Dying to Retire: Adverse Selection and Welfare in Social Security*

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Abstract

Despite facing some of the same challenges as private insurance markets, much less is known about the role of adverse selection in social insurance programs. This paper studies the role of adverse selection in Social Security retirement choices using data from the Health and Retirement Study. We find robust evidence that people who live longer choose larger annuities by delaying the age at which they first claim benefits, a form of adverse selection. To quantify the welfare consequences we develop and estimate a simple model of annuity choice. In the absence of exogenous price variation we exploit variation in longevity, the underlying source of private information, to identify the key structural parameters: the coefficient of relative risk aversion and the discount rate. We estimate adverse selection reduces social welfare by 1.4 - 2.5 percent, and increases the costs to the Social Security Trust Fund by 1.6 - 1.9 percent, relative to the first best allocation. Counterfactual simulations suggest minor program adjustments could generate both economically significant decreases in costs and small increases in social welfare. We estimate an optimal non-linear accrual rate which would result in welfare gains of 0.38 percent, and cost reductions of 3.23 percent of current program costs. These amount to 20 percent of the current shortfall in the Social Security Trust Fund.

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1 Introduction

Social Security retirement benefits account for 17 percent of federal spending in the United States.[1] One function of these benefits is to provide insurance against old-age poverty. The fundamental challenges to efficiently functioning insurance markets are adverse selection and moral hazard. While the consequences of asymmetric information in private insurance markets have been extensively studied, we know relatively little about the role of adverse selection in Social Security (Chetty and Finkelstein, 2012). This paper tests for the presence of adverse selection in Social Security retirement choices, assess its welfare consequences, and finds optimal policies that increase welfare and decrease costs.

Social security programs provide an annuity insuring against mortality risk. Individuals can choose the level of insurance because delayed claiming is equivalent to the purchase of additional social security annuities (Coile, Diamond, Gruber and Jousten, 2002). For individuals with private information about their life expectancy, a higher Social Security annuity may be more attractive to those who are likely to die later. It is also more expensive for the insurer to provide a higher annuity for people who die later; this is a potential source of adverse selection. A socially inefficient timing of Social Security claims, generates both social welfare losses and an additional financial burden on the Social Security Trust Fund, a particularly pertinent issue given the current shortfall in funding.[2]

The negative welfare consequences of adverse selection in insurance markets is a classic result in economic theory. An empirical literature documenting the existence of asymmetric information in a variety of insurance markets has developed.[3] Most recently, important work has been done quantifying the welfare implications of adverse selection in health care (Einav, Finkelstein and Cullen, 2010, and Bundorf, Levin and Mahoney, 2012) and in private annuity markets (Einav, Finkelstein and Schrimpf, 2010) and considering the effects of potential government intervention. There is a large literature on the influence of social security programs on retirement and savings behavior.[4] There has been a lack of empirical work on presence and the welfare consequences of adverse selection, and the resulting implications for the optimal design of Social Security. Using data from the Health and Retirement Study (HRS) this paper identifies the existence of adverse selection in Social Security, quantifies its welfare costs, and provides estimates of the socially optimal accrual rates and benefit levels.

Following the literature on the positive correlation test, we find a strong positive rela-

[1] In fiscal year 2011, the federal government spent \$3.6 trillion of which \$604 billion went to the Old-Age and Survivors Insurance (OASI) program, and \$132 billion to the Disability Insurance (DI) program.

[2] The 2012 Old-Age and Survivors Insurance and Disability Insurance (OASDI) Trustees Report (2012) estimates that the current shortfall is 16 percent of costs.

Hosseini (2010) points out the scope for these welfare loses in a model in which private information influences the purchase of annuities, highlighting the interaction between the private annuity market and Social Security.

[3] Markets that have been studied include automobile insurance, annuities, life insurance, and reverse mortgages (all products that center on mortality risk), long-term care, crop insurance, and health insurance (see Cohen and Siegelman, 2010, for a recent survey).

[4] See Feldstein and Liebman (2002), Gruber and Wise (1999, 2004) and Krueger and Meyer (2002) summarizing the existing evidence.

tionship between actual death ages and the age at which people claim benefits, providing clear evidence of asymmetric information.[5] Our estimates imply people who live one year longer on average claim benefits 1.4 months later and are 2 percentage points less likely to claim benefits at age 62. The HRS is a uniquely rich source of information on the lives of older Americans and contains a large set of covariates that are likely to affect the decision when to claim benefits (health, demographics, wealth and spousal characteristics). Once we include the full set of available observables the relationship remains statistically and economically significant, though the magnitude shrinks by nearly two-thirds. We find that spousal characteristics explain about one-quarter of the positive correlation, with wealth measures and health indicators also contributing to the positive death age-retirement correlation. In general, the positive correlation test can not distinguish between moral hazard and adverse selection, though moral hazard is arguably less important in the context of Social Security than for other forms of insurance. Indeed, evidence suggests that any effects of early retirement on longevity are positive (Insler, 2012), mitigating against finding a positive correlation.

To estimate the welfare consequences we develop and estimate a simple model of annuity choice: a discrete multinomial choice model of when to claim Social Security benefits, allowing for multiple sources of heterogeneity. In the absence of exogenous price variation we use variation in longevity, the underlying source of private information, to identify the key structural parameters: the coefficient of relative risk aversion and the discount rate. Using these estimates we calculate the degree of adverse selection and welfare losses under the current system. We also simulate how welfare and costs change under various counterfactual policies, and devise an optimal set of accrual rates which maximizes social welfare.

There is clear evidence of adverse selection: those who choose to claim benefits early are also those for who it is most expensive to provide those benefits. We estimate that the relative cost of providing benefits at age 62 (relative to age 65) for the median early claimant is \$14,866, while for the median person who retires at age 65 it is \$12,706. Overall, we find that between 8.6 and 10.2 percent of all claimants adversely select their Social Security retirement age benefits, nearly all of whom retire inefficiently early. This adverse selection decreases social welfare by between 1.4 and 2.5 percent (similar to the estimated welfare costs of asymmetric information in other insurance markets).[6]

Adverse selection places an additional burden on the Social Security trust fund since those who adversely claim benefits early are disproportionately expensive to the system. Our results suggest that in a first-best outcome Social Security would save around 1.6 - 1.9 percent of the current costs of the system (and even more at higher interest rates). To put these numbers into context the current projected deficit of the Social Security trust fund is 16 percent of program cost. According to our estimates adverse selection accounts for 10 - 12 percent of the shortfall.

It is worth noting that in a theoretical treatment of adverse selection mandates are a canonical solution to improve social welfare. However, as emphasized by Feldstein

[5] Chiappori and Salanie (2000) formalized the intuition for a basic test showing the existence of asymmetric information: people with higher expected claims buy more insurance.

[6] Cutler and Reber (1998); Einav, Finkelstein and Cullen (2010), Bundorf, Levin and Mahoney (2011); Einav, Finkelstein and Schrimpf (2010).

(2005) and others, are not necessarily welfare improving when individuals differ in their preferences. Instead, they involve a trade-off between reducing the allocative inefficiency produced by adverse selection and increasing allocative inefficiency by eliminating self-selection. We find that social welfare from the option to claim benefits is large for those who choose to exercise that option ($39,613 in the full specification), far larger than the costs to the system. Reducing choice by eliminating the early retirement option would entail large social welfare losses.

We provide estimates on the optimal design of the Social Security system. The social welfare maximizing linear accrual rate implies a benefit penalty of 23.2 percent for claiming benefits at age 62; the actual penalty for the cohorts we analyze is 20 percent. This policy cuts costs by 2.5 percent, but nevertheless increases social welfare by 0.28 percent. A non-linear accrual rates would further increase welfare and reduce costs, implementing such a schedule would decrease the fraction adversely claiming benefits early to 7.2 percent, increase social welfare by 0.38 percent, and reduce costs by 3.23 percent. Using our approach we show that minor program adjustments generate both non-trivial decreases in costs and small increases in social welfare. This is because the adjustment both reduces the degree of adverse selection and because inframarginal early claimants have a high valuation of that choice. The magnitude of the cost reductions is roughly 20 percent of the funding shortfall project for Social Security. More generally our approach may applicable in other settings. Our strategy is feasible in insurance markets where adverse selection is based on observable characteristics of insurance buyers that for various reasons are not used in setting insurance prices.[7] It requires a reliable measure of individual risk, correlated with both willingness-to-pay and costs to the insurer, and enough information to estimate the joint distribution of risk and preferences that affect annuity choice.

We describe a basic theoretical framework for understanding the welfare implications of adverse selection in Social Security in Section 2. In Section 3 we provide background on the Old-Age Social Security program and describe the Health and Retirement Survey. We then discuss the positive correlation for Social Security (identifying a correlation between life expectancy and the age at which individuals claim benefit) and present our results in Section 4. Section 5 we develop an empirical approach for estimating the welfare consequences of adverse selection by estimating a static model of annuity choice presents, present the results from our estimates, and develop the implications of various policy counterfactuals. Section 6 concludes.

2 Theoretical Framework: an Annuity Choice Model

2.1 Model

To study adverse selection in the timing of when individuals claim Social Security benefits we consider a situation where people either claim full benefits B at the full Social Security

[7] See Finkelstein and Poterba (2006) for a discussion of why insurance companies often do not to condition policy prices on all of the observable factors that are related to the insurance buyer's risk type.

retirement age, or decide to claim early on reduced benefits δB, $0 < \delta < 1$.[8] An individual who delays claiming benefits forgoes benefits during the delay period in exchange for an increase in benefit payments for life. The adjustment factor δ determines by how much a person's annual annuity is reduced by claiming early. It is inversely related to the pension accrual rate, the rate at which individuals can accrue additional benefits by retiring later. Further, while there is variability in contributions and benefit levels the relative benefit levels do not vary in the population, i.e. the adjustment factor is invariant to individual characteristics.

We allow for individuals to differ in their privately known forecastable life expectancy θ, as well as additional dimensions of consumer heterogeneity ζ. These include people's wealth, income and benefits, preferences over risk, whether they have a spouse and the characteristics of that spouse, health characteristics, their disutility of labor and any number of other factors that affect the decision to claim old-age social security.[9] We denote the value for an individual of type (θ, ζ) of claiming full benefits as $V_H(\theta, \zeta)$ and claiming benefits early as $V_L(\theta, \zeta)$. We let $\Delta V(\theta, \zeta) = V_L(\theta, \zeta) - V_H(\theta, \zeta)$ denote the incremental willingness-to-pay for claiming benefits early, denominated in dollars.

The expected monetary costs to the social security program of providing benefits depends on people's longevity and the benefit level. We denote these costs as $c_H(\theta, \zeta)$ and $c_L(\theta, \zeta)$, where the cost function is typically a function of a subset of the full vector of individual characteristics ζ, and assume that the difference $\Delta c(\theta, \zeta) = c_L(\theta, \zeta) - c_H(\theta, \zeta)$ is decreasing in θ, so that it is on average more costly to provide full benefits to those who are expected to live long.

An individual of type-(θ, ζ) decides to retire early if

$$\Delta V(\theta, \zeta) \geq 0$$

However, it is straightforward to see that it is socially efficient for an individual of type-(θ, ζ) if and only if

$$\Delta V(\theta, \zeta) - \Delta c(\theta, \zeta) \geq 0,$$

so that net utility outweighs the cost to the social security provider.

2.2 Efficiency in a Model Without Individual Heterogeneity

The standard framework for thinking about insurance, following the seminal work of Akerlof (1970) and Rothschild and Stiglitz (1976), effectively assumes that individuals are identical on all but one dimension θ, so that individuals with a given life expectancy have identical willingness-to-pay. Figure 1 provides a graphical illustration of that case. Individual's life expectancy is on the x-axis and dollars are on the y-axis. Willingness-to-pay for claiming benefits early $\Delta V(\theta)$ and the relative cost of providing benefits to

[8] The ability to choose the age at which to claim Social Security was introduced in 1956 for women and 1961 for men. Legal changes in these years allowed individuals to claim benefits anytime between ages 62 and 65, with an actuarial reduction for claiming before age 65.
We extend our model to allow individuals to claim benefits at ages 62, 63, 64 or 65 in Section 5.

