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Is the Adjustment of Social Security Benefits Actuarially Fair, and If So, for Whom?

Abstract

Disparities in Social Security claiming ages have risen since the early 1990s. With high earners increasingly likely to delay claiming, and also living longer on average than lower earners, late claimants may differ in critical ways from early claimants. Using Social Security Administration data and focusing on men, we find that late claimants have lower mortality than those who claim at age 62, so late claimants are adversely selected. As a result of selective claiming combined with improvements in actuarial adjustments, the return on delayed claiming has become systematically positive for those who actually delay, but not for those who claim early. We further find that selective claiming increases benefits more for those with higher lifetime earnings because their return on delaying exceeds actuarially fair amounts by larger margins. Lastly, we find that selective claiming has a modest effect on total payouts, but a more consequential effect on inequality in lifetime benefit payouts. In the aggregate, the increase in trust fund payouts as a result of adverse selection in claiming was 0.5% for the most recent retiring cohorts. Yet, lifetime benefit payouts are 1.9% higher for those in the highest quartile of lifetime earnings as a result of claiming-age differences, compared to what payouts would be if they had the same claiming ages as those in the lowest quartile. This contributes 2.8% to the difference in expected lifetime benefits between the highest and lowest quartiles.

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1. Introduction

While workers are first eligible to claim Social Security retirement benefits at age 62, and many do, disparities in claiming ages have arisen since the early 1990s.[1] Social Security is designed to deliver lifetime benefits that are equal in expectation, regardless of whether individuals claim benefits as early as age 62 or as late as age 70 (or age 65, for the cohorts we study, who retired before the mid-2000s). Through actuarial adjustments, the amount of the monthly benefit increase from delaying claiming is intended to be actuarially fair for workers with population-average mortality.[2] Yet, it is workers with relatively high levels of educational attainment and lifetime earnings who have grown increasingly likely to delay claiming, while at the same time, those with high socioeconomic status have experienced increasing lifespans relative to others (Sanzenbacher et al. 2019; Waldron 2013). The possibility of selective claiming, by which claiming ages are systematically correlated with life expectancy, raises two concerns. First, if late claimants are longer-lived, it undermines the neutrality built into the actuarial adjustments and exposes the Social Security Old Age Trust Fund to greater costs through adverse selection, relative to a base case in which claiming ages are uncorrelated with mortality. Second, if late claimants are both longer-lived and higher-earning, it undermines redistributive elements built into the Social Security

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[1] According to our tabulations, the median claiming age declined from 64.9 to 62.3 years between the 1900 and 1930 birth cohorts, which turned 62 in 1962 and 1992 respectively.

[2] The actuarial reduction factor (ARF), affecting claimers between the ages of 62 and the full retirement age (FRA), was established at the same time as the early retirement age (ERA) of 62. Later, the delayed retirement credit (DRC), affecting claimers after FRA up until age 70, was implemented as well. We collectively refer to the ARF and DRC as the actuarial adjustments.

benefits formula, which delivers a higher replacement rate of annual benefits relative to earnings for low earners than for high earners.[3]

We consider how increasing disparities in lifespans and correlated disparities in claiming ages influence actuarial fairness, costs faced by the Social Security Trust Fund, and inequality of expected lifetime benefits. We focus solely on the retired-worker benefit and defer to future research an analysis of the complicated interactions arising for spouses and survivors of retired workers. For this reason, we focus solely on men because, in the older cohorts we study (for whom mortality is observed for sufficient numbers), men are typically the primary earners, whereas women who claim retired-worker benefits typically switch to survivor benefits after their spouse's death. Lastly, we consider only beneficiaries who have never received disability insurance, as otherwise the claiming age is trivially determined at the full retirement age (FRA).

We find that late claimants have longer estimated life expectancy and higher average lifetime earnings. We demonstrate that, as claiming ages have diverged and actuarial adjustments have grown more generous, these patterns have altered lifetime benefits for late versus early claimants and for high versus low earners. This has caused a divergence in actuarial fairness among claimants, which has had a small effect on aggregate trust fund payouts and a more consequential effect on redistribution

[3] Benefits are based on average earnings through a formula that provides a higher replacement rate (benefits as a percent of average preretirement earnings) to workers with lower lifetime earnings. As Liebman (2002) showed using earlier data, however, the progressivity of the benefit schedule has been partially undone by inequality in attachment to the labor force, attachment to marriage, and lifespans for high versus low lifetime earners. We explore how life expectancy and claiming-age differences interact to alter lifetime payouts for high versus low earners.

between high and low earners. Selective claiming has increased trust fund payouts and, for cohorts that began retiring about 15 years ago, the return on delaying claiming has become positive for those who actually delay. We calculate that the increase in trust fund payouts was 0.2% for quite a while, possibly rising to around 0.5% for the most recent retiring cohorts. In other words, we find a modest degree of adverse selection, with trust fund liabilities rising relative to what they would be if claiming ages were uncorrelated with mortality. Meanwhile, selective claiming occurs within all earnings quartiles but is more costly among higher earners and contributes more to inequality than to the overall Trust Fund balance. Difference in claiming age patterns increase expected lifetime benefits of high earners by 1.9% for recent retiring cohorts, while contributing 2.8% to the difference in expected lifetime benefits of the highest versus lowest quartiles of lifetime earnings.

