \phi} \right)^\sigma \frac{\left( \frac{\phi}{1 - \phi} c_b + b \right)^{1-\sigma}}{1 - \sigma} \quad \text{if } \phi \in (0, 1), \quad (3.2)$$

where  $\phi$  refers to altruism and  $c_b$  refers to a consumption threshold. Both these parameters have intuitive interpretations.  $\phi$  can be interpreted as the marginal propensity to leave bequests out of a dollar in the last period of life. That is, for an extra dollar in the case where there are no precautionary savings incentives,  $\phi$  is the portion left as bequests (conditional on leaving a non-zero bequest).<sup>10</sup>  $c_b$  acts as a shifter that allows for bequests to be non-homothetic to consumption. The higher  $c_b$  is, the more bequests are a luxury good. It is a consumption threshold such that in the case where there are no precautionary savings incentives, bequests are only left if retiree consumption exceeds  $c_b$ .<sup>11</sup>

*Budget Constraints* – Preferences are subject to the following budget constraint each period:

$$A_{t+1} = (1 + r)A_t + y_t - \xi_t - \tau(A_t, y_t, SSB) + g_t - c_t \quad (3.3)$$

where  $A_t$  denotes assets (including housing),  $r$  denotes the interest rate,  $y_t$  denotes non-asset income,  $\xi_t$  denotes expenditure shocks (described further in the next subheading),  $\tau(A_t, y_t, SSB)$  denotes taxes, and  $g_t$  denotes government transfers.

Non-asset income  $y_t = y(t, SSB, PI, Fem)$  includes Social Security benefits, pensions, and annuities. We assume that non-asset income is a function of age  $t$ , Social Security benefits  $SSB$ , permanent income quartile  $PI$ , and gender  $Fem$ . Importantly,  $PI$  is constructed by birth year such that it is *not* affected by the Notch.<sup>12</sup> Retirees pay taxes on asset income  $rA_t$  and non-asset income  $y_t$  where the tax structure is captured using the function  $\tau$ .<sup>13</sup>

We assume that there is no borrowing, partly due to the fact that borrowing against

<sup>10</sup>See Section 4.3.1 for a further discussion on the parameterization of the bequest motive.

<sup>11</sup>To see this, observe that  $u'(c_b) = v'(0) = c_b^{-\sigma}$ .

<sup>12</sup>We describe the construction of the permanent income quartiles in Section 4.1.

<sup>13</sup>Due to wide variation in state tax code, only the federal income tax schedule is modeled. We also incorporate the fact that Social Security benefits are taxed differently compared to other sources of income. Refer to Appendix B.1 for details on how taxes are computed.

Social Security benefits and means-tested programs is illegal:

$$A_t \geq 0, \quad \forall t \quad (3.4)$$

Lastly,  $g_t$  represents a consumption floor guaranteed by government or societal transfers<sup>14</sup> (Hubbard et al., 1995):

$$g_t = \max\{0, \underline{c} - ((1+r)A_t + y_t - \xi_t - \tau(A_t, y_t, SSB))\} \quad (3.5)$$

Furthermore, we impose the consumption floor  $\underline{c}$  such that the following inequality holds.

$$c_t \geq \underline{c}, \quad \forall t \quad (3.6)$$

*Expenditure Shocks* – So far, our model follows other recent models in the literature that incorporate medical expenditure and/or long-term care insurance (De Nardi et al., 2010; Lockwood, 2016). However, instead of including multiple sources of risks that drive precautionary savings based on observable data, we rely on  $\xi_t$  to capture all expenditure risk, both observable and unobservable. Although we do not specify the sources of late-life income risks and expenditures, some common sources include medical expenditures and transfers to adult children. Figure D.2 shows that the simulated expenditure shocks roughly align with observed expenditures on out-of-pocket medical costs and inter vivos transfers in our data.

We allow expenditure shocks,  $\xi_t$ , to depend on age  $t$ , permanent income quartile  $PI$ , Social Security benefits  $SSB$ , and gender  $Fem$  in the following way:

$$\begin{aligned} \log \xi_t &= m(t, SSB, PI, Fem) + \sigma_\xi(t) \times (\psi_t + \eta_t), & \eta_t &\sim N(0, \sigma_\eta^2) \\ \psi_t &= \rho\psi_{t-1} + \epsilon_t, & \epsilon_t &\sim N(0, \sigma_\epsilon^2) \end{aligned} \quad (3.7)$$

We allow unobserved expenditures to have a first order autoregressive component and a white noise component.<sup>15</sup> The idea is for the autoregressive component to capture persistent costs such as long-term care. The specification also allows for the expenditure shocks to increase in variance by age and income, as we may expect from previous findings in the literature with regard to medical costs (De Nardi et al., 2010). We allow the mean of unobserved expenditures,  $m(t, SSB, PI, Fem)$ , to be a linear function of age, permanent income quartile, gender, log Social Security benefits, the interaction of age and permanent

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<sup>14</sup>This includes transfers from means-tested programs such as the Supplemental Security Income (SSI), the Supplemental Nutrition Assistance Program (SNAP), and Medicaid.

<sup>15</sup>This specification is based on French and Jones (2004), who show that it is able to fit medical costs well.

income quartile, and the interaction of permanent income quartile and gender. The standard deviation of unobserved expenditures,  $\sigma_\xi(t)$ , is assumed to be a linear function of age.

To give some intuition for the role of  $\xi$ , we draw an analogy with the control function approach of interpreting IV regressions. The residual from the first stage captures the component of the endogenous variable (in this case,  $SSB$ ) that does not depend on the instrument (in this case the Notch). Including the residual from the first stage in the second stage regression along with the endogenous variable of interest produces the IV coefficient for the endogenous variable by controlling for the component of  $SSB$  that is uncorrelated with the Notch but may be correlated with unobserved heterogeneity and  $SSB$ .

Consider the following first and second stage regressions under a standard IV framework.

$$SSB_i = \alpha_0 + \alpha_1 Wind_i + v_i^{SSB} \quad (3.8)$$

$$Beq_i = \omega_0^{beq} + \omega_1^{beq} \widehat{SSB}_i + v_i^{beq} \quad (3.9)$$

where  $SSB$  refers to Social Security benefits,  $Wind$  refers to an indicator for belonging to the Windfall cohort, and  $Beq$  refers to bequest-related outcomes. Note that equation (3.9) can be rewritten as:

$$Beq_i = \pi_0 + \pi_1 SSB_i + \pi_2 \widehat{v}_i^{SSB} + v_i$$

Then  $\pi_1$  is identical to  $\omega_1^{beq}$  from equation (3.9). Our model of savings behavior is clearly non-linear but the motivation is similar: we allow the unobserved expenditure risks in our model to depend on permanent income quartiles that are unaffected by the Notch, so that  $\xi_t$  (in the model) takes on the role of  $\widehat{v}_i^{SSB}$  in the instrumental variable regression. Indeed, it is  $\xi_t$  that will allow our model's simulated data to replicate the instrumental variable estimates in the true data.

*Recursive Formulation* – Denote the vector of state variables as  $\mathbf{X}_t = \{A_t, \psi_t, PI, Fem, SSB\}$  which consists of assets ( $A_t$ ), the persistent component of expenditure shocks ( $\psi_t$ ), gender ( $Fem$ ), permanent income quartile ( $PI$ ), and Social Security benefits ( $SSB$ ). For each period  $t$ , the optimization problem is as follows:

$$V_t(\mathbf{X}_t) = \max_{c_t} \left\{ u(c_t) + \beta \left( \delta_t(PI, Fem, SSB) \cdot E_t[V_{t+1}(\mathbf{X}_{t+1}|\mathbf{X}_t)] + (1 - \delta_t(PI, Fem, SSB)) \cdot v(A_{t+1}) \right) \right\} \quad (3.10)$$

subject to the constraints (3.3), (3.4), and (3.5). The probability of surviving to the next

period is denoted by  $\delta_t(PI, Fem, SSB)$  which is a function of age, permanent income, gender, and Social Security benefits.

*Discussion of the Model* – There are two points to note. First, retirees are not allowed to borrow against future Social Security benefits, an important institutional feature that ensure the annuity-nature of the benefits. This is key for the intuition behind the Notch instrument in its usefulness to distinguish between precautionary savings and bequest motives.

Second, our approach differs from prior attempts to separate bequest motives from precautionary savings by explicitly modeling various sources of expenditure risk such as medical expenditure or long-term care. While this is a substantial improvement to a model with no expenditure risk, there remain the potential for other unobserved expenditure risks that retirees face. We instead exploit the plausibly exogenous variation in Social Security benefits to avoid the pitfall of unobserved expenditure risk, and hence provide an alternate source of identification for bequest motives which does not require us to take a stand on how retirees make insurance choices. That is not to say that modeling other expenditure risks explicitly is not fruitful – we think that it is important to understand these other sources of risk. However, we believe that our approach focuses on distinguishing bequest motives and precautionary savings with fewer assumptions.

## 4 Estimation

We estimate the model in two stages. In the first stage, certain parameters that we assume to be exogenous in the model are either calibrated or estimated without explicitly using the model. Given the vector of first stage parameters  $\hat{\theta}_f$ , the second stage uses indirect inference to recover the rest of the parameters in the model. This is done by first, numerically solving the model by starting from the terminal period  $T = 110$  and iterating backwards to obtain the value functions and decision rules for each period.<sup>16</sup>

Next, we use our model solution and the first stage parameters to generate a sample of 25,000 simulated retirees and compute simulated asset profiles and bequests. To control for initial conditions, we use the first year of observation of each respondent in our data sample described in Section 4.1 to directly obtain initial state variables (namely, assets, Social Security benefits, permanent income quartiles, and gender). We then simulate forward and generate a set of data moments ( $\hat{M}$ ) using the simulated data and compare them with their counterparts ( $M$ ) in the true data from the HRS AHEAD sample.

The final estimate  $\hat{\theta}_s$  is chosen such that it minimizes the distance between the data

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<sup>16</sup>See Appendix B.2 for more detail on the model solution.

moments from the simulated data and the true data, weighted by the precision of the data moments computed from the true data ( $W$ )<sup>17</sup>:

$$\hat{\theta}_s = \operatorname{argmin}_{\theta_s} (M - \hat{M}(\hat{\theta}_f, \theta_s))' W (M - \hat{M}(\hat{\theta}_f, \theta_s)) \quad (4.11)$$

When computing the value functions and decision rules, we rely on the mortality probabilities  $\delta_t$  estimated from the first stage. However, in our simulations, we impose our simulated retirees to have the same death age as observed in the data. If we do not observe the respondent’s death date either due to missing data or the respondent being alive at last observation of the data, we use our estimated mortality probabilities to assign mortality shocks. This reduces the simulation bias that may arise from the model mortality probabilities not perfectly matching the true mortality risk that individuals face in the data.<sup>18</sup>

## 4.1 Data

To exploit the instrument, we require a sample of retirees whose birth years fall in the relevant period. The Health and Retirement Study, Assets and Health Dynamics of the Oldest Old (HRS AHEAD)<sup>19</sup>, has two features that make it ideal for our purposes. First, it includes retirees who were affected by our instrument. Second, it contains data on assets, Social Security benefits, mortality, and bequests. The HRS AHEAD surveyed retirees in 1993, 1995, 1998, and biannually henceforth. We use all available survey waves up to 2012.