[9] See Coile, Dimaond, Gruber and Jousten (2002) and Shoven and Slavov (2012) for a discussion of the incentives inherent in the decision to claim Social Security.

someone who claims early $\Delta c(\theta)$ are both decreasing in longevity. This is the key feature of an insurance market with adverse selection: individuals who have the highest willingness to pay for full benefits are those who have the highest expected costs. For illustrative purposes the situation we depict in Figure 1 is where the willingness-to-pay for early retirement is decreasing in θ more rapidly than the cost so that it is socially efficient for individuals with a longevity below θ^* to claim early, and with a longevity above θ^* to claim full benefits later. The essence of the adverse selection problem is that Social Security does not charge individuals based on information pertaining to their longevity. However, in the special case where longevity is the only source of heterogeneity determining willingness-to-pay and costs it is possible to achieve an efficient allocation by setting a payment $p^* = c(\theta^*)$ for claiming benefits early, where p^* could be more or less than zero.

People contribute toward Social Security throughout their working lives by paying the FICA tax.[10] When people select their Social Security annuity, by choosing when to claim benefits, there is no fixed fee for claiming early. Thus Social Security sets the price of claiming benefits early equal to zero, $p^{ss} = 0$, which may or may not coincide with p^*. Setting the price of claiming benefits early equal to zero, $p^{ss} = 0$ corresponds to a cut-off θ^{ss}. Individuals with an expected longevity below the cutoff claim benefits early, while those above the cutoff claim benefits later. If $p^* > p^{ss}$ then the current design of the Social Security system induces a socially inefficient number of individuals claiming early (those individuals with $\theta^* < \theta < \theta^{ss}$).

In order to analyze the welfare consequences of the Social Security system it is helpful to define demand and cost functions for claiming benefits early. The aggregate demand for claiming benefits early is given by

$$D(p) = \int 1(\Delta V(\theta) \geq p)\, dG(\theta)$$

where $G(\theta)$ is the distribution of longevity in the population. Charging different prices for claiming benefits early would result in different cut-off longevities, as a function of the willingness-to-pay schedule, which in turns changes the number of individuals claiming benefits early, depending on the distribution of θ in the population. The average (expected) cost to Social Security as a function of the payment p is

$$AC(p) = \frac{1}{D(p)} \int \Delta c(\theta)\, 1(\Delta V(\theta) \geq p)\, dG(\theta) = E[\Delta c(\theta) | \Delta V(\theta) \geq p]$$

Note that the average cost curve is determined by the costs of the sample of individuals who self-select into retiring early. The marginal (expected) cost curve in the market is given by

$$MC(p) = E[\Delta c(\theta) | \Delta V(\theta) = p]$$

The total social surplus derived from the option of claiming benefits early is given by

$$TS = \int (\Delta V(\theta) - \Delta c(\theta))\, 1(\Delta V(\theta) \geq p)\, dG(\theta)$$

[10] The Federal Insurance Contributions Act (FICA) tax is currently 6.2 percent of Social Security taxable income (all earned income below the Social Security earnings cap).

The key feature of adverse selection is that the individuals who have the highest willingness-to-pay are those who, on average, have the highest expected costs. In Figure 2 the relative price (or cost) of claiming benefits early is on the x-axis, and the share of individuals claiming benefits early is on the y-axis. Adverse selection is represented in the figures by drawing a downward sloping marginal cost (MC) curve. As the price falls, the marginal individuals who select to claim early have lower expected cost than infra-marginal individuals, leading to lower average costs. The socially efficient outcome could be achieved by pricing at p^*, where the marginal cost curve intersects the demand curve. This results in the socially efficient fraction of the population $Q^* = G(\theta^*)$, for whom $\Delta V(\theta) \geq \Delta c(\theta)$, to claim benefits early.

A price p^{ss} induces $Q^{ss} = G(\theta^{ss})$ number of early claimants. The case illustrated in Figure 2 is for $p^* < 0$ and thus a number of people with longevity between θ^* and θ^{ss} inefficiently do not claim benefits early, i.e. we have too little early retirement. The welfare loss due to inefficient pricing is the area between demand and marginal cost curves for those who suboptimally do not claim benefits early, which is represented by the shaded area in Figure 2.

2.3 Efficiency in a Model With Individual Heterogeneity

Cutler, Finkelstein and McGarry (2008) and Bundorf, Levin and Mahoney (2011) stress that a broad view of heterogeneity in preferences is important for understanding many aspects of insurance markets. If we extend the framework to allow individuals to vary both in longevity (θ) and on other dimensions that affect demand and costs ζ then there will, in general, both be people who inefficiently claim early and who inefficiently claim full benefits. Efficiency requires that all individuals with a willingness-to-pay above costs claim benefits early, and those with a willingness-to-pay below costs claim full benefits. In this case only if payments can vary with both θ and ζ such that $p(\theta, \zeta) = \Delta c(\theta, \zeta)$ will individuals self-select efficiently. With a uniform price self-selection of individuals will in general be inefficient.

This situation is depicted in Figure 3. The shaded area depicts the distribution of willingness-to-pay for individuals $\Delta V(\theta, \zeta)$. For any θ there exists a distribution of willingness-to-pay, $\Delta\tilde{V}(\zeta|\theta = \theta_0)$, the shape of which depends on the joint distribution of (θ, ζ). For simplicity of exposition in this figure (though not in our empirics) we assume that costs are solely a function of longevity, $\Delta c(\theta)$. The current system sets the price (uniformly) at zero. As depicted this means some individuals will choose to claim benefits early because their willingness-to-pay is greater than zero, but from society's perspective that is inefficient since their benefit is lower than the cost to Social Security.

Formally, an individual of type-(θ, ζ) claims benefits inefficiently early if

$$\Delta c(\theta, \zeta) \geq \Delta V(\theta, \zeta) \geq 0$$

Similarly, there will be those who claim full benefits even though the relative cost of is higher than their willingness-to-pay. An individual of type-(θ, ζ) claims benefits inefficiently late if

$$\Delta c(\theta, \zeta) \leq \Delta V(\theta, \zeta) \leq 0$$

The total welfare losses associated with both types of inefficiencies is given by

$$\begin{aligned} WL &= \int (\Delta V(\theta,\zeta) - \Delta c(\theta,\zeta))[1(\Delta c(\theta,\zeta) \geq \Delta V(\theta,\zeta) \geq 0) \\ &\quad + 1(\Delta c(\theta,\zeta) \leq \Delta V(\theta,\zeta) \leq 0)] dF(\theta,\zeta) \end{aligned}$$

where $F(\theta,\zeta)$ is the distribution of types-(θ,ζ) in the population. The degree of inefficiency depends on the distribution of individual characteristics, and the cost structure of the Social Security system. The empirical challenge is to estimate $\Delta V(\theta,\zeta)$ and $\Delta c(\theta,\zeta)$ for all types of individuals, determine the number of individuals who retire inefficiently and calculate the associated welfare losses.

In addition to the welfare losses generated by inefficient early and late social security retirement these inefficient choices also generate an additional financial burden on the Social Security trust fund. For those who retire inefficiently early the relative cost to the program of early retirement are positive, $\Delta c(\theta,\zeta) \geq 0$. It would be both social welfare increasing and less costly if they were to claim benefits at the normal retirement age. Similarly, for those who retire inefficiently late the relative cost to the system of early retirement are negative, $\Delta c(\theta,\zeta) \leq 0$, i.e. for those individuals it would be both social welfare increasing and less costly if they were to claim benefits early.

With individuals who differ on multiple dimensions self-selection in when to claim benefits can result in adverse selection for some individuals, and advantageous selection for others. The more standard case of adverse selection, discussed above, is more likely to arise since those with a lower life expectancy are likely to have both a higher willingness-to-pay and higher relative costs of claiming benefits early. Advantageous selection arises when costs are higher for the marginal individual than the infra-marginal individuals, i.e. cost curves are upward sloping. This situation may arise when life expectancy is negatively correlated with other factors that affect the willingness-to-pay for claiming benefits early, such as the disutility of labor or wealth. If, for example, people with a high life expectancy are also wealthier, which increases their marginal utility of leisure (assuming leisure is a normal good) and induces them to retire and claim benefits early, then demand for claiming benefits early and the costs may be negatively correlated.

2.4 Optimal Design of Social Security

Even with knowledge of $\Delta V(\theta,\zeta)$ and $\Delta c(\theta,\zeta)$ the optimal design of the Social Security system is challenging. A number of papers consider the effect of optimal uniform pricing in insurance markets (as opposed to competitive pricing), in models with a single source of individual heterogeneity. Bundorf, Levin and Mahoney (2012) consider the effect of risk-rated prices estimating the potential welfare gains associated with individualized pricing using only observable information on risk (since their model, like ours, allows for multiple sources of individual heterogeneity risk-rated pricing can not entirely eliminate welfare losses due to selection). Einav, Finkelstein and Schrimpf (2010) consider the consequences of government mandates that each individual purchases the same guarantee length, eliminating any contract choice; such mandates are the canonical solution to adverse selection in insurance markets (Akerlof, 1970).

In practice it is unlikely that Social Security would consider implementing uniform price for claiming benefits early (i.e. a lump-sum transfer on retiring early), much less optimal risk-related price based on a person's longevity. One reason prices are unlikely to be introduced is that Social Security functions as a forced savings program (Feldstein and Liebman, 2002). Policymakers are, however, willing to consider changes to the types of annuity contracts available to individuals. Specifically, two key issues in the design of Social Security are (i) the adjustment factor δ, the penalties reducing benefits for having retired before the normal retirement age, and (ii) the level of benefits B.

The problem of how to optimally design annuity contracts in the presence of adverse selection presents particular challenges. Analyzing the effect of price changes is simplified by the fact that it is reasonable to assume that both the willingness-to-pay (demand) function and the cost (supply) function are unaffected (provided that we can assume that income effects are small). In contrast, changing the adjustment factor will result in shifts of both $\Delta V(\theta,\zeta)$ and $\Delta c(\theta,\zeta)$ for all types-(θ,ζ). A lower adjustment factor, i.e. a higher penalty for claiming early, will in general both decrease the willingness-to-pay for early Social Security retirement and decrease the relative cost of providing benefits early. An adjustment factor that is too high will result in people claiming benefits inefficiently late, while an adjustment factor that is too low will induce people to claim benefits inefficiently early. The optimal choice of adjustment factor is found by maximizing the total social surplus derived from the option of claiming benefits early, and is given by

$$\delta^* = \arg\max \int \left(\Delta V(\theta,\zeta;\delta) - \Delta c(\theta,\zeta;\delta)\right) 1\left(\Delta V(\theta,\zeta;\delta) \geq 0\right) dG(\theta,\zeta)$$

which minimizes the welfare losses due to adverse selection.

3 Data

3.1 Background on Social Security Retirement Benefits[11]

An individual's Old-Age Social Security benefits depend on the average indexed monthly earnings (AIME), the pension coefficient and the age at which the individual retires. In order to be eligible for benefits a person has to have worked a minimum number of years. If you were born in 1929 or later, you need 40 credits (10 years of work). People born before 1929 need fewer than 40 credits (39 credits if born in 1928; 38 credits if born in 1927; etc.).[12]

The earliest age at which (reduced) benefits are payable is 62. Full retirement benefits depend on a retiree's year of birth. The normal retirement age for those born 1937 and

[11] The Social Security Administration documents all features of the system on it's website: www.socialsecurity.gov.

[12] The AIME is constructed by averaging an individual's 35 highest earning years (up to the social security earnings cap) adjusted by the national average wage index. The pension coefficient is a piecewise linear function, the primary insurance amount (PIA) is 90 percent of the AIME up to the first (low) bend point, and 32 percent of the excess of AIME over the first bend point but not in excess of the second (high) bend point, plus 15 percent of the AIME in excess of the second bend point. This PIA is then adjusted by automatic cost-of-living adjustments (COLA) annually starting with the year the worker turns 62.

prior is 65, which covers nearly everyone in our sample. The normal retirement age increases by two months for each ensuing year of birth until 1943, when it reaches 66 and stays at 66 until 1955. Thereafter the normal retirement age increases again by two months for each year until 1960, when normal retirement age is 67 and remains 67 for all individuals born thereafter. A worker who starts benefits before normal retirement age has their benefit reduced based on the number of months before normal retirement age they start benefits. This reduction is 5/9 percentage points for each month up to 36 and then 5/12 percentage points for each additional month. This formula gives an 80% benefit at age 62 for a worker with a normal retirement age of 65, a 75 percent benefit at age 62 for a worker with a normal retirement age of 66, and a 70 percent benefit at age 62 for a worker with a normal retirement age of 67. People can also choose to defer claiming Social Security beyond their full retirement age. For every year that benefits are deferred beyond the normal retirement age, benefits are increased, up until age 70, where the amount of the bonus is dependent on the person's birth date, ranging from 3 percent per year for birth cohorts 1917-24 to 8 percent per year for those born 1943 and later.

People can continue working while claiming benefits, however, their earnings are reduced. Currently, earnings reduce the benefit amount only until the person reaches the full retirement age, and after reaching the full retirement age the Social Security Administration recalculates the benefits. Before 2000 beneficiaries' earnings continued to face a deduction from the ages of 65-69. The Social Security Administration deducts $1 from the benefit payments for every $2 earned above the annual limit (the limit is higher and the deductions lower in the calendar year in which you reach the full retirement age). Pre-2000 the annual limit on earnings age 65-69 was higher than for those under 65, for example, in 1999 the annual limit for those under 65 was $9,600 and for those 65-69 it was $15,500.[13]

Social Security (Old-age, Survivors, and Disability Insurance) is primarily funded through a dedicated payroll tax. According to *The 2012 Old-Age and Survivors Insurance and Disability Insurance (OASDI) Trustees Report* under current projections, the annual cost of Social Security benefits expressed as a share of workers' taxable earnings will grow rapidly from 11.3 percent in 2007, the last pre-recession year, to roughly 17.4 percent in 2035, and will then decline slightly before slowly increasing after 2050. Costs display a slightly different pattern when expressed as a share of GDP. Program costs equaled 4.2 percent of GDP in 2007, and the Trustees project these costs will increase gradually to 6.4 percent of GDP in 2035 before declining to about 6.1 percent of GDP by 2050 and then remaining at about that level. The projected 75-year actuarial deficit for the combined OASDI Trust Funds is 2.67 percent of taxable payroll. This deficit amounts to 20 percent of program non-interest income or 16 percent of program cost.[14]

[13]In practice, there is a strong positive correlation between the decision to stop working and claim social security benefits. For the birth cohorts we use for this paper (1916-40) only 27 percent stop working before claiming benefits, and only 25 percent continue working full-time after claiming benefits.

[14]The 2012 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds.

3.2 Health and Retirement Survey

The University of Michigan Health and Retirement Study (HRS) is a longitudinal panel study that surveys a representative sample of more than 26,000 Americans 51 years and older, with surveys conducted over the period 1992 to 2010.[15] The survey is representative of the cross-section of older Americans at any given point in time, but is not representative of the longitudinal experience of any one particular cohort. The HRS typically learns of the death of a respondent when an interviewer attempts to reach the respondent for an interview during the main data collection period. The respondent's spouse or another close family member or friend is asked to provide a final interview on behalf of the respondent (the exit interview), the response rate has ranged between 84% and 92%.

The data provides detailed information in a number of domains relevant to the retirement decision: health, demographics, wealth and spousal characteristics. The available health information relates to the top four causes of death among those aged 65 and above: heart disease, cancer, chronic lower respiratory disease, and stroke, as well as diabetes, accounted for 68.4 percent of deaths in 2008.[16] The other main causes of death are Alzheimer's disease, influenza and pneumonia, unintentional injuries, and Nephritis, which are not causes of death that people are likely to anticipate when making their Social Security retirement decision. The demographic information includes years of schooling, whether the person has been or is married, whether they belong to an ethnic minority (Black or Hispanic) and year of birth. There are numerous indicators of a person's wealth, including: their social security benefit level, the capital income of the household, their total wealth (including housing), and income from employer provided pensions. We also use information from the HRS on the spouses Social Security benefits, their years of education and spousal death age (if the spouse died before the primary respondent).

Our empirical strategy, outlined below, requires that we observe both the age at which an individual chooses to retire and their age at death. We also exclude those individuals who at some point claim disability benefits, since it is likely that for many of those individual's retirement decisions are driven by other considerations than we capture in our model. Our final sample includes 1055 men and 630 women. Table 1 provides descriptive statistics for our sample. Around 50 percent of the sample claim benefits at the age of first eligibility (age 62) and only about 11 percent retire after the normal social security retirement age of 65. The average death age in our sample is 73.5 years, the maximum observed death age is 89 and the minimum, by construction, age 63. The average years of schooling is 11.7, and minorities (Black and Hispanic) are overrepresented in the HRS (15.5 percent of the sample).[17]

[15] The current version of the HRS was created in 1998 when the original HRS, which surveyed people born 1931-41, was merged with the Asset and Health Dynamics Among the Oldest Old (AHEAD), for cohorts born before 1924, study, as well as with two new cohorts: the Children of the Depression Era (CODA), born in 1924-30 and War Babies (WB), born in 1942-47.

[16] Heron (2008)

[17] Correcting for the sampling methodology has no impact on the correlation test below. Since we do not use weights in the structural estimation we present unweighted results in this paper.

4 Empirical Strategy I: the Positive Correlation Test

4.1 The Positive Correlation Test

The standard test for asymmetric information in an insurance market is to determine whether people with higher expected claims buy more insurance. This basic prediction of asymmetric information models of a "positive correlation" between the risk profile of an individual and the amount of insurance the individual purchases has been shown to be robust to a variety of extensions to the basic framework (Chiappori and Salanie, 2000; Chiappori, Jullien, Salanie and Salanie, 2006). There is an extensive empirical literature on adverse selection in insurance markets (Cohen and Siegelman, 2010; and Einav and Finkelstein, 2011); which argues that the magnitude and even sign of the correlation between preferences for insurance and expected claims is not the same across markets. Though in the private annuity markets that have been studied there is clear evidence of adverse selection: people who live longer are more likely to buy insurance (see also Cutler, Finkelstein and McGarry, 2008).

In the case of Social Security a natural way to test this correlation is to estimate the following regression

$$y^*_{ia} = \theta_i \mu_1 + B_i \mu_2 + X_i \mu_x + \varepsilon_{ia} \tag{1}$$

where y^*_{ia} is the unobserved latent utility for claiming benefits at age a for individual i, θ_i is a measure of life expectancy, B_i is the benefits an individual receives were they to claim at age 65, X_i is a set of additional control variables, and ε_{ia} is distributed standard normal. If the correlation is positive, $\mu_1 > 0$, that is evidence of adverse selection (or moral hazard), if it is negative, $\mu_1 < 0$, that is evidence of advantageous selection.

To implement the positive correlation test we require a good measure of people's life expectancy. Given the data available, we use their actual death age as a proxy for their expected death age. Actual death age is what matters for calculating the costs to the social security system, by assuming it is also people's expected death age we are able to use the same variable for calculating costs and estimating people's willingness to pay, tying our empirics to the theory outlined in Section 2.[18] This assumption is in line with the existing practice in the literature on annuity choices, see Finkelstein and Poterba (2004), Einav, Finkelstein and Schrimpf (2010) and Mitchell, Poterba, Warshawsky, and Brown (1999); and consistent with work by Hurd and McGarry (2002) who use the HRS

[18] The alternative would be to use a subjective probability measure. The HRS asks individuals about their subjective probability that they will live to age 75. Hurd, Smith and Zissimopoulos (2004) find that those with very low subjective probabilities of survival retire earlier and claim earlier than those with higher subjective probabilities, but the effects are not large. Our estimates suggest that those who expect to live past age 75 claim benefits 0.2 years (significant at the 5 percent significance level) earlier than those who do not. The problem with this measure for our purposes is that it is unclear how this subjective measure relates to the costs to the Social Security. The available measure does not provide information on how long people expect to live, simply what probability they assign to living to age 75. We would then have to then specify a model how this subjective probability relates to their actual death age, which is the variable that is relevant for assessing the costs of the system. Moreover, a large fraction of individuals, 16 percent in our sample, respond that their subjective probability of living to age 75 is 100 percent or zero percent, suggesting it is at best a crude measure of life expectancy.

to establish that subjective survival probabilities predict actual survival.

The correlation test asks whether an individual's mortality risk, as measured by actual longevity, is correlated with their annuity choice. In a decision model it is expectations that determine annuity choices. Even if actual death ages are an unbiased estimate of expected death ages we still have the problem that for any individual we would be measuring life expectancy with some measurement error. If that measurement error is uncorrelated with true life expectancy, conditional on the inclusion of covariates, then our estimates of μ_1 would be attenuated, and we would be estimating a lower bound on the degree of adverse selection. A number of factors may induce a correlation between life expectancy and the measurement error. For example, smokers live less long than non-smokers, and if they also consistently overestimated the mortality risk of smoking that would induce a correlation between the life expectancy and measurement error (Khwaja, Silverman, Sloan and Wang, 2009). Once we include a large number of covariates, such as smoking, education, occupation and permanent income, the case that measurement error is correlated with the remaining variation in life expectancy is less compelling, and we are likely finding a lower bound on μ_1.

In general, the positive correlation test cannot distinguish between adverse selection and moral hazard. Adverse selection induces the positive correlation because of *ex ante* selection on mortality risk, while moral hazard results in a positive correlation from *ex post* changes in behavior (Chiappori and Salanie, 2000). The distinction is not important when considering the welfare consequence of asymmetric information, but these two very different forms of asymmetric information typically have different implications for public policy. In the context of Social Security moral hazard would arise if people who claim benefits at the normal retirement age subsequently make greater efforts to live longer than people who claimed benefits early, or if retiring made you depressed and increased your mortality rate.[19] Moral hazard is arguably less important in the context of Social Security, like in the private UK annuity markets studied by Finkelstein and Poterba (2004) and Einav, Finkelstein and Schrimpf (2010), than for other forms of insurance. Indeed, evidence suggests that any effects of early retirement on longevity are positive. Insler (2012) finds that the retirement effect on health is beneficial; with additional leisure time, many retirees invest in their health via healthy habits. This effect will mitigate against finding a positive correlation between longevity and the age at which people claim benefits.

In many insurance markets an important consideration in applying the positive correlation test is the set of covariates included. One must condition on the consumer characteristics that determine the prices offered to each individual. In the absence of such conditioning, it is impossible to know whether a correlation arises due to demand (different individuals self selecting into different contracts) or supply (different individuals being offered the same contracts at different prices by the insurance company). While a problem in many private insurance markets, we know that Social Security does not use any individual characteristics to price early retirement (at age 62 everyone in our sample is eligible for 80 percent of the benefits they are eligible for at age 65). From an individual's perspective the choice is simply between different annuities, the magnitude of which depends on their past contributions, all of which are offered at the same effective price

[19] Coe and Lindeboom (2008) find no negative effects of early retirement on health.

(zero).

A positive correlation between longevity and the age of retirement could be caused by many different personal characteristics. Including covariates help us identify sources of adverse selection. Four types of personal characteristics are likely particularly important: health, demographics, wealth and spousal characteristics (Table 1 provides descriptive means on these characteristics). Each of these factors could explain some of the positive correlation between life expectancy and the decision to claim benefits, or they could offset such a positive correlation. For example, people who suffer from poor health might both have shorter lives and find work more disagreeable, therefore retiring earlier and inducing a positive correlation between death age and retirement. In contrast, wealthier people may choose to retire earlier (since leisure is a normal good) and may live longer, creating a negative correlation between death age and retirement.

4.2 Results

We present linear estimates of the correlation between death age and the age of social security retirement, μ_1 in equation (1), for men in Table 2 and for both men and women in Table 3. Non-linear estimates are presented in Table 4 and are very similar to the linear estimates. Each column of the tables corresponds to a specification with a different set of covariates. We present results for three measures of the dependent variable: a continuous measure of the age at which individual's claim social security benefits, the probability that individuals claim benefits at age 62 (the age of first eligibility), and the probability they claim benefits before the normal retirement age of 65.

We find a highly significant positive relationship between people's death age and Social Security retirement age, and a highly significant negative relationship between the probability an individual claims benefits early and their death age. This provides clear evidence of the existence of adverse selection in Social Security. The magnitude of the effect is large: people who live a year longer on average claim benefits 1.4 months later, and are 2 percentage points less likely to claim benefits at age 62 or before age 65.