Our sample consists of retirees born between 1905-1921. We focus on singles to avoid dealing with joint household decisions.<sup>20</sup> We narrow our sample to whites since non-whites account for a small fraction of our sample and the mortality risks for non-whites are considerably different. Retirees must have non-missing Social Security benefits and assets in 1995.<sup>21</sup> Furthermore, we also make use of the restricted version of the HRS to ensure that we only include retirees who received payouts based on their own earnings instead of spousal earnings.

We construct bequest data from the HRS Exit interviews which include information on

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<sup>17</sup>Following [Pischke \(1995\)](#), we use a “diagonal” weight matrix  $W$  where the diagonal elements are the inverse of the variances of each data moments and the off-diagonal elements are zero. This is because although the inverse of the variance-covariance matrix of the data moments is asymptotically efficient, in practice it can be severely biased in small samples as shown in [Altonji and Segal \(1996\)](#). Therefore, the diagonal weighting matrix is a common weighting matrix used in empirical papers using indirect inference.

<sup>18</sup>This approach is similar to that taken by [De Nardi et al. \(2010\)](#) and [Lockwood \(2016\)](#)

<sup>19</sup>All variables from the AHEAD Core survey are from the RAND version of the HRS data.

<sup>20</sup>This includes never married retirees, as well as divorcees, widows, and widowers. Roughly 80% of our sample consists of widows and widowers.

<sup>21</sup>We use assets in 1995 instead of 1993 because of a well-known under-reporting problem in the asset data from 1993 ([Rohwedder et al., 2006](#)).



how each respondent’s assets were distributed after death (typically by interviewing next-of-kin). We include bequests to spouses, children, siblings, relatives, friends, charities, and others.<sup>22</sup> To maximize sample size, we also impute assets in the year prior to death if bequest amounts are unknown.<sup>23</sup> Assets refer to non-annuitized sources of wealth, including housing, stocks, savings and checking accounts, and bonds. This yields a final sample of 955 respondents.

Aside from data on assets, bequests, and Social Security benefits, we also construct permanent income quartiles. Using the restricted version of the HRS, we are able to base the quartiles on the earnings over the career of retirees. However, since Social Security benefits are subject to the changes from the Notch, quartiles are birth year specific, so that the Notch does *not* affect the computation of the quartiles. Finally, we also use reported death dates to estimate mortality risk.

## 4.2 First Stage Parameters

*Rate of return and discount factor* – Real interest rate for assets is set as  $r = 0.03$  and discount factor is set as  $\beta = 0.97$ . These are commonly assumed values as they fall into the range of parameter values estimated by representative works in the literature (Brown and Finkelstein (2008), Gourinchas and Parker (2002), Cagetti (2003)).

*Mortality rates* – To predict the probability of death given state variables in the model, we run a logistic regression with the log-odds of survival as the dependent. We include quadratic age effects, effects of each income quartile, and the interaction between income quartile and age. We also control for gender and Social Security benefits. The predicted mortality rates fit the data well, as shown in Figure D.3 of the Appendix.

*Non-asset income* – We use the sum of Social Security benefits, pensions, and annuities as our measure of non-asset income. We assume that the non-asset income is exogenous and estimate it by regressing log non-asset income on age and age quadratic, dummies for permanent income quartile, log Social Security benefits, a dummy for gender and the interaction between age and log Social Security benefits. Table D.10 reports the estimated OLS coefficients.

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<sup>22</sup>The survey includes information on either the dollar amount or the percentage of the estate with the total estate amount. We use both types of information.

<sup>23</sup>In practice, the key moments we match with and without the imputed observations do not differ significantly, although standard errors are larger when we use only non-imputed observations. We also include a balance check to see if the respondents with imputed bequests differ in their probability of being affected by the Notch (see Table 2.1).

### 4.3 Second Stage: Indirect Inference

The remaining 22 parameters are estimated via indirect inference. These include two bequest preference parameters ( $\phi$ ,  $c_b$ ), the coefficient of relative risk aversion ( $\sigma$ ), minimum consumption floor ( $\underline{c}$ ), standard deviation of the white noise and autoregressive components of expenditure risk ( $\sigma_\eta$ ,  $\sigma_\epsilon$ ), the first order autoregressive coefficient ( $\rho$ ), and the mean and variance coefficients for expenditure risk (a total of 15 parameters).

Indirect inference is suitable since the OLS and IV estimates from Section 4.3.1 can be included in the set of data moments that we choose to match in a natural way. While the model’s parameters jointly play a role in all of the moments, the following section describes which moments are especially informative of our key model parameters.

#### 4.3.1 Data Moments

In this section, we describe how we use the Notch to generate data moments for estimating our model.

For the Notch to be useful as an instrument, benefits must be sufficiently different across the Windfall and non-Windfall cohorts. Our first stage regresses annual Social Security benefits on an indicator for being born in the Windfall cohort (1911-1916), linear cohort trends, and gender:

$$SSB_i = \alpha_0 + \alpha_1 Wind_i + \alpha_2 Birthyr_i + \alpha_3 Fem_i + v_i^{SSB} \quad (4.12)$$

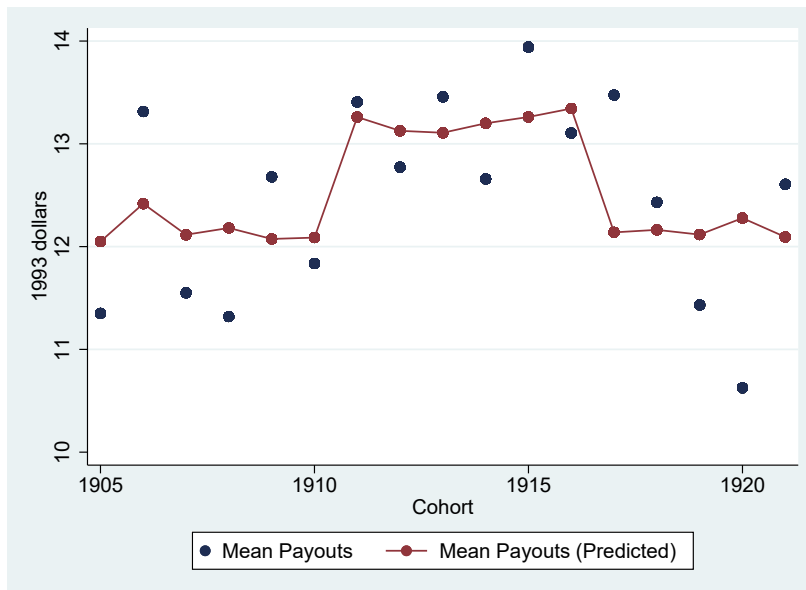
where  $SSB$  refers to Social Security benefits,  $Wind$  refers to an indicator for belonging to the Windfall cohort,  $Birthyr$  refers to birth year, and  $Fem$  refers to a gender dummy. Our first stage regression is represented by the difference in mean Social Security benefits between the Windfall cohort and the non-Windfall cohorts as seen in Figure 4.2.

Our second stage regresses two bequest-related outcomes on predicted benefits:

$$Beq_i = \omega_0^{beq} + \omega_1^{beq} \widehat{SSB}_i + \omega_2^{beq} Birthyr_i + \omega_3^{beq} Fem_i + v_i^{beq} \quad (4.13)$$

The first outcome is bequests (in thousands of 1993 dollars), and the second is an indicator for positive bequests (linear probability model). The regression results are presented in Table 4.2, along with estimates from a corresponding Ordinary Least Squares (OLS) regression for comparison. The results show that a \$1,000 increase in yearly annuity income leads to a \$16,740 increase in bequests and a 5 percentage point increase in the probability of leaving one. As a robustness, we run the same regressions with additional controls including education, an indicator for having children, and being born during World War 1. The

**Figure 4.2:** Annual Social Security Benefits by Birth Year



*Notes:* Sample consists of single, white, male and female retirees in the HRS AHEAD data. Benefits are measured in thousands of 1993 dollars.

estimates are very similar (see Appendix Table A.4). We also use alternate discount rates (3%, 6% and 9%) and present qualitatively similar results in Appendix Table A.3.

Our IV estimates have two main implications. First, they suggest that bequest motives are in fact important since bequests are responsive to a change in benefits. Both bequest amounts and the probability of leaving non-zero bequests increase significantly with an increase in benefits. This result is consistent with papers that have documented higher levels of intergenerational transfers associated with higher Social Security benefits (Moulton, 2014; Mukherjee, 2018). Second, the disparity between the OLS and IV estimates suggest that unobserved heterogeneity that is positively correlated with benefits/income and negatively correlated with bequests are important. A prominent example of such a source of heterogeneity would be medical costs (see De Nardi et al. (2010)). For a further discussion on our regression-based results, see Appendix A.

To see how the instrument helps with the estimation of our model, particularly in recovering  $\phi$  and  $c_b$ , consider a simplified version of our model where  $T = 1$ ,  $r = 0$ , and  $\beta = 1$  with no expenditure risks and no mortality risk. This is a special case of the full model presented above. The only decision is the allocation of resources to consumption and bequests. Equating the marginal utility of consumption and bequests (based on equations (3.1) and

**Table 4.2:** The Effect of Annual Social Security Benefits on Bequests

<b>Panel A: First stage</b>		<b>Social Security benefits (\$1,000)</b>	
Windfall		<b>1.044</b>	
		(0.313)	
Weak identification test (F stat.)		11.919	
<b>Panel B: Second stage</b>		<b>Bequests (\$1,000)</b>	<b>Any bequests<sup>†</sup></b>
Annual Social Security benefits (\$1,000)		<b>16.740</b>	<b>0.051</b>
		(9.553)	(0.029)
<b>Panel C: OLS</b>		<b>Bequests (\$1,000)</b>	<b>Any bequests<sup>†</sup></b>
Annual Social Security benefits (\$1,000)		<b>3.992</b>	<b>0.011</b>
		(0.932)	(0.001)
Observations		955	955

*Notes:* Panels A and B report IV regression results while Panel C reports results from OLS regressions. Sample consists of single, white, male and female retirees in the HRS AHEAD data. Benefits and bequests are measured in thousands of 1993 dollars, and bequests are discounted to 1993 (3% discount rate). Standard errors in parentheses.

<sup>†</sup> “Any bequests” refers to an indicator for leaving positive bequests.

(3.2)), and substituting in the budget constraint (equation 3.3):

$$u'(c) = v'(b)$$

$$(A_1 + SSB - b)^{-\sigma} = \left( c_b + \frac{1 - \phi}{\phi} b \right)^{-\sigma}$$

we obtain:

$$b^* = \max \{ 0, \phi(SSB + A_1 - c_b) \}$$

Note that if  $SSB + A_1 < c_b$ , no bequests are left behind. Therefore,  $c_b$  has a natural interpretation as the minimum consumption needed, under no uncertainty, for non-zero bequests. This implies that for retirees whose initial assets are low, an increase in  $SSB$  means higher consumption but no increase in savings since the entire increase is consumed. However, some of them may “tip over” into leaving some bequests behind. Our IV estimates of the effect of  $SSB$  on the probability of leaving bequests therefore speaks to the magnitude of  $c_b$ .