The inclusion of covariates reduces the magnitude of the relationship between death age and Social Security retirement. Once we include the full set of available observables and cohort fixed effects the relationship remains statistically highly significant, however, the magnitude shrinks by nearly two-thirds. We find that living a year longer is, conditional on all covariates, associated with claiming benefits 0.47 months later and decreases the likelihood of retiring at age 62 by 0.9 percentage points and that of retiring before age 65 by 0.7 percentage points. For the full sample of both men and women the relationship is somewhat strong; a year of longer life expectancy is associated with claiming benefits 0.52 months later and decreases the probability of retiring before age 65 by 0.11 percentage points. Cohort fixed effects reduce the correlation between the age of death and social security retirement age substantially, as does the inclusion of spousal characteristics and health indicators.

Table 5 presents the specification with the full set of covariates, estimated both on the sample of men and for both men and women. Own life expectancy is positively correlated with age of social security retirement, as is spouses life expectancy, but only for men. Individuals with higher levels of social security benefits, i.e. those with high lifetime earnings and many years of employment, claim earlier (at a decreasing rate); however, higher spousal benefits results in people claiming later. Higher household capital income and higher earnings at retirement are associated with delaying the age of Social Security retirement. Poor health is associated with claiming benefits earlier, and while the health indicators are jointly significant, individually only cancer and lung disease are statistically significant for women.

To understand which factors account for adverse selection in our sample of Social Security beneficiaries we apply recent work by Gelbach (2009) which attributes to each group of covariates the degree to which they reduce (or increase) the raw correlation between the retirement and death ages. Table 6 presents the results of this decomposition. The outcome is the age at which a person first claims benefits, and we use as our baseline the specification with cohort fixed effects. The description of the methodology is in the Appendix. We find that spousal characteristics explain about one-quarter to one-fifth of the positive correlation; with wealth measures and health indicators also contributing to the positive death age-retirement correlation. Conditioning on the level of Social Security benefits actually decreases the correlation between age of death and claiming benefits; people who have a history of higher earnings claim benefits earlier, but die later. This suggest that people with high benefit levels both live longer and claim benefits earlier which reduces program costs and thus a source of advantageous selection.

5 Empirical Strategy II: Estimating the Annuity Choice Model

5.1 Model

In this section, we outline a discrete choice model that allows us to estimate consumer preferences for when to claim Social Security benefits and the associated costs to the Social Security program. We present a parsimonious model that has the advantage that it can be used to identify key parameters that affect the choice of annuity: the coefficient of relative risk aversion and the discount rate. This enables us to conduct welfare analysis, evaluate reforms to the Social Security program and provide estimates pertaining to the optimal design of the system without having to calibrate those parameters. [20]

We begin by considering the binary case where individuals only have the choice between two annuities: the annuities available when claiming benefits at age 62 and at age 65. We define an individual's lifetime utility having claimed benefits early as

$$V_{Li} = \alpha_{t=0}^{\theta-1} \beta^t u\left(\delta B_i\right) + W_{Li} + v_{Li}$$

where this expected lifetime utility depends on the per period monetary utility associated with benefits δB, $u\left(\delta B\right) = \frac{(\delta B_i)^{1-\rho}}{1-\rho}$, summed over the number of years the person expects to live beyond age 62 θ, and discounted by $\beta < 1$.[21] We scale by the reciprocal of

[20] More complex models, such as a random coefficients model, may not be identified by the data given the non-linear structure outlined below.

[21] The monetary utility function only includes Social Security annuity wealth. Wealth at retirement is

the marginal utility of wealth α to ensure that willingness-to-pay is denoted in dollar terms. Any number of observed and unobserved factors that affect individual's utility when having claimed benefits early are captured by W_{Li} and v_{Li}. The lifetime utility associated with claiming full benefits three years later is

$$V_{Hi} = \alpha_{t=3}^{\theta-1}\beta^t u\left(B_i\right) + W_{Hi} + v_{Hi}$$

where $u\left(B_i\right) = \frac{B_i^{1-\rho}}{1-\rho}$ is the per period utility associated with full benefits B_i, which is the person's life expectancy beyond age 65, and W_{Hi} and v_{Hi} are other observed and unobserved factors which affect the person's utility of claiming benefits late and in the three years in which they do not received benefits. Hence, the relative utility associated with claiming benefits early is

$$\Delta V_i = \frac{\alpha}{1-\beta}\left[\beta^\theta\left(u\left(B_i\right) - u\left(\delta B_i\right)\right) + u\left(\delta B_i\right) - \beta^3 u\left(B_i\right)\right] + \Delta W_i + \Delta v_i \tag{2}$$

where $\Delta W_i = W_{Li} - W_{Hi}$ and $\Delta v_i = v_{Li} - v_{Hi}$. We assume that the per period utility function exhibits constant relative risk aversion (CRRA), governed by an elasticity of inter-temporal substitution parameter $1/\rho$ and ρ is the coefficient of relative risk aversion.

There are a number of limitations to our approach, in part necessitated by the data available in the HRS. We assume that the decision to claim benefits is an individual rather than household decision.[22] Spouse characteristics can enter the individual's preferences (as a component of Δv_i), but we do not have an explicit model of the household. We also do not allow for any spouse characteristics in the cost functions. Social Security does have provisions for both spousal benefits and survivor benefits, making spouse characteristics an important part of the total costs to the system.[23] Another important simplification we make is that we ignore any interactions between Old-Age Social Security and other social insurance programs, notably disability insurance. Recent years have seen a dramatic rise in the number of individuals claiming disability and transiting directly into Old-Age Social Security when eligible, see Autor and Duggan (2006). Finally, we do not allow for individual choices on other dimensions than claiming benefits, particularly we model neither savings nor labor supply decisions.

The cost function is given by the design of the Social Security system. The expected present discounted value lifetime payments to an early claimant and someone who claims full benefits three years later are:

$$c_{Li} =_{t=0}^{\theta-1} \phi^t \delta B_i, \quad c_{Hi} =_{t=3}^{\theta-1} \phi^t B_i -_{t=0}^{2} \phi^t w_i \tau_i$$

where $\phi = \left(\frac{1}{1+r}\right)^3$ and $r > 0$ is the annual interest rate, and we deduct the present discounted value revenue raised from social security taxes τ_i on the individual's income w_i earned during the three years where they do not claim benefits. The net cost to the

missing for roughly 65 percent of the sample. Average private pension wealth is only 16 percent of all annuity payments in our sample. We include other annuity income and wealth measures as covariates.

[22]Given the distribution of spousal death ages in our data only one-eighth of our sample belong to a household where we observe both male and female death ages.

[23]See Shoven and Slavov (2012) for a detailed description of those rules.

system of an individual claiming benefits early is

$$\Delta c_i = \frac{B_i}{1-\phi}\left[\delta + (1-\delta)\,\phi^{\theta} - \phi^3 + (1-\phi^3)w_i\tau_i\right]$$

To provide intuition it is helpful to consider several key comparative statics. First, our model has the feature that both the value and costs of claiming benefits early are, all else equal, declining in life expectancy, resulting in adverse selection:

$$\begin{aligned}\frac{\partial \Delta V_i}{\partial \theta} &= \ln\beta\frac{\beta^{\theta}}{(1-\beta)}\alpha\left(u\left(B_i\right) - u\left(\delta B_i\right)\right) < 0 \\ \frac{\partial \Delta c_i}{\partial \theta} &= \ln\phi\frac{\phi^{\theta}}{1-\phi}\left(1-\delta\right)B_i < 0\end{aligned}$$

Second, a decrease in the adjustment factor will decrease the willingness-to-pay to claim benefits early and therefore more people will wait until age 65 to claim benefits. The relative cost to Social Security of claiming benefits early will also decrease. The partial derivative of value and cost function with respect to the adjustment factor are:

$$\begin{aligned}\frac{\partial \Delta V_i}{\partial \delta} &= \frac{1-\beta^{\theta}}{1-\beta}\delta^{-\rho}B_i > 0 \\ \frac{\partial \Delta c_i}{\partial \delta} &= \frac{B_i}{1-\phi}\left(1-\phi^{\theta}\right) > 0.\end{aligned}$$

5.2 Structural Estimation

We take the binary model in equation (2) and extend it to include multinomial choice of discrete retirement ages between 62 and 65. The model above is a simple non-linear in parameters probit when we assume v_i is normally distributed, and ΔW_i to be a vector of observed characteristics. We index choices by retirement age a, and individuals choose the age at which they claim benefits based on a latent index $\Delta V\left(a|\theta,\zeta\right)$; retiring at age a if it provides the highest utility.[24] So the optimal retirement age a^* is given as:

$$a_i^* = \arg\max_{a\in[62,65]} \quad \{\Delta V(a|\theta_i,\zeta_i)\}, \tag{3}$$

where ζ_i includes the social security basis B_i, a vector of individual characteristics X_i and the utility associated with the income derived from working $u\left(w_i\left(1-\tau\right)\right)$, where w_i are average indexed monthly earnings (AIME), as our best measure of the wage, and τ_i is the income tax rate at age 62. We define surplus and costs, as above, relative to claiming benefits at age 65, and begin the decision problem at age 62 (such that both $a=0$ and $t=0$ correspond to age 62). Relative utility of retiring at age a as opposed to age 65 is given by:

$$\begin{aligned}\Delta V\left(a|\theta_i,\zeta_i\right) \;\; = \;\; & \left[{}_{t=a}^{\theta-1}\beta^t u\left(\delta_a B_i\right) + \sum_{t=0}^{a-1}\beta^t u\left(w_i\left(1-\tau_i\right)\right)\right] - \left[\sum_{t=a}^{\theta-1}\beta^t u\left(B_i\right) + \sum_{t=0}^{2}\beta^t u\left(w_i\left(1-\tau_i\right)\right)\right] \\ & + X_i\left(\gamma_\alpha - \gamma_{65}\right) + v_{ai} - v_{65i}\end{aligned}$$

[24]We include post-65 retirement in the age 65 category.

where δ_a is the adjustment factor to social security payments associated with retiring at age a

The log-likelihood of a given Social Security retirement age being observed for individual i is simply:

$$\ell\left(d_i = a\right) = \log\left(P\left\{V\left(a|\theta_i, \zeta_i\right) > V\left(a'|\theta_i, \zeta_i\right)\right\}, \forall a \neq a'\right)$$

We estimate the non-linear-in-parameters probit using a simulated maximum likelihood (SMLE) to obtain estimates of the discount rate β and the coefficient of relative risk aversion ρ, the age-specific indices γ_a, and Σ the covariance matrix of υ.[25]

We have two sources of identifying variation: the overall correlation between longevity and Social Security retirement age, and variation in Social Security retirement age for a fixed longevity. In a multinomial choice model with four possible Social Security retirement ages, observing one choice implies three inequalities must be satisfied. In a binary choice model only one inequality needs to be satisfied and we consequently we cannot identify both ρ and β. Thus the multinomial choice model combines with time separable utility and a constant discount factor in identifying two parameters from the joint distribution of longevity and Social Security retirement ages.[26] Note that due to the constant relative risk aversion assumption the relative utility derived from choosing between any two Social Security retirement ages does not depend on the benefit level.[27] To calculate $\Delta V_i\left(a\right)$ we draw values of the unobservable utility term, which is distributed $N\left(0, \hat{\Sigma}\right)$. The costs Δc_i for each individual are calculated using the information available in the HRS assuming different values for the real interest rates used by the government.

[25]To smooth the likelihood we employ a logit-smoothed kernel for the choice probability, for the r-th simulation, we calculate:

$$P(d_i = a|\theta_i, \zeta_i) = \frac{e^{(V^r(a|\theta_i,\zeta_i) - \max_{\tilde{a}\in A}\{V^r(\tilde{a}|\theta_i,\zeta_i)\})/\tau}}{\sum_{a'} e^{(V^r(a'|\theta_i,\zeta_i) - \max_{\tilde{a}\in A}\{V^r(\tilde{a}|\theta_i,\zeta_i)\})/\tau}},$$

where A are the choice set. We then average over the $R = 200$ draws and set $\tau = 5$.

[26]To see this note that an individual i choosing to claim at age 62 must have the following inequalities satisfied (abstracting from other covariates):

$$\begin{aligned}
\frac{\delta_{62}^{1-\rho}}{\delta_{62}^{1-\rho} - 1} &> \frac{\beta^3 + ... + \beta^{\theta_i}}{1 + \beta + \beta^2} \\
\frac{\delta_{62}^{1-\rho}}{\delta_{62}^{1-\rho} - \delta_{64}^{1-\rho}} &> \frac{\beta^2 + ... + \beta^{\theta_i}}{1 + \beta} \\
\frac{\delta_{62}^{1-\rho}}{\delta_{62}^{1-\rho} - \delta_{63}^{1-\rho}} &> \frac{\beta + ... + \beta^{\theta_i}}{1},
\end{aligned}$$

thus imposing the other inequality constraints generates more identifying restrictions. That is ρ and β adjust to satisfy the three inequalities for a given θ_i.

[27]Including the benefit levels linearly in the set of covariates allows for preference heterogeneity which is correlated with permanent income.

5.3 Estimates and Welfare Consequences of Adverse Selection

Table 7 presents our main results using the full sample of both men and women, and a government real discount rate of 3 percent, which is in the mid-range of those used by the *The 2012 Old-Age and Survivors Insurance and Disability Insurance (OASDI) Trustees Report*. The first column is a baseline model where we only include cohort fixed effects and the Social Security benefit level. The second and third columns include health and demographic variables. The fourth column includes the full set of individual characteristics as covariates, but does not include spouse characteristics; these are included in the specification in column five. Table 8 reports welfare estimates under varying assumptions about the real interest rate (from 1 to 5 percent) for the specification where we include the full set of individual and spousal characteristics.

5.3.1 Parameter Estimates

Our estimates for the coefficient of relative risk aversion are in the range 1.57 to 1.69, depending on the set of covariates we include in our willingness-to-pay specification. These estimates are close to Hurd (1989) who studies the bequest motives of the elderly.[28] However, recent work on annuity markets, see Einav, Finkelstein and Schrimpf (2010) in the UK annuity market, assumes a coefficient of relative risk aversion equal to 3 (a value frequently used for simulation purposes). Bundorf, Levin and Mahoney (2011) in estimating health plan choices choose a constant absolute risk aversion specification with a parameter which is equivalent to $\rho = 4$, which is near the top end of estimates in the literature (Cohen and Einav, 2007).

We also estimate a common private discount factor for individuals in the range of 0.95 and 0.98, or equivalently an annual discount rate in the range of 0.016 to 0.047. This is on the lower end of discount rates typically assumed in the literature, for example, Einav, Finkelstein and Schrimpf (2010) assume it is equal to the real interest rate of 0.0426 in the UK annuity market.

The model fit is presented in Table 9. The table compares simulated choices for each of the four claiming ages, averaging over 200 simulations. Each column shows results for a different claiming age, and each row for a different sub-sample in the data. Overall we slightly over-predict the fraction claiming at age 62, under-predict the fraction claiming at age 65 or above and closely fit the data for those claiming at ages 63 and 64. The model fit does not change appreciably above and below the median longevity, benefit level and by gender.

5.3.2 Welfare Estimates

We are able to quantify willingness-to-pay, costs, the amount of adverse selection and social welfare using our estimates of $\Delta V_i(a)$ and $\Delta c_i(a)$. There is clear evidence of adverse selection: those who have the highest willingness-to-pay for claiming benefits early are also those for who it is most expensive to provide those benefits. The relative

[28]Einav, Finkelstein, Pascu and Cullen (2012) argue that there is a both a domain-specific and a common component to risk aversion.

cost of providing benefits early (as opposed to at age 65) to the median early claimant is is \$14,866, while the relative (counterfactual) cost of providing benefits early to the median person who retires at age 65 would be \$12,706. Social welfare from the option to claim benefits is large for those who choose to exercise that option (a mean of \$39,613 in the full specification) and negative for those who do not (a mean of -\$56,412). While the exact welfare estimates vary across specifications, our broad finding of adverse selection in Social Security benefit choice and large welfare gains from claiming benefits early are robust to whether we include specific covariates or not. They are also robust to varying assumptions about the government interest rate, see Table 8, though the relative costs of providing benefits early are increasing in the interest rate.

In our sample nearly all the adverse selection is among people who inefficiently choose to claim benefits before age 65, i.e. $\Delta c_i(a) \geq \Delta V_i(a) \geq 0$. We find that between 8.6 and 10.2 percent of all claimants adversely select their Social Security retirement age. This finding is also robust to the use of different government interest rates. The fraction increases with our estimate of the coefficient of relative risk aversion, with our estimate of the individual discount factor, and with the interest rate. While we find many people claim benefits earlier than socially optimal, the social welfare loss associated with adverse selection is considerably smaller. Most adversely selecting individuals are near the margin of whether they should claim benefits early or not, and for those individuals the difference between their willingness-to-pay and costs tends to be small. Meanwhile, there are individuals who place a very high value on the option of claiming benefits early, the benefits that accrue to those individuals are far larger than welfare costs of adverse selection. Adverse selection in Social Security decreases social welfare by between 1.4 and 2.5 percent depending on the specification. Social welfare losses are increasing in the estimate of the coefficient of relative risk aversion and with the interest rate. Our results are similar to the estimated welfare costs of asymmetric information in other markets. In the UK annuity market Einav, Finkelstein and Schrimpf (2010) find that asymmetric information reduces welfare relative to a first-best symmetric information benchmark by about 2 percent of annuitized wealth. There are numerous studies relying on data from employer provided health insurance who consistently find welfare losses due to adverse selection of 1-4 percent (Cutler and Reber, 1998; Einav, Finkelstein and Cullen, 2010;.and Bundorf, Levin and Mahoney, 2011). Despite the very different markets and institutional settings there appears to be a fair amount of agreement between studies on the welfare costs associated with adverse selection.

Adverse selection places an additional burden on the Social Security Trust Fund since those who adversely claim benefits early are disproportionately expensive to the system. Our results suggest that in a first-best outcome Social Security would save 1.6 - 1.9 percent of the current costs of the system (and even more at higher interest rates). To put these numbers into context, the current projected deficit of the Social Security trust fund is 16 percent of program cost. According to our estimates adverse selection accounts for 10 - 12 percent of the shortfall. In comparison, the Report of the National Commission on Fiscal Responsibility and Reform (2010), co-chaired by Alan Simpson and Erskine Bowles, finds that: adjusting the COLA formula to reflect chained CPI would reduce the deficit by 26 percent, indexing the retirement age to life expectancy would decrease it by 21 percent, and raising the payroll tax cap to cover 90 percent of earnings would decrease the deficit by 35 percent.

6 Optimal Design of Social Security Adjustment Factors

Table 10 presents the impact of various counterfactual policy changes on social welfare and program costs. We present results using the full sample of both men and women, a government real discount rate of 3 percent, and a full set of individual and spousal characteristics as covariates. The first column repeats the estimates of the baseline model (based on the system relevant for birth cohorts 1916-40) for comparison. The second column presents the effects of changing the accrual rate from the baseline to the social welfare maximizing linear accrual rate, which lowers benefits proportionally at every age. The estimates in the third column are based on a specification allowing for non-linear accrual rates between the ages of 62 and 65, which only requires that benefits increase with age at which individuals first claim. The fourth column considers the effects of mandating that people can not claim Social Security benefits before the age of 65. All three policies would reduce the costs of the Old-Age Social Security, but while changing the accrual rate also increases social welfare, eliminating the early Social Security retirement option would substantially decrease social welfare.

Figure 4 shows the change in the fraction of individuals adversely claiming benefits early and late as a function of the adjustment factor. Notice that under an adjustment factor of 80 percent nearly all adverse selection is on account of individuals claiming benefits inefficiently early. Figure 5 depicts the welfare costs of adverse selection and the total cost to the program as a function of the adjustment factor. The social welfare maximizing linear accrual rate implies a benefit penalty of 23.2 percent for claiming benefits at age 62; the actual penalty for the cohorts we analyze is 20 percent. Our results suggest that decrease in the adjustment factor would result in a 2.5 percent reduction in costs, but nevertheless increase social welfare by 0.28 percent. We estimate that while early claimants' median willingness-to-pay would fall by \$1,363, compared to the status quo, the average early claimant would cost the system \$4,049 less, and the fraction of individuals who claim benefits inefficiently would fall to 7.4 percent (though now there would be both individuals claiming benefits inefficiently early and inefficiently late). In the presence of individual heterogeneity on multiple dimensions the social welfare gains of such a policy change are small, however, the additional savings would reduce the Social Security deficit by around 15 percent.

Allowing for non-linear accrual rates would further increase welfare and reduce costs. We estimate that the socially optimal adjustment factor at age 62 continue to be 0.768, but that the accrual rate increases with age. We find that the social welfare maximizing accrual rate schedule is 5.5, 5.6 and 12.1 percentage points between ages 62 and 65, that is the age 63 benefit is 82.3 percent of the full benefit, and age 64 is 87.9 percent. Our results suggest that implementing such a schedule would decrease the fraction adversely claiming benefits early to 7.2 percent, increase social welfare by 0.38 percent, and reduce costs by 3.23 percent or \$3,655 per claimant (or 20 percent of the current shortfall). Welfare losses from adverse selection would decrease from 1.60 percent to 1.15 percent.

The cost reductions of a mandate that everyone claim benefits at age 65 are large: 12 percent of total costs, equivalent to three-quarters of the current Social Security deficit, and $13,581 per claimant. We estimate that the welfare losses of such a mandate would be substantially larger than any cost reductions, on average $46,454 per retiree. People are willing to pay substantial amounts of money to claim benefits early (which is why so many do) and eliminating that option would correspondingly decrease social welfare. While mandates do resolve the adverse selection problem they, as emphasized by Feldstein (2005) and others, are not necessarily welfare improving when individuals differ in their preferences. Instead, they involve a trade-off between reducing the allocative inefficiency produced by adverse selection and increasing allocative inefficiency by eliminating self-selection. As comparison, Einav, Finkelstein and Schrimpf (2010) consider the consequences of government mandates that each individual purchases the same guarantee length in the UK annuity market, eliminating any contract choice. They find that mandates have ambiguous welfare consequences in an annuity market with risk and preference heterogeneity. We find that in Social Security there is no such ambiguity, the welfare benefits of allowing individuals to choose the age at which they claim benefits are substantial.

7 Conclusions

This paper contributes to the nascent literature that attempts to detect adverse selection in insurance markets, quantify the implications for welfare and consider the implications of counterfactual policy reforms. We have done so in the specific context of U.S. Old-Age Social Security, which accounts for around 7 percent of U.S. GDP and currently provides benefits to about 38 million retired workers (OASDI Trustees Report, 2012). Our methodology can also be applied to other public pension programs, and more generally, in insurance markets where adverse selection is based on observable characteristics of insurance buyers that for various reasons are not used in setting insurance prices. We find robust evidence that people who live longer choose higher annuities, by delaying the age at which they first claim benefits, resulting in adverse selection (since it is also more expensive for Social Security to provide a higher annuity for people who die later). We estimate adverse selection reduces social welfare by 1.4 - 2.5 percent, and increases the costs by 1.6 - 1.9 percent (more than 10 percent of the current shortfall in funds).

Counterfactual policy simulations suggest that a simple social welfare maximizing linear accrual rate equivalent to a benefit penalty of 23.2 percent for claiming benefits at age 62 (the actual penalty for the cohorts we analyze is 20 percent). This would increase social welfare slightly, 0.28 percent, and decrease the costs of the program by 2.5 percent. An optimal non-linear accrual rate schedule performs better raising welfare by 0.38 percent and reducing costs by 3.23 percent.

The ability to choose when to claim benefits is very valuable ($54,479 for the median early claimant in our sample), generating substantial social surplus which far outweighs the costs generated by adverse selection. The trade-off between the welfare gains generated by self-selection and the inefficiencies from asymmetric information is worth exploring further in the context of other social insurance programs, such as disability, unemployment and health insurance. There are also a number of important dimensions on which our analysis of adverse selection in Social Security can be extended, in particular by modeling benefit claiming choices as household decisions, and accounting for savings and labor supply decisions.