Further, the altruism parameter  $\phi$  is precisely the effect of wealth or benefits on bequests. Under the assumption that there is no unobserved heterogeneity correlated with benefits/wealth and bequests, and under the naive model with no risks, OLS estimates are indicative of bequest motives. However, since there are many potential unobservables that

threaten the identification of  $\phi$ , our instrument serves as a means to address this. As argued before, this is a qualitatively different approach from the previous literature which relied on observable expenditures.

To distinguish between precautionary savings and bequest motives, we again consider a simple case of our main model. This time we take a two period model  $T = 2$ , again with  $r = 0$  and  $\beta = 1$ . In this version, there is no other expenditure risk aside from the consumption associated with the ‘risk’ of living in the second period. Consider a retiree who is wealthy enough to consume so that:

$$[A_2] : \underbrace{(A_1 + SSB - A_2)^{-\sigma}}_{\text{MU of } c_1} = \underbrace{(1 - \delta)(A_2 + SSB - b)^{-\sigma}}_{\text{MU of } c_2} + \underbrace{\delta \left( \frac{\phi}{1 - \phi} \right)^\sigma \left( \frac{\phi}{1 - \phi} c_b + A_2 \right)^{-\sigma}}_{\text{MU of bequest}}$$

The key observation is that our instrument shifts  $SSB$  in *both* periods, essentially providing additional insurance against mortality risk. If our instrument only shifts  $A_1$  (i.e., a one time wealth shock in period 1), the left hand side (marginal utility of  $c_1$ ) will fall.  $A_2$  will have to increase in response to offset the lower marginal utility of  $c_1$  until the first order condition is satisfied again. That is, retirees who are given a positive one-time wealth shock would save more for precautionary reasons even if there were no bequest motives. Hence the change in savings behavior can be explained by either precautionary savings or bequest motives and the two motives are not distinguishable.

On the other hand, if there were no bequest motives (i.e., marginal utility of bequest is zero) and  $SSB$  was increased in both periods, then  $A_2$  would decline. Since consumption is higher in period 1 than period 2 before the shift in  $SSB$  (given risk averse retirees), then an increase in  $SSB$  across both periods would mean that the marginal utility of  $c_1$  declines to a smaller extent than the decline in the marginal utility of  $c_2$  (holding  $A_2$  fixed). This in turn implies that consumption in period 1 needs to increase (i.e.,  $A_2$  needs to decrease) to fulfill the first order condition after the change in benefits. Therefore, if retirees respond to the increase in benefits by saving more (i.e.,  $A_2$  increases), this must indicate the presence of a bequest motive that overwhelms the incentive to save less for precautionary reasons. The extent to which they save more identifies the strength of the bequest motive. Note that the argument carries through if we extend the number of periods or introduce other expenditure risks, as long as  $SSB$  is received in all states of the world (except death).

Suppose now that our retiree is not wealthy enough to fulfill the first order condition.

Instead,

$$[A_2] : \underbrace{(A_1 + SSB - A_2)^{-\sigma}}_{\text{MU of } c_1} > \underbrace{(1 - \delta)(A_2 + SSB - b)^{-\sigma}}_{\text{MU of } c_2} + \underbrace{\delta \left( \frac{\phi}{1 - \phi} \right)^\sigma \left( \frac{\phi}{1 - \phi} c_b + A_2 \right)^{-\sigma}}_{\text{MU of bequest}}$$

even when  $A_2 = 0$ . Here, the ‘risk’ is mortality risk but we can also incorporate other types of risks such as large medical shocks. Our retiree is unable to insure herself against mortality risk with savings and has to rely on government transfers since her incentive to save (marginal utility of  $c_2$ ) is swamped by the marginal utility of current consumption and she consumes all her assets in period 1. One possibility is that the increase in  $SSB$  is too small to change savings behavior and she still consumes all assets as well as the increase in  $SSB$ . On the other hand, her assets may be sufficiently large such that even though she is unable to fulfill the first order condition before the  $SSB$  increase, she is able to do so if she receives the Windfall. In this case, the increase in savings may reflect not just the bequest motive but also precautionary motives. It would reflect only precautionary motives if  $c_b$  is sufficiently large so that her consumption does not exceed the threshold required for bequests to become important.

Both vignettes serve to illustrate the role of the instrument in improving the precision of estimating bequest motives (i.e., pinning down the role of bequest motives): first, by dealing with unobserved heterogeneity and second, by providing variation in the incentive to save for precautionary reasons.

In addition to the Notch-related moments, we also match median asset profiles by age, permanent income quartile, and birth cohort. We also match asset profiles separately for females.<sup>24</sup> Since the intertemporal elasticity  $\sigma$  governs the speed in which assets are decumulated over the life-cycle, median asset profiles by age are especially informative of this parameter. The variation across income quartiles is informative of  $\underline{c}$ , affecting mainly the lowest quartile.

Note that in our model, unobserved heterogeneity comes in the form of unobserved expenditure risks  $\xi$ .<sup>25</sup> Therefore, in addition to the asset moments by Notch status, we match the OLS estimates of the effect of benefits on bequests since the parameters that govern  $\xi$  are reflected in the wedge between the OLS and IV estimates. In total, 86 moments are matched in the estimation procedure.

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<sup>24</sup>For asset profile moments, we only include cells (age  $\times$  permanent income quartile  $\times$  birth cohort) with observations of 25 or more.

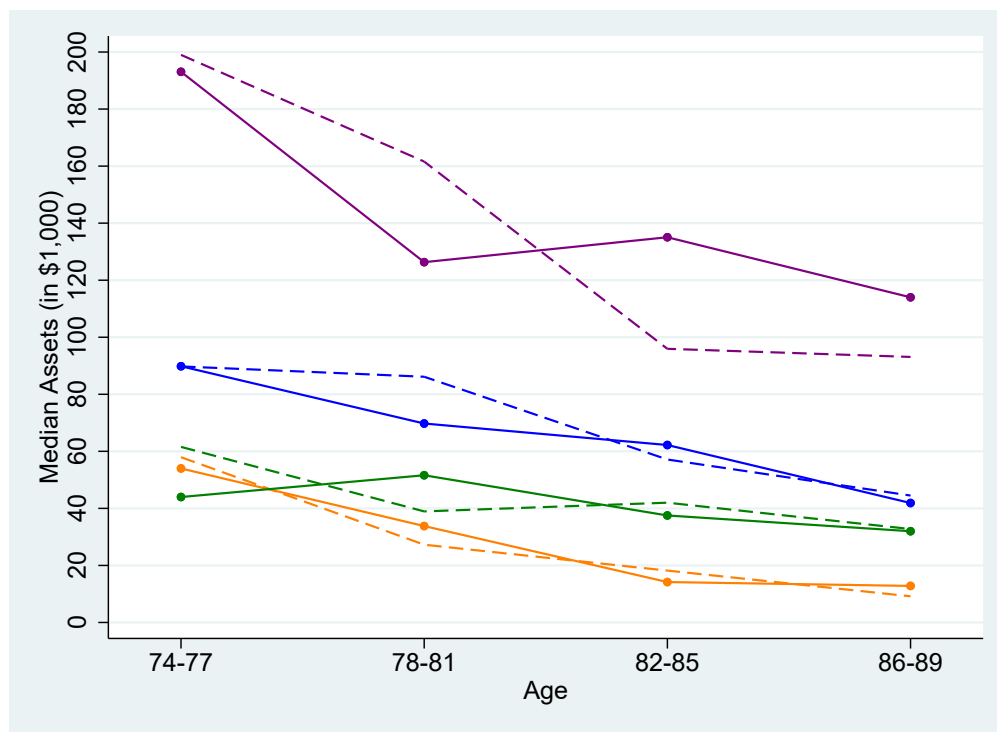
<sup>25</sup>Recall that the mean of these shocks depend on permanent income quartile, gender, Social Security benefits, and age. The variance of these shocks depend on age.

## 5 Results

The estimated parameters are shown in Table 5.3. Our estimates confirm that bequests are a luxury good since  $c_b > 0$ , although the consumption threshold for leaving bequests under no risk is moderate (\$12,738). Further, we find that  $\phi$  is large (note that  $\phi$  is between 0 and 1). These results are consistent with the fact that a significant portion of retirees increased bequests in response to an increase in benefits, and that the pass-through rate was large. If only a small number of wealthy retirees had changed their savings behavior in response, then the consumption threshold  $c_b$  would have been higher. If the pass-through rate had been lower, then  $\phi$  would have been lower.

Our estimated parameters produce a good fit of the summarized asset moments. The data moments for median assets by income quartiles and the simulated moments are shown in Figure 5.3. In Appendix D, we show more detailed model fit for the quartile-by-cohort moments that we target (Figures D.4 and D.5). We also report the IV and OLS moments for the effect of the Notch on bequests in Table 5.4.

**Figure 5.3:** Median Asset Profiles by Income Quartiles



*Notes:* Data moments (dashed lines) and simulated moments (solid lines) by permanent income quartile. Median asset profiles in thousands of 1993 dollars, discounted to 1993 (3% interest rate).

**Table 5.3:** Estimated Model Parameters

Parameter	Estimate	90% CI*
$\sigma$ : relative risk aversion coefficient	3.20	(3.17, 5.84)
$\phi$ : bequest motive	.93	(.84, .95)
$c_b$ : bequests motive (\$)‡	12,738	(11,721, 14,743)
$\underline{c}$ : consumption floor (\$)‡	3,822	(725, 6,675)
Expenditure shocks		
$m_t(Fem, y)$ : mean†		
Income Quartile 1 (bottom)	1.86	(1.83, 1.92)
Income Quartile 2	-1.63	(-1.72, -1.56)
Income Quartile 3	-1.69	(-1.79, -1.34)
Income Quartile 4 (top)	-0.06	(-.12, -.04)
Income Quartile 1 x Female	-.32	(-.39, -.27)
Income Quartile 2 x Female	.29	(.24, .32)
Income Quartile 3 x Female	.12	(.09, .15)
Income Quartile 4 x Female	.39	(.33, .42)
Income Quartile 1 x Age	-.002	(-.004, .02)
Income Quartile 2 x Age	.02	(.02, .06)
Income Quartile 3 x Age	.05	(.04, .08)
Income Quartile 4 x Age	.06	(.05, .06)
log SSB	.41	(.39, .44)
$\sigma_{\xi_t}$ : variance†		
Constant	.64	(.50, .71)
Age	.007	(.004, .01)
$\rho$ : autocorrelation of persistent shock	.86	(.73, .89)
$\sigma_\epsilon$ : variance of innovation to persistent shock	.19	(.02, .28)
$\sigma_\eta$ : variance of white noise	.75	(.65, .83)

\* 90% confidence intervals in parentheses computed by bootstrap. Refer to Appendix C for details on how the confidence intervals were computed.

† The mean and variance function of the expenditure shock is a linear function of age quartic, gender, and income quartile dummies.