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Appendix: Decomposition Method

To understand which factors account for adverse selection in our sample of Social Security beneficiaries, we apply recent work by Gelbach (2009) which allows us to attribute to what degree each group of covariates affects the correlation between the retirement and death ages. Our baseline model has the form:

$$R_i = \alpha_0^B + \alpha_d^B DeathAge_i + \alpha_1^B X_{i1} + \varepsilon_i^B, \tag{4}$$

where the superscript "B" denotes baseline. In a full regression we then include a large set of regressors: social security benefits (X_{i2}), a health history (X_{i3}), demographic information (X_{i4}), 2-digit occupation fixed effects (X_{i5}), financial information (X_{i6}) and spousal characteristics (X_{i7}). That is we run:

$$\begin{aligned} R_i = \;& \alpha_0^F + \alpha_d^F DeathAge_i + \alpha_1^F X_{i1} + \alpha_2^F X_{i2} + \alpha_3^F X_{i3} + \alpha_4^F X_{i4} \\ & + \alpha_5^F X_{i5} + \alpha_6^F X_{i6} + \alpha_7^F X_{i7} + \varepsilon_i^F, \end{aligned} \tag{5}$$

where the superscript "F" denotes what we refer to as our full specification with all controls.

We use a method developed by Gelbach (2009) which nests the well known Oaxaca-Blinder decomposition. Gelbach points out that from the perspective of Equation (5) being the complete model, Equation (4) is just a model with the variables $X_{i2}, X_{i3}, X_{i4}, X_{i5}, X_{i6}, X_{i7}$ omitted. Thinking about Equation (4) in this way the well known omitted variable bias formula applies. That is, the relationship between α_d^B and α_d^F is:

$$\begin{aligned} \alpha_d^B = \;& \alpha_d^F + \left[\sum_{j=1}^{N_2} \theta_{2j}\alpha_{2j}^F\right] + \left[\sum_{j=1}^{N_3} \theta_{3j}\alpha_{3j}^F\right] + \left[\sum_{j=1}^{N_4} \theta_{4j}\alpha_{4j}^F\right] + \left[\sum_{j=1}^{N_5} \theta_{5j}\alpha_{5j}^F\right] + \ldots \\ & + \left[\sum_{j=1}^{N_6} \theta_{6j}\alpha_{6j}^F\right] + \left[\sum_{j=1}^{N_7} \theta_{7j}\alpha_{7j}^F\right], \end{aligned} \tag{6}$$

where the α_{kj}^F for $k = 1, ..., 7$ are defined in Equation (5) and there are N_k covariates in each of the k-groups. The θ_{kj} are the k elements in each θ_j vector defined by the auxiliary regression:

$$DeathAge_i = \theta_0 + \theta_1 X_{i1} + \theta_2 X_{i2} + \theta_3 X_{i3} + \theta_4 X_{i4} + \theta_5 X_{i5} + \theta_6 X_{i6} + \theta_7 X_{i7} + \eta_i. \tag{7}$$

Rearranging terms, a decomposition of how much each set of factors contribute to explaining the gap in outcomes is:

$$\begin{aligned} (\alpha_d^B - \alpha_d^F) = \;& \left[\sum_{j=1}^{N_2} \theta_{2j}\alpha_{2j}^F\right] + \left[\sum_{j=1}^{N_3} \theta_{3j}\alpha_{3j}^F\right] + \left[\sum_{j=1}^{N_4} \theta_{4j}\alpha_{4j}^F\right] + \left[\sum_{j=1}^{N_5} \theta_{5j}\alpha_{5j}^F\right] + \ldots \\ & + \left[\sum_{j=1}^{N_6} \theta_{6j}\alpha_{6j}^F\right] + \left[\sum_{j=1}^{N_7} \theta_{7j}\alpha_{7j}^F\right], \end{aligned} \tag{8}$$

where each term in the brackets is that part of the correlation explained by sum of the respective covariates.

Figure 1: Claiming Benefits Early and Longevity: The Case of No Heterogeneity and Uniform Pricing

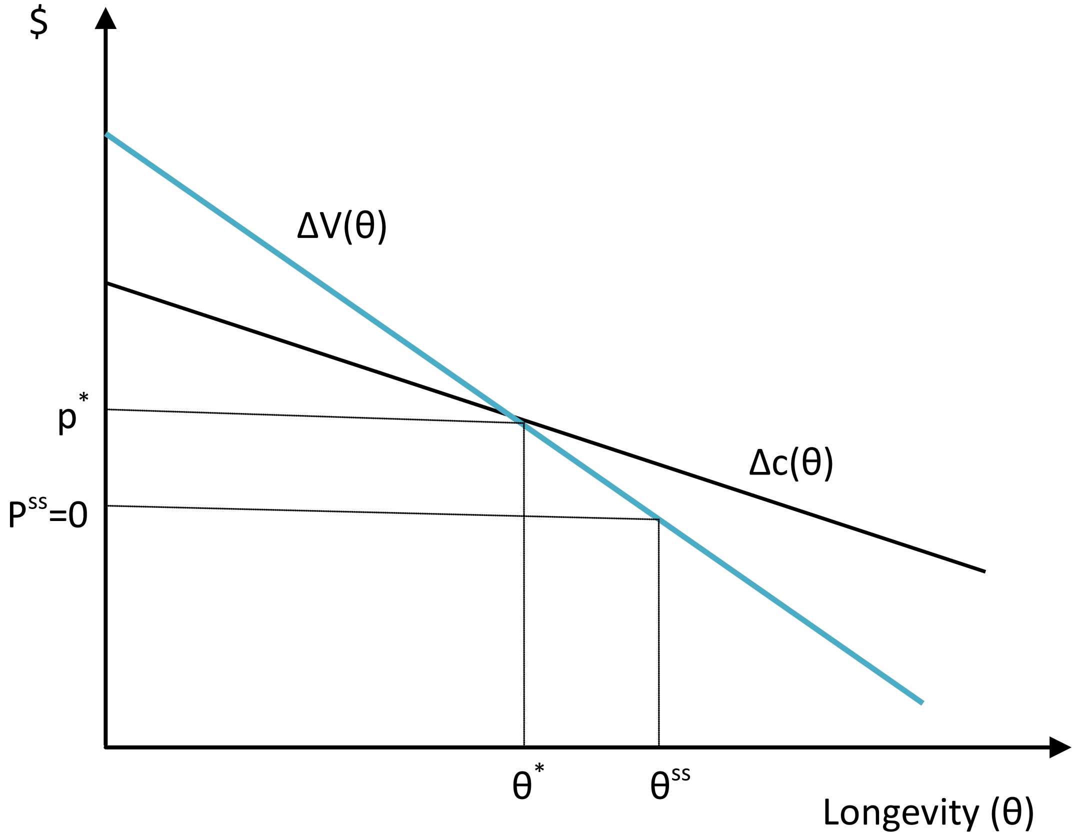

Figure shows a special case where there is no heterogeneity among individuals other than in life expectancy (θ). The steeper line $\Delta V(\theta)$ shows the relationship between the incremental willingness-to-pay for claiming benefits early. The line $\Delta c(\theta)$ shows the relationship between incremental cost to Social Security and longevity. p^* shows the uniform premium that efficiently allocates individuals across Social Security annuity choices.

Figure 2: Efficiency Costs of Adverse Selection in Social Security

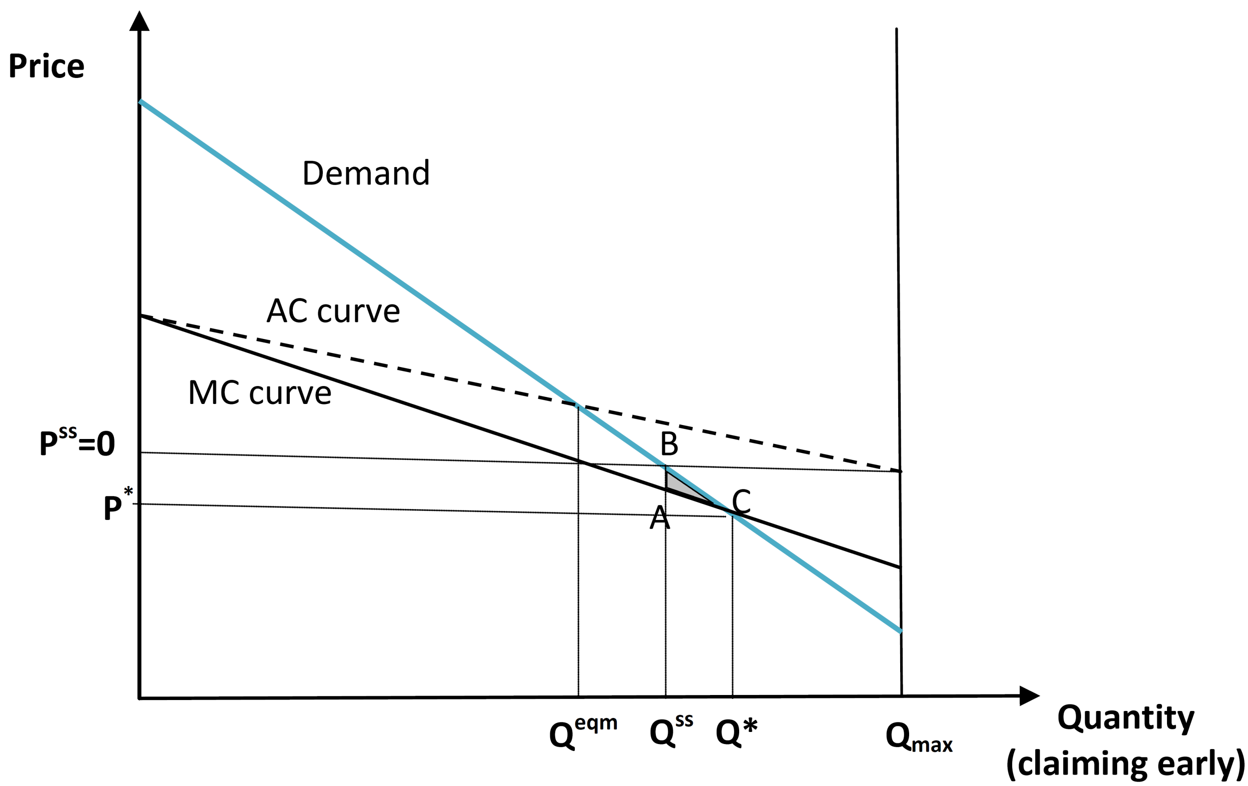

Figure represents the theoretical efficiency cost of adverse selection. It depicts a situation of adverse selection because the marginal cost curve is decreasing in quantity, indicating that the people who have the highest willingness to pay for claiming benefits early also have the highest expected cost to the insurer. p^* is the uniform premium that efficiently allocates individuals across Social Security annuity choices, $P^{ss} = 0$ is the current premium. Q^* and Q_{ss} are the corresponding fraction of individuals claiming benefits early. The triangle ABC is the welfare cost from inefficient choice of Social Security annuity due to adverse selection.

Figure 3: Claiming Benefits Early and Longevity: the Case With Heterogeneity and Uniform pricing

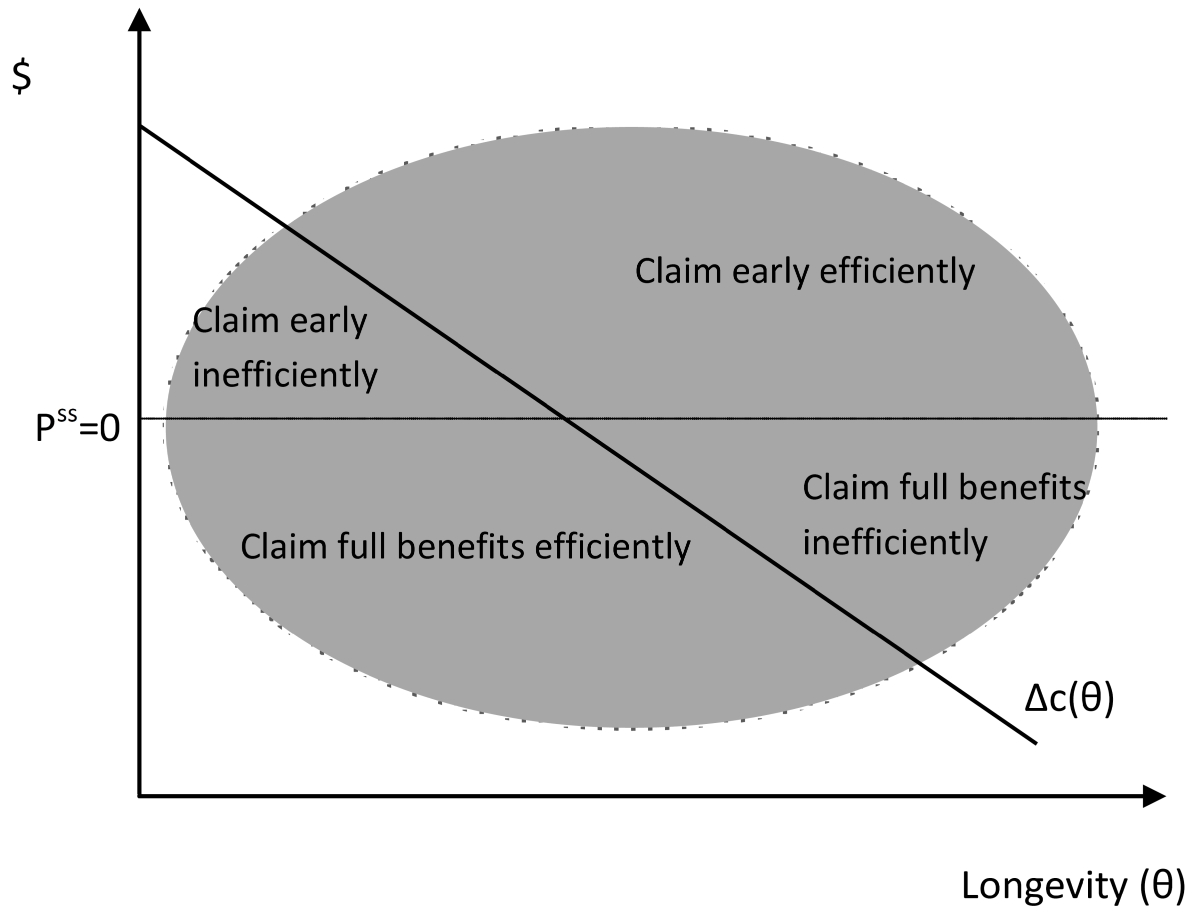

Figure shows mis-allocation from uniform pricing with heterogeneous preferences. The shaded region shows the distribution of $|deltaV(\theta, \zeta)$. For these individuals, the y-axis value is the incremental willingness-to-pay for claiming benefits early and the x-axis value is longevity (θ). The line $\Delta c(\theta)$ shows the relationship between incremental cost to Social Security and longevity. $P^{ss} = 0$ is the current lump-sum premium charged by Social Security for claiming benefits early that allocates individuals in Social Security retirement ages.

Figure 4: Adverse Selection Under Different Early Retirement Penalties

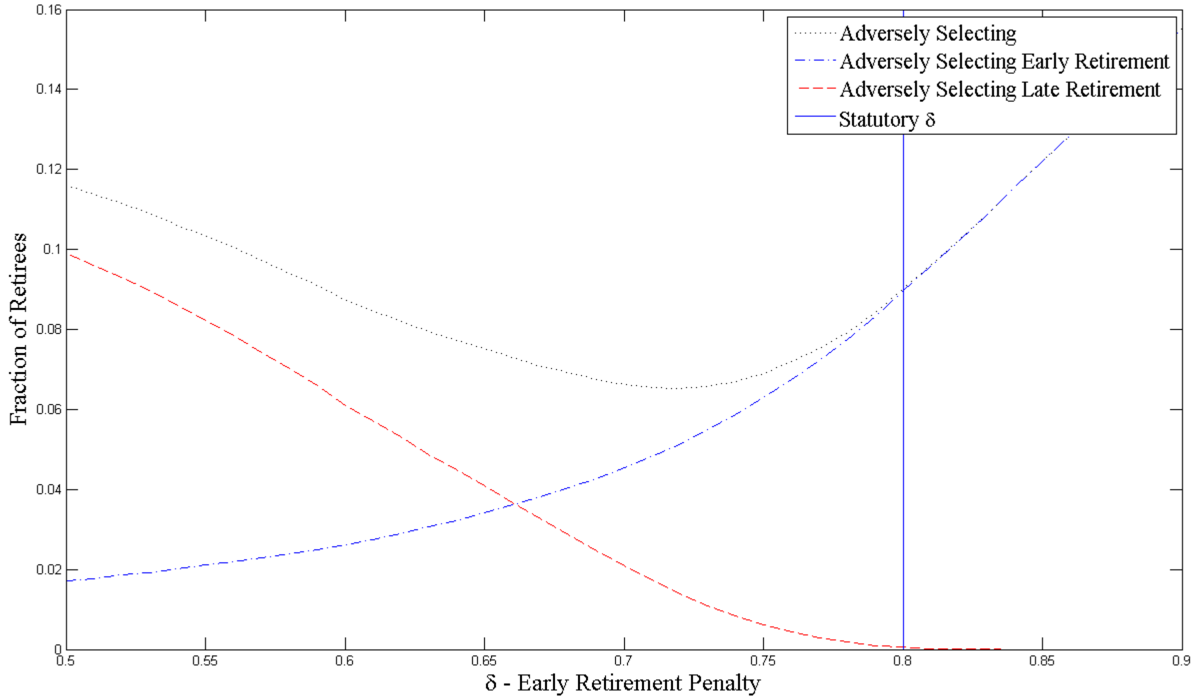

Figure 5: Net Costs from Adverse Selection

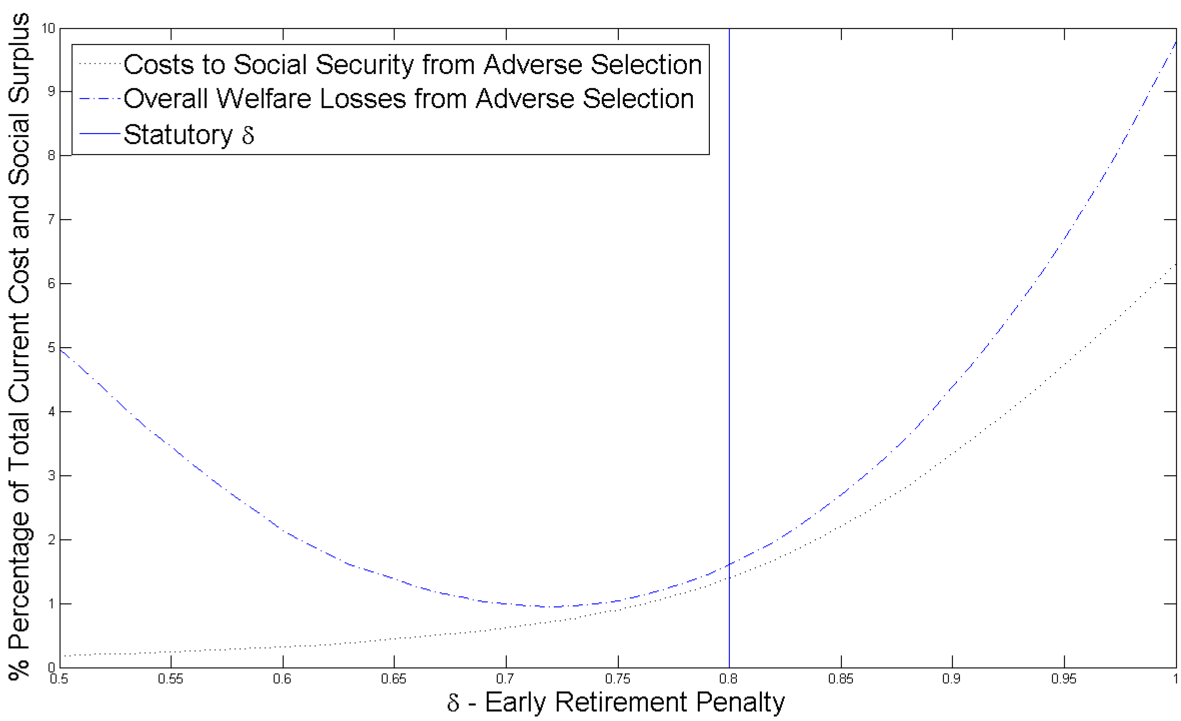

Table 1: Descriptive Means[a]

Social Security Retirement Age (RA)	Male	Female
RA = 62	0.496	0.513
RA = 63	0.120	0.149
RA = 64	0.081	0.076
RA = 65	0.191	0.144
65 < RA <=70	0.113	0.118
Death Age	73.58	73.53
Health Conditions at 62		
Had Heart Disease	0.092	0.040
Had Cancer	0.028	0.084
Had Stroke	0.030	0.030
Had Diabetes	0.115	0.089
Had Lung Disease	0.110	0.135
Had Arthritis	0.404	0.541
Ever Smoke	0.816	0.630
Demographics at 62		
Education (years)	11.660	11.748
Ever Married	0.969	0.960
Minority	0.144	0.173
Mean Birth Year	1929	1930
Financial Information		
Social Security Age 62 Benefit ($)	12,636	9,986
Household Capital Income at Retirement ($)	11,037	14,249
Total Wealth at Retirement ($)	206,344	132,845
Income from Private Pension ($)	2,486	8,342
Zero Private Pension	0.345	0.306
Missing Capital Income	0.585	0.654
Missing Wealth	0.585	0.654
Missing Pension	0.585	0.654
Spouse Characteristics		
Spouse Death Age	70.730	75.499
Spouse Death Age Missing	0.808	0.714
Spousal Social Security Benefit	5,961	13,280
No Spousal Social Security Benefit	0.503	0.538
Spousal Education (years)	11.760	11.995
N	1055	630

[a]Sample is restricted to men and women who did not claim Social Security Disability Benefits prior to age 62, and did claim old-age retirement benefits. Sample includes those born after 1915 and before 1941.

Table 2: Correlation Test: Retirement and Death Age, Men[a]

	Continuous Retirement Age							
Death Age	0.107***	0.066***	0.066***	0.06***	0.058***	0.056***	0.055***	0.039**
	(0.010)	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
N	1055	1055	1055	1055	1055	1055	1055	1055
R^2	0.095	0.155	0.158	0.168	0.177	0.185	0.219	0.241
	P(Retirement Age = 62)							
Death Age	-0.021***	-0.013***	-0.013***	-0.012***	-0.012***	-0.011***	-0.011**	-0.009**
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
N	1055	1055	1055	1055	1055	1055	1055	1055
R^2	0.051	0.089	0.091	0.096	0.099	0.114	0.142	0.156
	P(Retirement Age < Full)							
Death Age	-0.021***	-0.013***	-0.013***	-0.012***	-0.012***	-0.011***	-0.010**	-0.007*
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
N	1055	1055	1055	1055	1055	1055	1055	1055
R^2	0.068	0.102	0.091	0.121	0.13	0.142	0.157	0.171
Controls								
Cohort FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SS Benefit	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Health History	No	No	No	Yes	Yes	Yes	Yes	Yes
Demographics	No	No	No	No	Yes	Yes	Yes	Yes
Occupation FE	No	No	No	No	No	Yes	Yes	Yes
Financial Information	No	No	No	No	No	No	Yes	Yes
Spousal Characteristics	No	No	No	No	No	No	No	Yes

[a]Sample includes all men who died during the sampling time-frame and also reported claiming individual social security benefits between age 62 and age 70. Each cell is the coefficient on death age from a linear probability model, ***,** and *, denote significance 10,5 and 1% levels respectively.

Table 3: Correlation Test: Retirement and Death Age, Men and Women[a]

	Continuous Retirement Age							
Death Age	0.106***	0.065***	0.066***	0.061***	0.060***	0.057***	0.057***	.0430***
	(0.008)	(0.012)	(0.015)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
N	1685	1685	1055	1685	1685	1685	1685	1685
R^2	0.091	0.132	0.158	0.140	0.143	0.151	0.177	0.189
	P(Retirement Age = 62)							
Death Age	-0.019***	-0.012***	-0.013***	-0.012***	-0.012***	-0.011**	-0.011**	-0.010**
	(0.002)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
N	1685	1685	1685	1685	1685	1685	1685	1685
R^2	0.042	0.064	0.066	0.068	0.069	0.078	0.097	0.100
	P(Retirement Age < Full)							
Death Age	-0.023***	-0.015***	-0.013***	-0.013***	-0.013***	-0.013***	-0.013***	-0.011***
	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
N	1685	1685	1055	1685	1685	1685	1685	1685
R^2	0.073	0.095	0.091	0.104	0.107	0.118	0.131	0.140
Controls								
Cohort FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SS Benefit	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Health History	No	No	No	Yes	Yes	Yes	Yes	Yes
Demographics	No	No	No	No	Yes	Yes	Yes	Yes
Occupation FE	No	No	No	No	No	Yes	Yes	Yes
Financial Information	No	No	No	No	No	No	Yes	Yes
Spousal Characteristics	No	No	No	No	No	No	No	Yes

[a]Sample includes all men and women who died during the sampling time-frame and also reported claiming individual social security benefits between age 62 and age 70. Each cell is the coefficient on death age from a linear probability model, ***,** and *, denote significance 10,5 and 1% levels respectively.