‡ Dollar values in 1993 dollars.

$$\text{Utility Functions: } u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}, v(b) = \left(\frac{\phi}{1-\phi}\right)^\sigma \frac{\left(\frac{\phi}{1-\phi}c_b+b\right)^{1-\sigma}}{1-\sigma}$$



**Table 5.4:** Model Fit for IV and OLS Moments

	Bequests (\$1,000)	Any bequests
IV Moments		
Data	16.740 (9.553)	0.051 (0.029)
Model	12.57	0.039
OLS Moments		
Data	3.992 (0.932)	0.011 (0.001)
Model	5.227	0.014

*Notes:* Standard errors in parentheses. “Any bequests” refers to an indicator for leaving positive bequests.

In comparison to the literature, our estimate for  $c_b$  is moderate while our estimate for  $\phi$  is large. Recent estimates range from \$3,500 to \$25,000 and 0.5 to 0.9 respectively. Our estimate for  $\sigma$  is also moderate, with the literature ranging from 2.5 to 5.85, showing that retirees are fairly risk averse.<sup>26</sup>

## 5.1 Bequest Motives and the Notch

We present estimates for two additional versions of our model that demonstrate the role of the Notch and the role of bequest motives in our model. In the first version (labelled “no IV”), we do not match the IV estimates but only the OLS estimates. Our results in Table 5.5 show that without exploiting the instrument, bequest motives are underestimated, with  $\phi = 0.83$ . As such, risk aversion has to compensate to explain high levels of savings and is estimated to be  $\sigma = 6.11$ . Perhaps more importantly, the confidence intervals when estimating without the IV moments increase dramatically, underscoring the importance of the Notch instrument in pinning down bequest motives and risk preferences.

The second version of the model is similar to the baseline, except that  $\phi$  is constrained to be 0. This means that retirees receive no utility from bequests. Our estimates in Table 5.6 show that to compensate for the lack of a bequest motive, risk aversion has to increase dramatically, with  $\sigma = 5.41$ . Our results are in line with Lockwood (2016) who finds that bequest motives are important for explaining annuity choices as well as asset profiles.

<sup>26</sup>See for example, Ameriks et al. (2015a,b, 2011); De Nardi et al. (2010, 2016a); Lockwood (2016).

**Table 5.5:** Comparing Parameter Estimates and Moment Fit - “No IV”

Parameter	$\sigma$	$\phi$	$c_b$	$\underline{c}$
Baseline	3.20 (3.17, 5.84)	.93 (.84, .95)	12,738 (11,721, 14,743)	3,821 (725, 6,674)
No “IV”	6.11 (2.83, 8.13)	.83 (.48, .96)	12,395 (9,993, 28,872)	4,446 (45.33, 8,095)
IV Moment Fit	Bequests (\$1,000)		Any bequests	
Baseline	12.57		0.039	
No “IV”	5.54		0.029	

*Notes:* “No IV” estimates and fit indicate model parameter estimates and moment fit when the model is estimated without matching the IV moments. 90% confidence intervals in parentheses computed via bootstrap. Standard errors in parentheses for the IV data moment. “Any bequests” refers to an indicator for leaving positive bequests.

**Table 5.6:** Comparing Parameter Estimates: No Bequest Motives

Preferences	$\sigma$	$\phi$	$c_b$	$\underline{c}$
Baseline	3.20 (3.17, 5.84)	.93 (.84, .95)	12,738 (11,721, 14,743)	3,821 (725, 6,674)
No bequest motives ( $\phi = 0$ )	5.41 (4.38, 12.19)	-	-	505 (10.76, 6,862)

*Notes:* 90% confidence intervals in parentheses computed via bootstrap.

## 5.2 Decomposing Bequests, Expenditure Risk, and Mortality Risk

We also use our baseline model to decompose bequests and assets. We wish to uncover the proportion of left bequests that are attributable to voluntary bequest motives or accidental bequests arising from precautionary savings. To do this, we simulate our baseline model under the restriction that bequests yield no utility ( $\phi = 0$ ). All savings under this regime stem from precautionary reasons. On top of that, we simulate the model under the *additional* restriction that the variance of expenditure shocks  $\xi_t$  is zero ( $\sigma_\eta^2 = \sigma_\epsilon^2 = 0$ ). Under this regime, savings are precautionary, hedging specifically against mortality risk.

Due to the non-linearities in the model, it is possible that the order of the counterfactuals matter for the decomposition result. We chose this order since we believe that most models of late life savings behavior would begin with some notion of mortality risk, and the question we are trying to address is whether the addition of bequest motives and expenditure risks would be important for explaining asset accumulation.

The bequest distributions under the baseline, the model with no utility from bequests, and the model with neither expenditure risk nor utility from bequests are presented in Figure 5.4. Our counterfactuals show that roughly 35% of bequests ( $1 - \frac{43.50}{67.06}$ ) are voluntary, about \$30,000 per retiree. About 24% ( $\frac{43.50-27.32}{67.06}$ ) can be explained by precautionary savings against expenditure risks. The remainder is due to mortality risk. The proportion of retirees who leave non-zero bequests also declines from 64% to 55% and 45%.

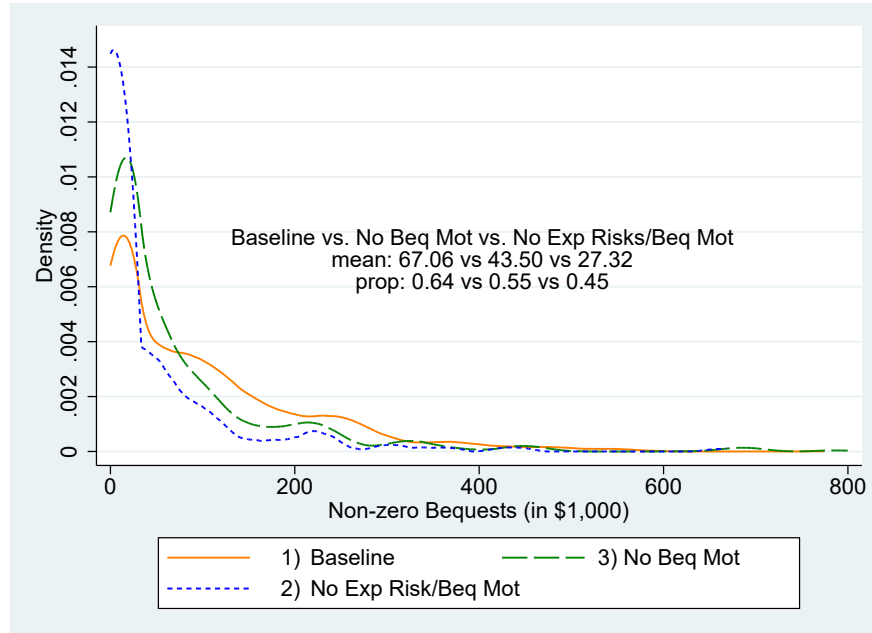
We note that retirees are using savings to insure themselves against risk, which may be an indication that annuity markets are too expensive for most retirees due to adverse selection (Laitner et al., 2018; Lockwood, 2012). The relative strength of bequest motives and precautionary savings can thus shed light on the extent to which Social Security is a useful government intervention to insure retirees against mortality risk.

We also document that bequest motives explains roughly 35% of bequests across most of the non-zero bequest distribution. In Figure 5.5, we plot the mean counterfactual bequest to mean baseline bequest within 4 percent quantiles of baseline bequests under the two counterfactuals described. We find that the gap from the 45 degree line is present across the bequest distribution, implying that bequest motives are important for most retirees.

Another way to see the role of bequest motives is to examine median asset profiles. Under the counterfactual model of no bequest motives, the median asset profiles show an even more dramatic decline for the 2nd and 4th income quartiles as seen in Figure 5.6.

An important caveat in our sample is that it does not include significant numbers of the wealthiest retirees since the HRS is underrepresented at the top of the wealth distribution, for whom the role of voluntary bequests may be different. However, this indicates that even among more moderately wealthy retirees, bequest motives are important.

**Figure 5.4:** Decomposing Bequests - Bequest Motives vs. Precautionary Savings



*Notes:* Densities of bequests under 1) the baseline model and the counterfactual model of 2) no bequest motives and 3) neither bequest motives nor expenditure shocks. Densities are conditional on non-zero bequests. The Epanechnikov kernel is used.

### 5.3 Policy Counterfactual: Benefit Cuts

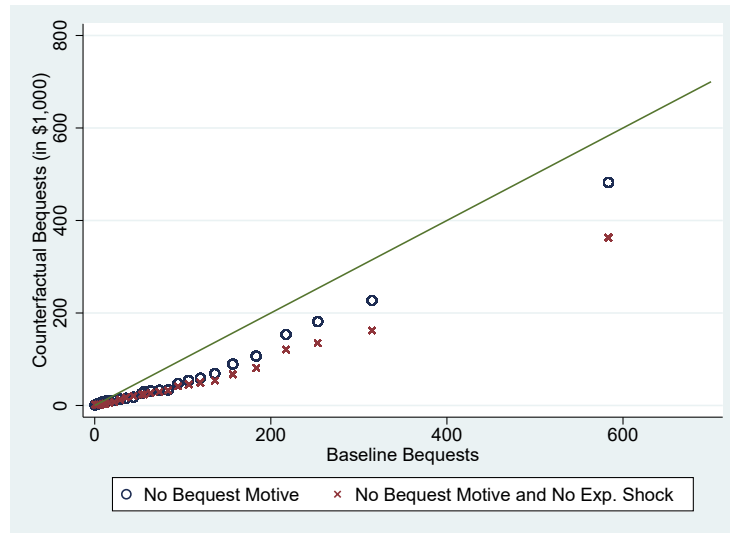
Thus far we have used the estimated model to understand the role of bequest motives in driving the savings behavior of retirees. One advantage of this is to generate counterfactual behavior under different policy environments. A wide variety of policies have been proposed to reduce the anticipated budget deficits that the Social Security program faces. The major proposals include increasing the minimum and full retirement ages, raising the wage caps used to calculate Social Security payroll taxes, and reducing benefits (see for example [114th Congress \(2015\)](#); [Congressional Budget Office \(2014\)](#)). Our model is suitable for exploring the effects of policies that reduce benefits for current retirees.<sup>27</sup>

Instead of replicating particular policies proposed, we summarize potential policies for benefit reduction as a cap on benefits at the 80th percentile of our sample (roughly \$16,000 a year). We argue that most of the policies proposed would likely be progressive in nature.<sup>28</sup>

<sup>27</sup>Changes in retirement age and wage caps for taxes could induce large changes in savings and labor force participation before retirees claim benefits (see [Scholz et al. \(2006\)](#), for example), and our model is silent on those choices.

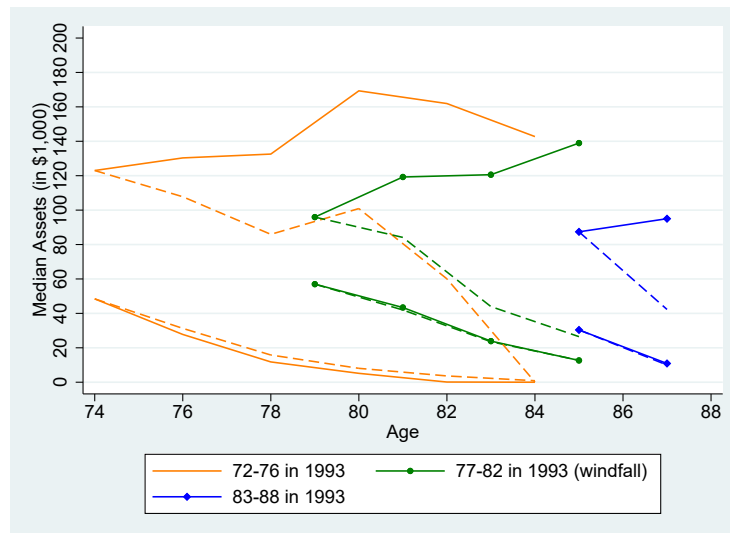
<sup>28</sup>Refer to [Social Security Administration \(2017\)](#) for the SSA’s summary of possible program changes and

**Figure 5.5:** Counterfactual Bequests versus Non-zero Baseline Bequests



*Notes:* Simulated bequests under the two counterfactuals of 1) no bequest motives and 2) neither bequest motives nor expenditure shocks are plotted against non-zero baseline bequests. Each point is the average counterfactual bequest within a 4 percent quantile of baseline bequests.

**Figure 5.6:** Median Asset Profiles Under No Bequest Motives

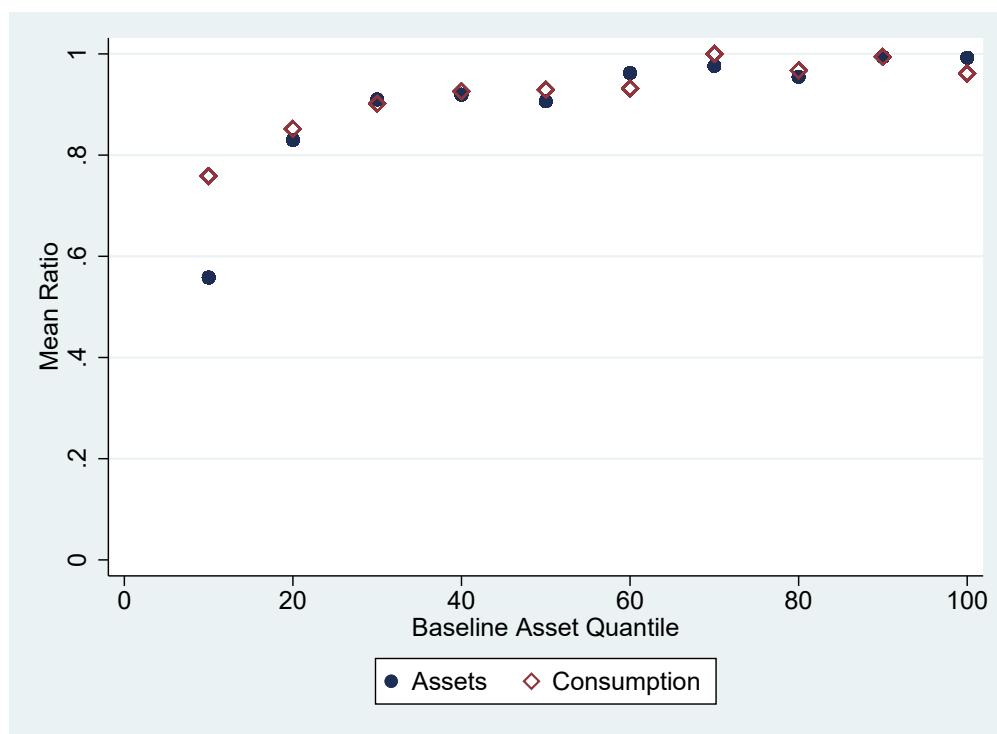


*Notes:* Median asset profiles for the baseline model (solid lines) and the counterfactual model of no bequest motives (dashed lines) by birth cohort and permanent income quartile (second and fourth).

We simulate the savings behavior of retirees from the top quartile of benefits but instead assign them \$16,000 a year in benefits. We plot the ratio of counterfactual consumption over baseline consumption against baseline consumption (see Figure 5.7). A ratio equal to 1 means that consumption did not change in response to the benefit cuts.

We find that retirees in the top benefits quartile respond by reducing savings, while consumption levels virtually do not change. In other words, the loss in welfare comes from a reduction in bequests. Given our estimates that bequests are a luxury good, this is not unexpected. We find that while for the most part, the consumption ratio is very close to 1, a small fraction of retirees ( $\sim 20\%$ ) at the lower end of the consumption distribution are adversely affected by the benefit cuts. These were retirees among the top 20% of benefits who had lower assets and larger negative expenditure shocks. Policy changes in benefits may wish to put in place exemptions for those retirees.

**Figure 5.7:** Consumption and Asset Ratios by Baseline Asset Quantile at Age 84



*Notes:* Consumption and assets of retirees in the top quartile of Social Security benefits. Scatterplot reflects the ratio of counterfactual consumption/assets (under the benefits cap) and baseline consumption/assets by baseline asset quantile. A ratio of 1 indicates no change when benefits are capped.

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their financial impact on the Social Security Trust Funds. Many of these provisions are progressive in nature including changes in PIA computation formula adjusting for inflation, longevity, etc.

Our findings imply that a reduction of benefits for the highest income retirees will not substantially reduce welfare derived from consumption but instead reduces bequests. To the extent that Social Security benefits are meant as an insurance against consumption risk arising from lifespan uncertainty, this may serve as a powerful justification for a more progressive benefit schedule, particularly in light of the solvency issues faced by Social Security.

## 6 Conclusions

Our paper has provided strong evidence for the presence of economically significant bequest motives by exploiting a novel instrument in the form of the Social Security Notch. We combine instrumental variable estimates with a dynamic structural model of post-retirement savings behavior to recover estimates of preference parameters governing bequests and precautionary savings. We show that without our instrument as a source of identification, bequest motives are underestimated and less precise. We use the model to decompose savings into precautionary versus bequest motives and find that bequest motives explain 35% of left bequests, consistent with the evidence from the IV regressions that bequest motives are economically significant.

Finally, we investigate the consequences of a moderate reduction in Social Security benefits in the form of a benefits cap for retirees in the top quartile of benefits. We find that retirees respond by reducing savings (and hence bequests) rather than cutting back on consumption. This suggests that such policies can alleviate the costs faced by Social Security without significantly compromising retiree consumption. It also highlights the nontrivial potential effects of changes to Social Security on bequest beneficiaries, a feature that deserves a closer look when evaluating policies surrounding Social Security benefits.

We acknowledge a number of important caveats. First, our model does not allow for retirees to adjust non-benefit income through earnings or other sources. Second, our model is estimated using a sample of singles born from specific cohorts, and may not apply to non-single retirees.<sup>29</sup> However, our approach can pave the way for future work to address these issues if the model is suitably enriched.

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<sup>29</sup>See [De Nardi et al. \(2021\)](#) for a working paper studying retiree savings for couples.

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# Appendix

## A The Effect of the Notch

In Section 4.3.1, we lay out the instrumental variable based moments that we use for estimating our model of bequest motives. Here, we discuss additional details about the IV moments.

Our results may be threatened if the increase in benefits not only lowered the need for precautionary savings by raising insurance payouts but also affected bequests through other channels. This includes behaviors and outcomes that occur both before and after retirement. We document key historical events in Table A.1 to illustrate the relative ages of our treatment and control cohorts for major events. Note that since our control cohorts include older and younger retirees than our treatment cohorts, the correlation of these historical events with cohorts must specifically benefit only our treatment cohorts to significantly impact our results, which we believe is unlikely. Also, as shown in the table, these major events typically affect either all or none of the cohorts (both treatment and control). In some rare cases such as the Spanish flu pandemic, the Windfall cohort and at least one of the control groups (Notch 1916–1921 or Notch 1905–1911) were affected.

Aside from pre-retirement events, post-retirement events matter as well. One potential post-retirement threat to identification is if the increase in benefits led to shorter lifespan, as documented by [Snyder and Evans \(2006\)](#). In this case, the estimated increase in bequests could be due to higher accidental bequests from earlier deaths rather than a response driven by the bequest motive. We deal with this in two ways. First, the specific issue of longevity is explicitly addressed in our model for post-retirement savings behavior and we account for the possibility that mortality is affected by changes in benefits. Second, we add lifespan as a control and find that our results are robust (see Table A.4 in the Appendix).

We also compile estimated effects of the Notch on various post-retirement outcomes from the literature (see Table D.9 of the Appendix). Most of these outcomes deal with health

**Table A.1:** Historical Events by Cohort

Birth Year	Notch	Windfall						Notch
	1905	1911	1912	1913	1914	1915	1916	1921
Age at...								
1914 - WWI outset	9	3	2	1	0	n.b.	n.b.	n.b.
1917 - America's entry in WWI	12	6	5	4	3	2	1	n.b.
1918 - WWI end	13	7	6	5	4	3	2	n.b.
1919 - Spanish Flu Pandemic*	14	8	7	6	5	4	3	n.b.
1929 - Stock Market Crash	24	18	17	16	15	14	13	8
1941 - Pearl Harbor**	36	30	29	28	27	26	25	20
1945 - End of WWII	40	34	33	32	31	30	29	24
1950 - Korean War begins	45	39	38	37	36	35	34	29
1950 - SSA coverage expands^^								
1953 - Korean War ends***	48	42	41	40	39	38	37	32
1955 - Polio Vaccine^	51	45	44	43	42	41	40	35
1964 - Gulf of Tonkin Resolution	59	53	52	51	50	49	48	43

\* Mortality rates for the Spanish Flu were highest for ages 0-5, relative to 6-10.

\*\* The Selective Service and Training Act of 1940 was expanded in 1941 compelling all men 20-44 to enroll for military service.

^^ The Social Security Act amendments of 1950, 1952, and 1954 expanded occupations covered by Social Security, notably to self-employed, domestic workers, farm workers, and state and local employees.

\*\*\* The Selective Service Act of 1948 included men 18-26; fathers were given waivers until 1953.

^ The height of the polio epidemics, an annual occurrence, was in the summers of 1952 and 1953. When the vaccine was introduced, about a third of affected individuals were adults.

expenditure and can be viewed as mediators rather than threats to our interpretation of our estimated effects, but regardless, we argue that the reported effects are not sizeable enough to account for our estimates. Cohabitation is another outcome that is negatively affected by benefits (Engelhardt et al., 2005), which suggests that the increase in bequest amounts may be due to frictions in housing as an asset. Higher benefits allow the elderly to maintain homes rather than downsizing, leading to higher bequest amounts. However, Engelhardt et al. (2005) find that most of the effect is concentrated among the less educated, whereas our estimates seem to be driven by the wealthier retirees, as we show below in Figure A.1.

## A.1 Marginal Propensity to Save

An alternate regression examines the effect of Social Security *wealth* rather than annual benefits on bequests. This effectively captures the pass-through rate of the windfall – how much of the additional income was left behind rather than consumed. We compute Social Security wealth by summing Social Security benefits from retirement to death, discounted to 1993 (3%). Retirees are responding to changes in their annuitized wealth in the form of Social Security benefits over a horizon of roughly 25 years – the span of time between retirement and death. The estimated pass-through rate can be interpreted as the (local) average marginal propensity to save in the (very) long run.