Table 4: Correlation Test: Retirement and Death Age, Men and Women, Non-Linear Models[a]

									Marginal Effect
					Continuous Retirement Age				
Death Age	0.186***	0.117***	0.120***	0.111***	0.109***	0.103***	0.104***	0.081***	0.081***
	(0.016)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.025)
N	1685	1685	685	1685	1685	1685	1685	1685	-
Pseudo-R^2	0.024	0.034	0.035	0.037	0.037	0.04	0.047	0.05	-
					P(Retirement Age = 62)				
Death Age	-0.050***	-0.032***	-0.033***	-0.031***	-0.032***	-0.030***	-0.033***	-0.027***	-0.010***
	(0.006)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.004)
N	1685	1685	1685	1685	1684	1684	1684	1684	-
Pseudo-R^2	0.0307	0.0475	0.0491	0.0512	0.0514	0.0582	0.074	0.078	-
					P(Retirement Age $<$ Full)				
Death Age	-0.072***	-0.046***	-0.047***	-0.043***	-0.043***	-0.041***	-0.043***	-0.035***	-0.011***
	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)	(0.003)
N	1685	1630	1630	1630	1629	1629	1629	1629	-
Pseudo-R^2	0.064	0.071	0.072	0.08	0.082	0.094	0.106	0.112	-
Controls									
Cohort FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SS Benefit	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Health History	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Occupation	No	No	No	No	No	Yes	Yes	Yes	Yes
Financial Information	No	No	No	No	No	No	Yes	Yes	Yes
Spousal Characteristics	No	No	No	No	No	No	No	Yes	Yes

[a]Sample includes all men and women who died during the sampling time-frame and also reported claiming individual social security benefits between age 62 and age 70. The first row of estimates are from a Tobit model censored at age 62, the second and third rows are from probit models; ***,** and *, denote significance 10,5 and 1% levels respectively.

Table 5: Full Estimates, Linear Models[a]

Control	Men	Men and Women
Death Age	0.039 **	0.044 ***
	(0.016)	(0.013)
Social Security Benefit-62	-0.077 ***	-0.047 **
	(0.026)	(0.019)
Social Security Benefit ^{2}	0.002 **	0.001 *
	(0.001)	(0.001)
Demographics		
Education	0.028	0.001
	(0.022)	(0.018)
Education Missing	-0.178	-0.312
	(1.742)	(1.745)
Minority	-0.155	0.036
	(0.163)	(0.125)
Ever Married	-0.108	0.023
	(0.337)	(0.247)
Health		
Ever Smoke	-0.041	-0.029
	(0.146)	(0.102)
Had Lung Disease	-0.268	-0.306**
	(0.174)	(0.135)
Had Arthritis	-0.071	-0.178**
	(0.112)	(0.088)
Censored Diabetes	0.285	-0.041
	(0.201)	(0.153)
Had Diabetes	0.073	-0.088
	(0.176)	(0.143)
Censored Cancer	0.255	0.083
	(0.213)	(0.174)
Had Cancer	-0.207	-0.292
	(0.333)	(0.201)
Censored Heart	0.068	-0.082
	(0.150)	(0.118)
Had Heart Disease	-0.240	-0.102
	(0.197)	(0.173)
Censored Stroke	0.133	0.248
	(0.262)	(0.207)
Had Stroke	-0.363	-0.009
	(0.321)	(0.251)
Household (HH) Financial Information (1K$)		
HH Capital Income	0.009***	0.007**
	(0.003)	(0.002)
HH Financials Missing	-0.547**	-0.430**
	(0.259)	(0.203)
HH Total Wealth (100K)	0.010	0.034
	(0.010)	(0.123)
Employer Pension or Annuity Income	0.011	0.004
	(0.015)	(0.013)
Zero pension income	0.201	0.030
	(0.257)	(0.206)
Earnings at retirement	0.010***	0.012***
	(0.003)	(0.002)
Spouse Characteristics		
Spouse Death Age	0.031 *	0.009
	(0.017)	(0.013)
Spouse Death Age Missing	0.048	-0.032
	(0.141)	(0.108)
Spouse SS Benefit	0.022*	0.020**
	(0.012)	(0.009)
Spouse SS Benefit Mis	0.370*	0.342**
	(0.201)	(0.146)
Spouse SS Benefit = 0	-0.045	-0.084
	(0.141)	(0.115)
Spouse Education	-0.025	-0.003
	(0.025)	(0.019)
Constant	59.650***	59.930***
	(2.123)	(1.694)
N	1055	1685
R^2	0.231	0.184

[a] *,**,*** denotes significant at the 10,5,and 1% levels respectively. Both Columns include all controls. Health measures leave out the indicator for never having the condition, censoring occurs because we cannot observe health at age 62 for individuals who also had the condition afterage 62 and observation. Education is measured in years of schooling. All monetary values are in 2010 constant dollars. 2-digit occupation and cohort fixed effects are included in the specifications.

Table 6: Decomposing the Death Age-Retirement Correlation[a]

	Continuous Retirement Age	
Death-Age Coefficient:	Men	Men and Women
Baseline Model	0.066	0.065
	(0.015)	(0.012)
Full Model	0.040	0.045
	(0.016)	(0.013)
Fraction of Correlation Explained by:		
Social Security Benefit	-0.109*	-0.086**
Health History	0.068	0.080*
Demographics	0.028	-0.002
Occupation	0.048	0.049
Financial Information	0.120**	0.077**
Spousal Characteristics	0.242***	0.216***

[a]Samples include all men, and all men and women, who died during the sampling time-frame and also reported claiming individual social security benefits between age 62 and age 70. The Baseline model include only death age and cohort fixed effects. *,**,*** denotes significant at the 10,5,and 1% levels respectively.

Table 7: Structural Estimates and Welfare[a]

	Multinomial Probit Model				
Estimates	(i)	(ii)	(iii)	(iv)	(v)
ρ	1.573***	1.584***	1.596***	1.636***	1.692***
	(0.099)	(0.139)	(0.134)	(0.206)	(0.060)
β	0.984***	0.969***	0.966***	0.952***	0.975***
	(0.024)	(0.036)	(0.028)	(0.034)	(0.011)
Negative Log-likelihood	1,882.9	1,859.3	1,855.8	1,826.4	1,815.5
Welfare and Costs					
Fraction Adversely Selecting	0.090	0.086	0.102	0.109	0.090
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
Social Welfare Loss/Current SW	0.014	0.015	0.021	0.025	0.016
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
Optimal Costs/Current Costs	0.984	0.984	0.981	0.981	0.985
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Median Early Retiree					
Willingness to Pay ($)	59,486	61,064	53,659	46,625	54,479
Relative Costs ($)	15,086	14,884	14,929	14,936	14,866
Median Late Retiree					
WTP for Age 62 Ret. ($)	-40,850	-40,096	-33,643	-37,383	-43,706
Relative Costs of Age 62 Ret. ($)	13,177	13,165	13,004	12,951	12,706
Controls					
Cohort FE	Yes	Yes	Yes	Yes	Yes
AIME Wage Average	Yes	Yes	Yes	Yes	Yes
Health History	No	Yes	Yes	Yes	Yes
Demographics	No	No	Yes	Yes	Yes
Financial Information	No	No	No	Yes	Yes
Spouse Characteristics	No	No	No	No	Yes

[a]Sample size for all models is 1674, and includes all men and women excluding those with longevity less than three. Costs are calculated using a government annual interest rate of 3% for discounting. Welfare calculations are based on 50 simulation draws for unobserved utility. All monetary values are discounted, 2010-constant dollars. ***,** and * denote significance at the 10,5 and 1% levels respectively

Table 8: Welfare and Costs with Varying Interest Rates[a]

	Government Interest Rate:				
Welfare and Costs	1%	2%	3%	4%	5%
Fraction Adversely Selecting	0.084	0.086	0.090	0.095	0.099
	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)
Social Welfare Loss/Current SW	0.014	0.015	0.016	0.018	0.019
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Optimal Outlays/Current Outlays	0.988	0.986	0.985	0.983	0.980
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Median Early Retiree					
Willingness to Pay ($)	54,479	54,479	54,479	54,479	54,479
Relative Costs ($)	13,319	14,107	14,866	15,699	16,532
Median Late Retiree					
Willingness to Pay for Age 62 Ret. ($)	-43,706	-43,706	-43,706	-43,706	-43,706
Relative Costs of Age 62 Ret. ($)	8,948	10,813	12,706	14,261	15,805
Controls					
Cohort FE	Yes	Yes	Yes	Yes	Yes
AIME Wage Average	Yes	Yes	Yes	Yes	Yes
Health History	Yes	Yes	Yes	Yes	Yes
Demographics	Yes	Yes	Yes	Yes	Yes
Financial Information	Yes	Yes	Yes	Yes	Yes
Spouse Characteristics	Yes	Yes	Yes	Yes	Yes

[a]Sample size for all models is 1674, and includes all men and women excluding those with longevity less than three. Costs are calculated using a government annual interest rate of 3% for discounting. Welfare calculations are based on 50 simulation draws for unobserved utility. All monetary values are discounted, 2010-constant dollars.

Table 9: Within Sample Fit, Multinomial Probit[a]

	Fraction Retiring At Age:							
	62		63		64		$\geq$65	
Demographic:	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed
Overall	0.512	0.494	0.130	0.131	0.088	0.081	0.271	0.295
θ_i Below Median	0.593	0.578	0.147	0.144	0.097	0.091	0.163	0.186
θ_i Above Median	0.450	0.429	0.116	0.121	0.081	0.073	0.353	0.377
B_i Below Median	0.518	0.492	0.136	0.123	0.092	0.083	0.254	0.303
B_i Above Median	0.506	0.495	0.124	0.140	0.084	0.079	0.287	0.286
Male	0.501	0.484	0.127	0.120	0.088	0.083	0.284	0.313
Female	0.531	0.509	0.134	0.149	0.088	0.077	0.248	0.265

[a]Sample size is 1674. Predictions are from the model including all covariates, averaged over 200 unobserved utility draws.

Table 10: Evaluating Counterfactual Policies[a]

Percentage:	Baseline (Current)	Counterfactual Policy: Linear Accrual Rate	Optimal Non-Linear Accrual Rates	Mandated Age 65 Retirement
Change In Costs	-	-2.532	-3.230	-12.002
Change in Social Surplus	-	0.276	0.383	-100
Adversely Selecting	9.010	7.421	7.243	0
Welfare Losses from AS as Percent of Baseline SS	1.602	1.185	1.154	0
Dollar Changes in				
SW per Early Retiree ($)	-	181	255	-
SW per Retiree ($)	-	128	178	-46,454
Costs per Early Retiree ($)	-	-4,049	-5,227	-
Costs per Retiree ($)	-	-2,865	-3,655	-13,581
Median Early Retiree				
Willingness to Pay ($)	54,479	53,116	53,034	-
Relative Costs ($)	14,866	11,661	10,993	-
Median Late Retiree				
WTP for Age 62 Ret. ($)	-43,694	-45,008	-44,401	15,320
Relative Costs of Age 62 Ret. ($)	12,706	7,013	6,850	11,558
Policy Parameters				
δ_{62}	0.800	0.768	0.768	0.800
δ_{63}	0.867	0.847	0.823	-
δ_{64}	0.933	0.923	0.879	-

[a]Sample size for all models is 1674, and includes all men and women excluding those with longevity less than 3. Costs are calculated using a government annual interest rate of 3% for discounting. Welfare calculations are based on 50 simulation draws for unobserved utility. Simulations are based on the model including all sets of controls. All monetary values are discounted, 2010-constant dollars.