The results in Table A.2 show that on average, retirees passed roughly 50% of their increase in Social Security wealth through bequests. This finding is in stark contrast to Altonji and Villanueva (2007) who find a pass-through of only 3% in bequests to adult children, similar to our OLS estimates. An important difference is that we consider all bequests, not only to adult children. However, the main implication is that retirees consume considerably less of an extra dollar of wealth than what we would expect based on prior estimates.

To investigate heterogeneity in the pass-through rate by wealth levels, we allow for an

interaction effect between assets at first observation ( $A_i$ ) and Social Security benefits:

$$SSW_i = \alpha_0^{xa} + \alpha_1^{xa} Wind_i + \alpha_2^{xa} Wind_i \times A_i + \alpha_3^{xa} Birthyr_i + \alpha_4^{xa} Fem_i + v_{1,i}^{xa} \quad (\text{A.14})$$

$$SSW_i \times A_i = \beta_0^{xa} + \beta_1^{xa} Wind_i + \beta_2^{xa} Wind_i \times A_i + \beta_3^{xa} Birthyr_i + \beta_4^{xa} Fem_i + v_{2,i}^{xa} \quad (\text{A.15})$$

$$Beq_i = \omega_0^{xa} + \omega_1^{xa} SSW_i + \omega_2^{xa} SSW_i \times A_i + \omega_3^{xa} Birthyr_i + \omega_4^{xa} Fem_i + v_{3,i}^{xa} \quad (\text{A.16})$$

where  $SSW$  refers to Social Security wealth and  $A$  refers to assets.

The total effect of benefits is given by:

$$Total\ Effect_i = \omega_1^{xa} + \omega_2^{xa} \times A_i \quad (\text{A.17})$$

We plot the total effect against asset percentile in Figure A.1.<sup>30</sup> The interaction effect  $\omega_2^{xa}$  is positive, indicating an increasing pass-through rate or marginal propensity to save along the wealth distribution.

This is in line with the hypothesis that bequests are luxury goods: retirees only leave bequests if their consumption levels exceed a certain threshold. The propensity to save for bequests instead of consume is therefore higher if the retiree is already wealthy and consuming at a level where the marginal utility of consumption is considerably lower than the marginal utility of additional bequests. As a result, the wealthiest retirees (roughly the top 3%) allocate all of the increase in benefits to bequests.

In Section 3, we introduce our model of savings behavior and choose a utility function for bequests that can capture these data facts.

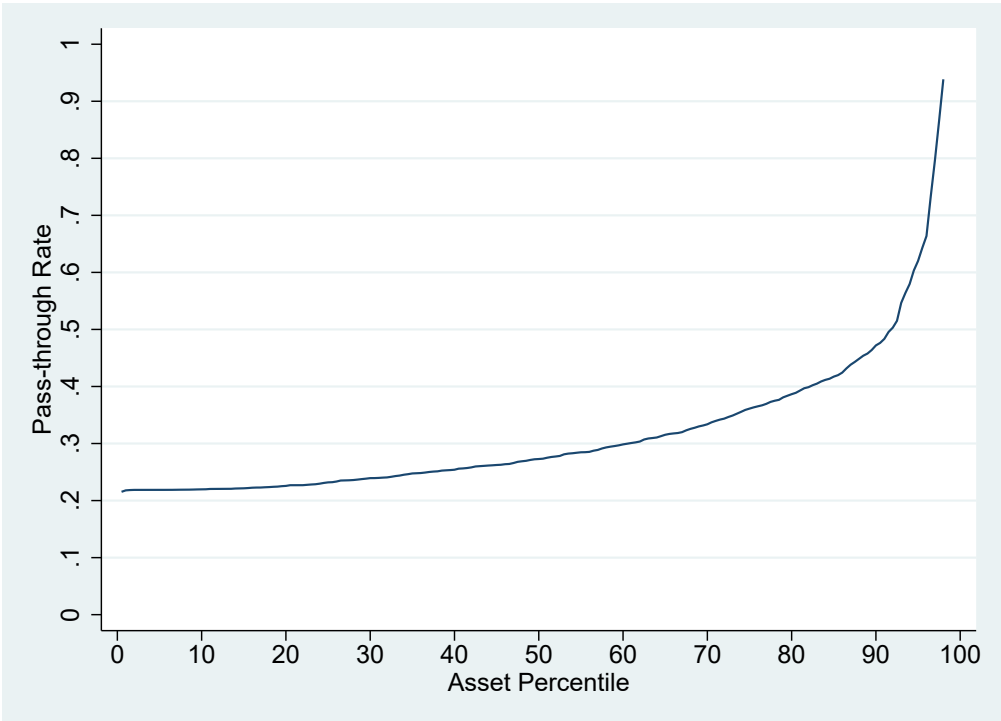
## A.2 Supplemental Regressions

In this section, we show that our instrumental variable estimates are not sensitive to a number of robustness checks. First, we show that the estimates are similar if we choose a

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<sup>30</sup>The estimated coefficients can be found in Table A.6 of the Appendix.

**Figure A.1:** The Effect of Lifetime Social Security Wealth on Bequests by Asset Percentile



*Notes:* Sample consists of single, white, male and female retirees in the HRS AHEAD data. Social Security wealth and bequests are measured in thousands of 1993 dollars. Bequests are discounted to 1993 (3% discount rate). Asset percentiles are calculated based on assets at first observation.



different discount rate for calculating bequests in 1993 dollars (Table A.3).

Tables A.4 and A.5 report results for our other robustness checks. Table A.4 shows that the estimates are qualitatively similar conditional on pre-retirement characteristics, including education, an indicator for having children, and an indicator for being born during World War I (“Full controls”). Next, Panel A of Table A.5 shows that our results are robust to using an alternate definition of the Windfall cohort, namely the 1913-1916 birth cohort instead of the 1911-1916 birth cohort. This is motivated by the fact that the 1913 cohort is the earliest cohort of retirees who were definitely affected by the 1972 amendments. In Panel B of Table A.5, we show results for our placebo tests where the Windfall cohort is defined as 1906-1911 instead of the true Windfall cohort. The estimated coefficient is both small and statistically insignificant and this remains true when we restrict the sample to the 1900-1911 cohorts. Lastly, Panel C of Table A.5 shows that our results are robust to restricting the sample only to retirees born after 1910. This addresses the fact that some of the cohorts in our control group who were born prior to 1911 may have been affected by the treatment and received the Windfall.

Finally, we report the regression results investigating heterogeneity in the bequest response of retirees (see Table A.6). In particular, we show that the interaction between initial observed assets and benefits is statistically significant.

## B Model Details

### B.1 Taxes

We follow the federal income tax schedule for single filers in 1993 to compute  $\tau(A_t, y_t, SSB)$ . First, taxable income  $I_t$  is defined as the sum of asset income ( $rA_t$ ), non-asset income excluding Social Security benefits ( $y_t - SSB$ ), and taxable Social Security benefits, minus the standard deduction (\$6,750). Taxable Social Security benefits are computed according to Table B.7. Based on taxable income  $I_t$ , we compute the amount of federal income tax

**Table A.2:** The Effect of Lifetime Social Security Wealth on Bequests

<b>Panel A: First Stage</b>	<b>Social Security wealth (\$1,000)</b>	
Windfall	<b>27.894</b>	
	(11.815)	
Weak identification test (F stat.)	11.310	
<b>Panel B: Second stage</b>	<b>Bequests (\$1,000)</b>	<b>Any bequests<sup>†</sup></b>
Social Security wealth (\$1,000)	<b>0.493</b>	<b>0.002</b>
	(0.292)	(0.001)
<b>Panel C: OLS</b>	<b>Bequests (\$1,000)</b>	<b>Any bequests (<math>\times 10^{-3}</math>)<sup>†,‡</sup></b>
Social Security wealth (\$1,000)	<b>0.069</b>	0.112
	(0.035)	(0.073)
Observations	955	955

*Notes:* Panels A and B report IV regression results while Panel C reports results from OLS regressions. Sample consists of single, white, male and female retirees in the HRS AHEAD data. Social Security wealth and bequests are measured in thousands of 1993 dollars. Bequests are discounted to 1993 (3% discount rate). Standard errors in parentheses.

<sup>†</sup> “Any bequests” refers to an indicator for leaving positive bequests.

<sup>‡</sup> For simplicity, the OLS estimate and standard error for the effect of Social Security wealth on leaving positive bequests are expressed in  $10^{-3}$ .

**Table A.3:** The Effect of Annual Social Security Benefits by Different Discount Rates

	<b>Bequests (\$1,000)</b>	<b>Any bequests<sup>†</sup></b>
Baseline	<b>16.740</b>	<b>0.051</b>
	(9.553)	(0.029)
3% discount rate	22.019	0.041
	(13.938)	(0.029)
6% discount rate	<b>12.962</b>	<b>0.053</b>
	(7.477)	(0.032)
9% discount rate	<b>10.525</b>	<b>0.053</b>
	(6.401)	(0.032)

*Notes:* This table reports IV regression results based on our sample of the HRS AHEAD data. Sample consists of single, white, male and female retirees. Benefits and bequests are measured in thousands of 1993 dollars. Bequests are discounted to 1993. Standard errors in parentheses.

<sup>†</sup> “Any bequests” refers to an indicator for leaving positive bequests.

$\tau(A_t, y_t, SSB)$  according to Table B.8.

## B.2 Model Solution

In this section we provide further detail on how we solve our model. Since the model does not have an analytical solution, it is solved numerically. We compute the value function and decision rules at each value of the state vector starting from the terminal period  $T$  and work backwards until the starting period  $t_1$ . We set the value of the terminal period for a given state vector  $\Theta_T$  as the value of the bequest utility  $V_T(\Theta_T) = v(b_T)$  since all individuals die with certainty at  $T$  and leave all remaining assets as bequests. This allows us to compute the decision rules for period  $T - 1$  and  $V_{T-1}$ . This process is iterated for period  $T - 1, T - 2, T - 3, \dots, t_1$ . The state vector  $\Theta$  is discretized to finite points and linear interpolation is used to compute state vector values that do not correspond to the discretized grid values that we directly compute.

In order to reduce the dimensionality of our state space, we redefine the problem in terms of cash-on-hand  $x_t$ , where

$$x_t = (1 + r)A_t + y_t - \xi_t - \tau(A_t, y_t, SSB) + g_t$$

This yields the following constraints:

$$A_{t+1} = x_t - c_t \tag{B.18}$$

$$x_{t+1} = (1 + r)(x_t - c_t) + y_{t+1} - \xi_{t+1} - \tau(x_t - c_t, y_{t+1}, SSB) + g_{t+1} \tag{B.19}$$

$$\underline{c} \leq c_t \leq x_t \tag{B.20}$$

Then for each value of the state vector  $\Theta_t = (x_t, \psi_t, PI, Fem, SSB)$ , the value function is

defined as follows:

$$V_t(\Theta_t) = \max_{c_t} \left\{ u(c_t) + \beta \left( \delta_t(PI, Fem, SSB) \cdot E_t[V_{t+1}(\Theta_{t+1})|\Theta_t] + (1 - \delta_t(PI, Fem, SSB)) \cdot v(x_t - c_t) \right) \right\} \quad (\text{B.21})$$

subject to constraints (B.20) and (B.20).

We take expectation over both the persistent and transitory components of unobserved expenditure risk  $\psi_{t+1}$  and  $\eta_{t+1}$  in order to compute the continuation value  $E_t[V_{t+1}(\Theta_{t+1})|\Theta_t]$ . First, we discretize the process for the persistent expenditure risk shock  $\psi_t$  using the Rouwenhorst method (Rouwenhorst, 1995). The transitory process  $\eta_t$  is also discretized using the Gaussian quadrature method. Given  $\Theta_t$  and  $c_t$ , each combination of  $\psi_{t+1}$  and  $\eta_{t+1}$  will give the value of  $x_{t+1}$ . Therefore, summing the next period value  $V_{t+1}(\Theta_{t+1})$  weighed by the realization probability for each grid point  $(\psi_{t+1}, \eta_{t+1})$  yields the expected continuation value  $E_t[V_{t+1}(\Theta_{t+1})|\Theta_t]$ . Linear interpolation is used if  $x_{t+1}$  does not directly correspond to the  $x_t$  grid that we discretized.

## C Bootstrap

Confidence intervals for our estimates are obtained by bootstrap. For each bootstrap replication  $s$ , we construct a bootstrap sample from the true data by sampling with replacement and generate initial state variables, moments ( $M_s$ ) and weights ( $W_s$ ) from this bootstrap sample. The parameter estimates from each bootstrap sample is denoted as  $\hat{\theta}_s$ . We perform 100 bootstrap replications and take the 5th and 95th percentiles of the  $\hat{\theta}_s$  distribution as our 90% confidence intervals.

## D Supplemental Tables and Figures

This section contains additional tables and figures.

**Table A.4:** The Effect of Annual Social Security Benefits (Robustness Checks)

		Bequests (\$1,000)	Any bequests <sup>†</sup>
Additional controls <sup>‡</sup>	coef.	<b>21.677</b>	0.064
	s.e.	(12.149)	(0.041)
	p-value	0.074	0.119
Retirement Year	coef.	14.001	<b>0.075</b>
	s.e.	(9.398)	(0.036)
	p-value	0.136	0.039
Lifespan	coef.	<b>18.595</b>	<b>0.062</b>
	s.e.	(8.454)	(0.028)
	p-value	0.028	0.028

*Notes:* This table reports IV regression results based on our sample of the HRS AHEAD data. Sample consists of single, white, male and female retirees. Benefits and bequests are measured in thousands of 1993 dollars. Bequests are discounted to 1993 (3% discount rate).

<sup>†</sup> “Any bequests” refers to an indicator for leaving positive bequests.

<sup>‡</sup> Additional controls include education, an indicator for having children, and an indicator for being born during World War I.

**Table A.5:** The Effect of Annual Social Security Benefits (Robustness Checks)

		Bequests (\$1,000)	Any bequests
<b>Panel A: Alternative definition of Windfall cohort</b>			
Windfall 1913-1916 <sup>†</sup>	coef.	17.198	0.032
	s.e.	(11.208)	(0.034)
	p-value	0.125	0.353
<b>Panel B: Placebo tests defining “Windfall” as 1906-1911 cohort</b>			
Full Sample	coef.	-7.763	-0.132
	s.e.	(47.016)	(0.262)
	p-value	0.869	0.616
Sample 1900-1911 <sup>‡</sup>	coef.	1.280	-0.032
	s.e.	(18.471)	(0.067)
	p-value	0.945	0.632
<b>Panel C: Sample restrictions</b>			
Sample 1911-1921 <sup>*</sup>	coef.	16.707	<b>0.072</b>
	s.e.	(11.145)	(0.041)
	p-value	0.125	0.078

*Notes:* This table reports IV coefficients from regressing bequest amounts and the probability of leaving any bequests on annual Social Security benefits. Sample consists of single, white, male and female retirees from the HRS AHEAD data. Benefits and bequests are measured in thousands of 1993 dollars. Bequests are discounted to 1993 (3% discount rate).

<sup>†</sup> Defining the Windfall cohort as those born from 1913 to 1916 instead of 1911 to 1916.

<sup>‡</sup> Restricts the estimation sample to the 1900-1911 birth cohort.

<sup>\*</sup> Restricts the estimation sample to respondents born from 1911 to 1921.

**Table A.6:** The Effect of Social Security Payouts Interacted with Assets

Dependent variable: Bequests (\$1,000)			
		“Social Security payouts” defined as:	
		(a)	(b)
		Annual benefits	Lifetime wealth
Social Security payouts	coef.	7.910	0.230
	s.e.	(10.661)	(0.341)
	p-val.	0.458	0.500
Social Security payouts × Assets	coef.	<b>0.023</b>	<b>0.001</b>
	s.e.	(0.003)	(0.000)
	p-val.	0.000	0.000
Observations		821	821

*Notes:* This table reports IV estimates from regressing bequest amounts on Social Security payouts and the interaction of Social Security payouts and assets (as measured at first observation). Sample consists of single, white, male and female retirees in the HRS AHEAD data.. Benefits and bequests are measured in thousands of 1993 dollars. Bequests are discounted to 1993 (3% discount rate).

**Table B.7:** Taxable Social Security Benefits (in \$)

Provisional Income <sup>†</sup>	Taxable Social Security Benefits
(A) Less than \$25,000	None
(B) \$25,000 to \$34,000	Lesser of $0.5SSB$ or 50% of provisional income above \$25,000 (max \$4,500)
(C) Greater than \$34,000	Lesser of $0.85SSB$ or 85% of provisional income above \$34,000 plus the amount from line (B)

*Source:* Table 1 from Congressional Research Service, *Social Security: Taxation of Benefits* (CRS Report RL32552), June 12, 2020.

<sup>†</sup> Provisional income is defined as the sum of asset income, non-asset income excluding Social Security benefits, and 50% of Social Security benefits ( $rA_t + (y_t - SSB) + 0.5SSB$ ).

**Table B.8:** Federal Tax by Taxable Household Income Brackets (in \$)

Taxable Household Income ( $I_t$ )	Federal Income Tax ( $\tau(A_t, y_t, SSB)$ )
0 - 22,100	$0.15 \times I_t$
22,101 - 53,500	$3,315 + 0.28 \times (I_t - 22,100)$
53,501 - 115,000	$12,107 + 0.31 \times (I_t - 53,500)$
115,001 - 250,000	$31,172 + 0.36 \times (I_t - 115,000)$
250,000+	$79,772 + 0.396 \times (I_t - 250,000)$

*Note:* All values are in 1993 dollars.

**Table D.9:** Other Effects of the Notch

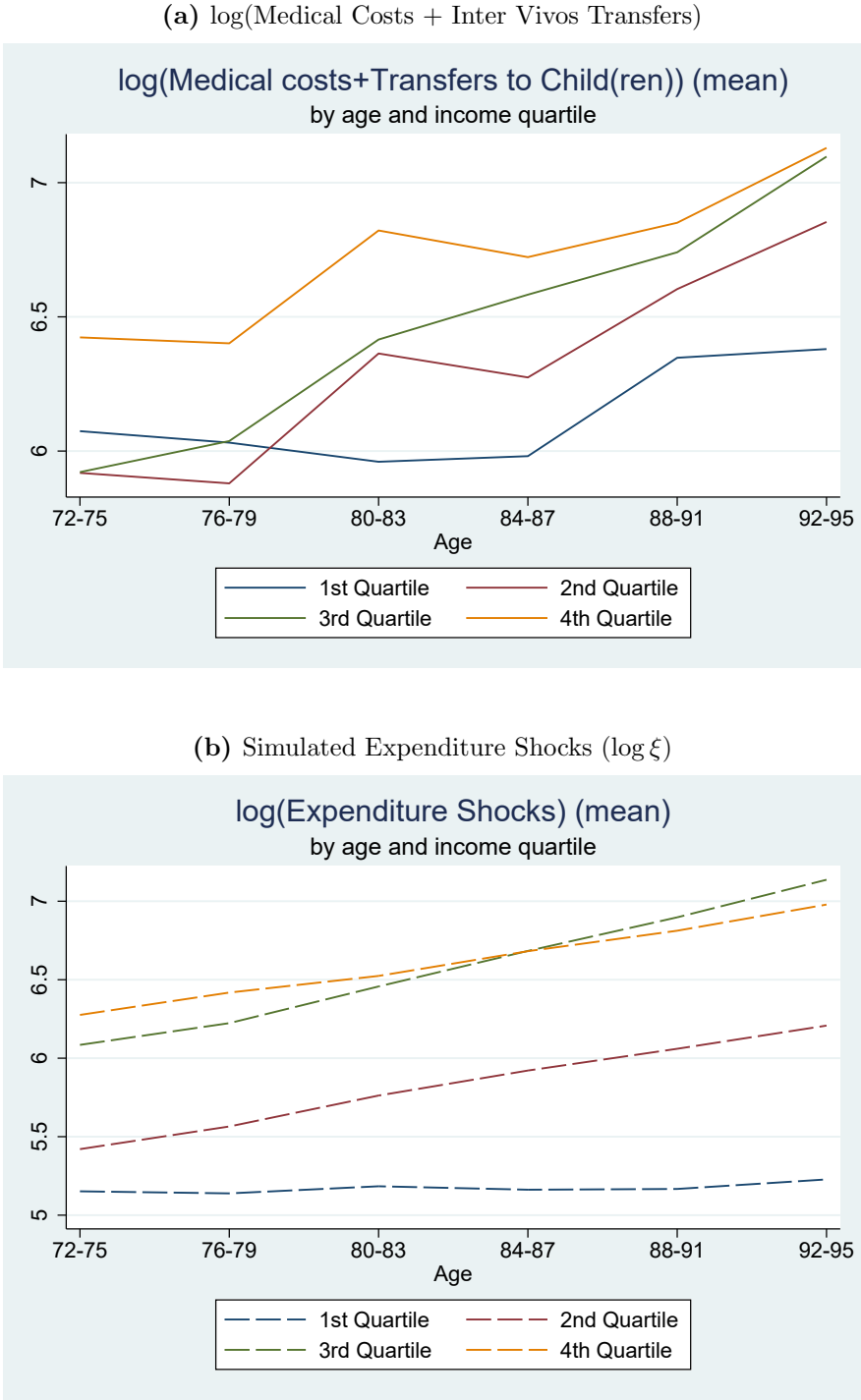
Outcome	Effect	Authors
Labor force participation	-	<a href="#">Krueger and Pischke (1992)</a>
Last year of positive earnings <sup>†</sup>	0.16 years	<a href="#">Gelber et al. (2016)</a>
Out-of-pocket medical expenses (quarterly)	\$83	<a href="#">Tsai (2016)</a>
Number of prescriptions (annual)	0.55	<a href="#">Moran and Simon (2006)</a>
Home care use	3 p.p.	<a href="#">Goda et al. (2011)</a>
Nursing home use	-2 p.p.	<a href="#">Goda et al. (2011)</a>
Mortality	-2%	<a href="#">Snyder and Evans (2006)</a>
Cohabitation	-2 p.p.	<a href="#">Engelhardt et al. (2005)</a>

*Notes:* This table reports statistically significant effects from the Notch literature. Health expenses are estimated to increase with higher benefits, while cohabitation rates decrease. Despite the fact that higher benefits encourage higher health expenditure, they do not seem to be large enough to erode the bequest effects. Also, some of these reported effects are concentrated among the less educated ([Engelhardt et al., 2005](#); [Moran and Simon, 2006](#); [Tsai, 2016](#)) whereas our estimates are concentrated among the wealthy.

<sup>†</sup> While “retirement” is referred as the first year of Social Security benefit receipt in this paper, [Gelber et al. \(2016\)](#) define it as the last calendar year that an individual earned a positive amount.



**Figure D.2:** Observed Post-Retirement Expenditures vs. Simulated Expenditure Shocks



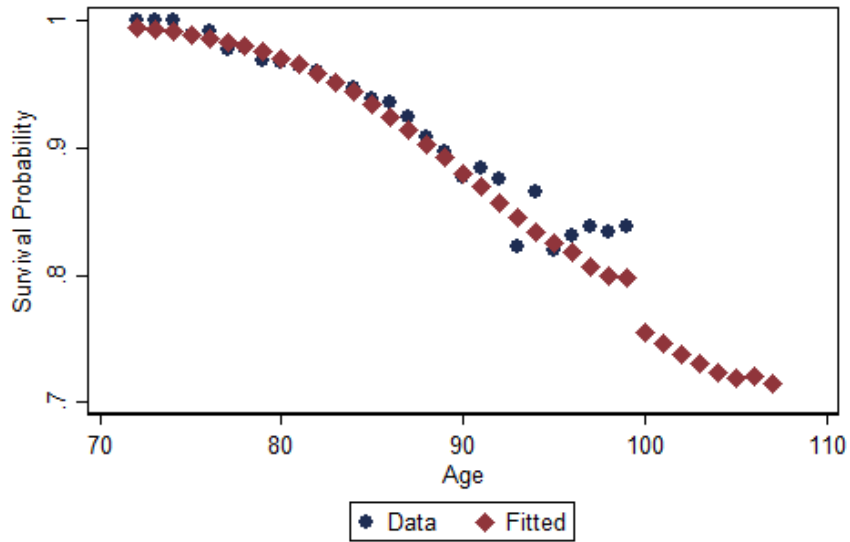
*Notes:* Panel (a) represents the mean of log out-of-pocket expenditures and transfers to adult children by age group and income quartile in our data sample. Panel (b) illustrates the average log expenditure shock ( $\log \xi$ ) by age group and income quartile using our simulated data from the estimated model.

**Table D.10:** Estimates of the Non-Asset Income Function

	Log Non-Asset Income
Age	0.184 (0.084)
Age sq./100	-0.044 (0.029)
Permanent Income Quartile	
Quartile 2	0.0114 (0.052)
Quartile 3	0.101 (0.053)
Quartile 4	0.255 (0.067)
Female	-0.030 (0.050)
log(Social Security benefits)	1.646 (0.644)
Age $\times$ log(Social Security benefits)	-0.015 (0.008)
Observations	3,289

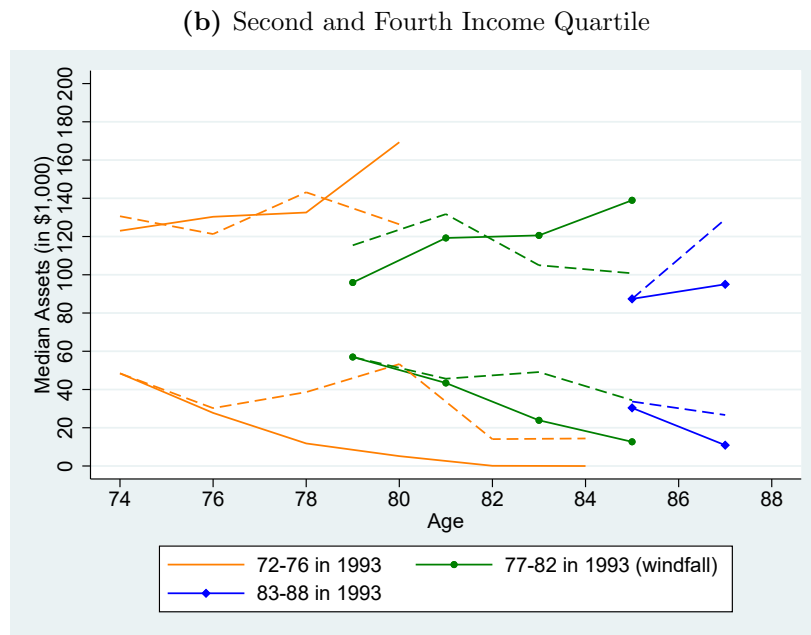
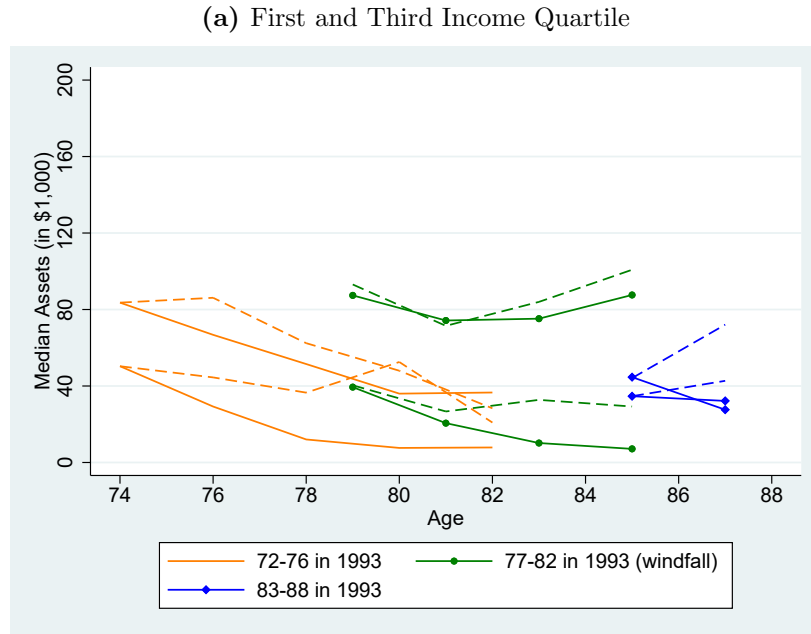
*Notes:* Dependent variable: log non-asset income. Non-asset income is defined as the sum of Social Security benefits, pensions, and annuities. This table reports OLS regression results based on our sample of the HRS AHEAD data. Sample consists of single, white, male and female retirees. All sources of income are measured in 1993 dollars. Standard errors (clustered at the individual level) are in parentheses.

**Figure D.3:** Survival Probabilities by Age



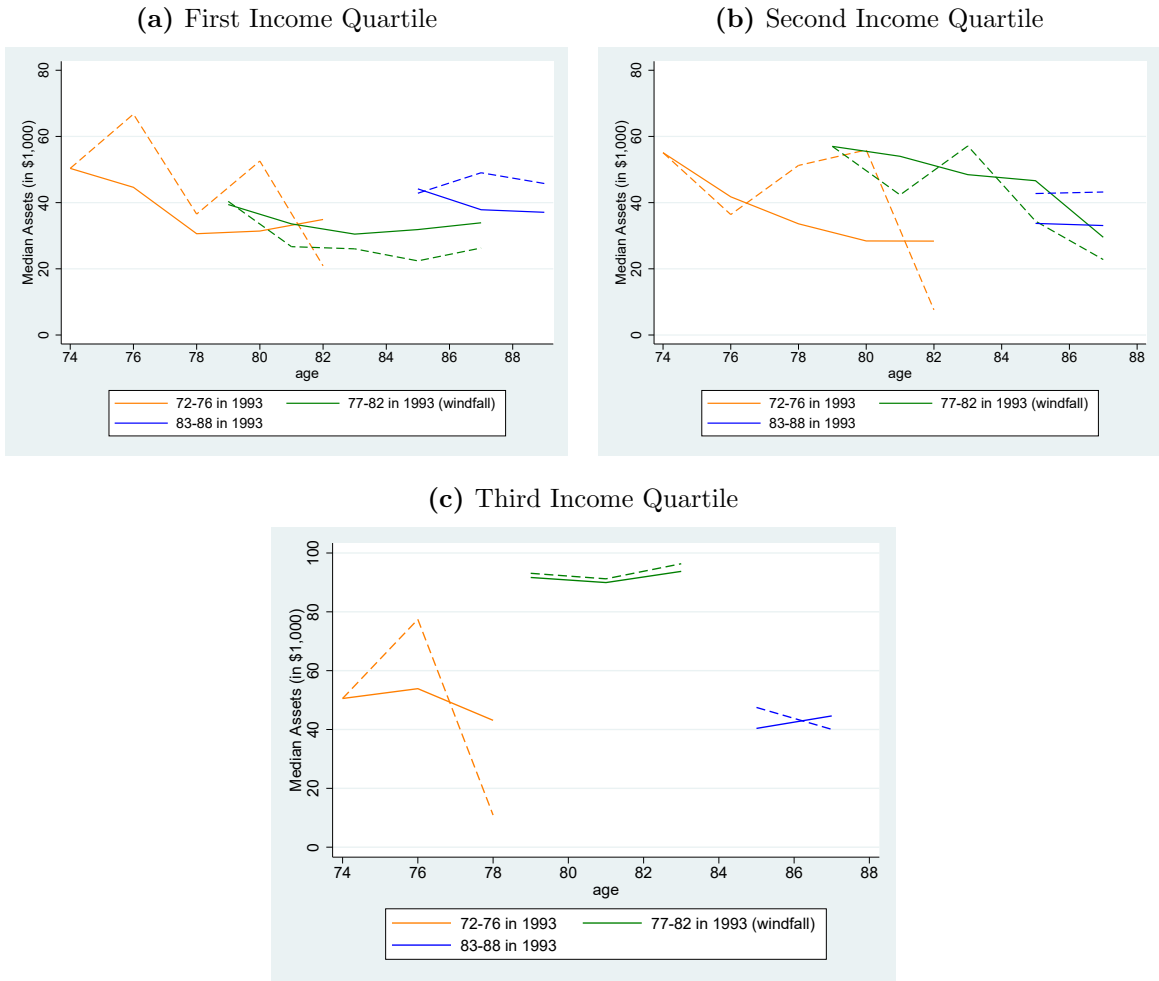
*Notes:* Fitted survival probabilities are based on a logistic regression controlling for quadratic in age, income quartile, interaction of age and income quartile, gender, and Social Security benefits. Sample consists of single, white, male and female retirees in the HRS AHEAD data.

**Figure D.4:** Median Asset Profiles by Birth Cohort and Income Quartiles



*Notes:* Targeted data moments (dashed lines) and simulated moments (solid lines) by birth cohort and permanent income quartiles. Median asset profiles in thousands of 1993 dollars, discounted to 1993 (3% interest rate).

**Figure D.5:** Median Asset Profiles by Birth Cohort and Income Quartiles (Females)



*Notes:* Targeted data moments (dashed lines) and simulated moments (solid lines) by birth cohort and permanent income quartiles for female respondents. The fourth income quartile is not included as moments due to small cell sizes. Median asset profiles in thousands of 1993 dollars, discounted to 1993 (3% interest rate).