We obtain our results using administrative data from the U.S. Social Security Administration (SSA).[4] The analysis consists of four steps. First, we quantify changes in claiming ages by birth cohort and by lifetime earnings. Second, we investigate how life expectancy differs by claiming age, and because we are studying cohorts whose members have not all died, we estimate a Gompertz survival model, commonly used in demography. Third, we compute expected lifetime benefits for individuals claiming between ages 62 and 70 under different mortality assumptions: assuming that they have population-average mortality by cohort (from SSA life tables); or average mortality of all beneficiaries whose initial claim is for retired-worker benefits, from our full set of

[4] In comparison, a detailed survey like the Health and Retirement Study is too small to enable a study of claiming after the FRA, which is still relatively uncommon, and relies on self-reported claiming data, which is imperfect.

estimates by cohort; or average mortality by observed claiming age, from our estimates that allow claiming-age specific mortality. As our measure of expected benefits, we compute the expected present value (EPV) for each dollar of the primary insurance amount (PIA, the benefit payable to a worker if they were to claim at FRA. The percentage difference in this EPV by claiming age reveals the annual return on delayed claiming. Fourth, we repeat the analysis above distinguishing not by only claiming age but also lifetime earnings quartile, so we can disentangle the relationships between claiming age, mortality, and lifetime earnings. We use a 10% sample of all Social Security beneficiaries for our analysis: Even though this is quite large, few enough individuals in the latest cohorts we examine have died that in some cases we lack precision in some of the estimated relationships between claiming ages and mortality.

We begin by quantifying the increasing dispersion in claiming ages in recent cohorts. Typical claiming ages rose and claiming ages began to diverge considerably after the 1931-32 cohort started to claim benefits beginning in 1993. The median claiming age was 62.25 for the 1932 and 1933 cohorts, then rose to around 63 for the cohorts born around 1940 and almost 64 for cohorts born around 1945, while the 25th percentile claiming age remains just over 62 and the 75th percentile has risen to 66. Next, we investigate mortality of late versus early claimants using estimates from our mortality model. For the 1931-32 cohort and later, life expectancy at age 62 for age-62 claimants has been around one to two years lower than for age-66 claimants, so late claimants are adversely selected. While life expectancy since then has continued to increase, it has done so for early and late claimants, and we lack sufficiently long mortality histories for recent retiring cohorts to identify differential trends.

The impact on benefit payouts and actuarial fairness of selective claiming depends on changes in actuarial adjustments over time in combination with our identified claiming-age trends and mortality differentials. For the 1931-32 birth cohort, the return to delay was -1.88% if calculated based on all retired-worker claimant mortality. It was -0.32% (and so a better deal) if calculated for claimants who actually delayed until age 66, versus -2.63% (a worse deal) for those who actually claimed at 62 had they waited until age 66.[5] For later cohorts, the return on delaying has become systematically positive for those who actually delay claiming, but not for those who claim early.

Selective claiming has a small effect on the Trust Fund, but we find that it has a more consequential effect on lifetime benefit payout inequality. The effect on the trust fund is modest because the excess in benefits paid out due to the higher rate of return on delaying for those who actually delay only applies to the additional benefits that are gained by delaying. We calculate that the increase in trust fund payouts for the 1931-32 cohort, described above, was 0.3%. This amount may have increased to 0.5% for the most recent retiring cohorts, accounting for adjustments to our mortality model estimates for possible bias when estimating longevity for recent-retiring cohorts.

Lastly, we consider how these patterns have evolved for beneficiaries with different lifetime earnings. We find that selective claiming occurs within all earnings quartiles, but increases benefits more for those with higher lifetime earnings because such claiming is more prevalent and the return on delaying for high earners who actually

[5] As a reminder, this is for male retired-worker beneficiaries who did not initially claim disability insurance.

delay exceed actuarially fair amounts by larger margins. We further calculate that lifetime benefit payouts for the most recent retiring cohorts are 1.9% higher for those in the highest quartile of lifetime earnings as a result of claiming-age differences, compared to what payouts would be if those in the highest quartile had the same claiming ages as those in the lowest quartile. This contributes 2.8% to the difference in expected lifetime benefits between the highest and lowest quartiles. Thus, the redistributive effects of selective claiming are more consequential than the aggregate effects on payouts.

Our contributions extend the literature on claiming-age patterns and benefits inequality. Previous research has shown that high socioeconomic status workers are more likely to delay claiming (Coile et al. 2002; Hurd et al. 2004; Waldron 2001, 2002, 2004; Sass et al. 2013; Armour and Knapp 2021), that heterogeneity in claiming ages arises both within and across earnings groups (Waldron 2020b), and that economic and demographic inequality undoes much of the redistribution intended by the Social Security benefit formula (Liebman 2002). An analysis of recent data from the Health and Retirement Study (HRS) in Jaimes (2020) concluded that the mortality rate of men claiming retired worker benefits at age 65 was significantly and substantially lower than the mortality rate of men claiming at age 62, which updates similar results found earlier (Wolfe 1983; Waldron 2001, 2002, 2004; Duggan and Soares 2002). Our use of administrative data allows us to further examine how mortality has changed across retiring cohorts.

2. Social Security claiming incentives

2.1 The structure of Social Security benefits

The United States Social Security program provides three types of retirement benefits: 1) a retired worker benefit, 2) a spousal benefit payable to spouses of retired or disabled workers, if that benefit exceeds the spouse's own retired worker benefit, and 3) a survivor benefit payable to surviving spouses of a worker eligible for retirement benefits, if that benefit exceeds the surviving spouse's own retired worker benefit. The full retired-worker benefit is payable to workers who claim at their FRA, age 66 for those currently retiring, and increasing to age 67 for those born 1960 and later. The retired-worker benefit can be claimed as early as age 62 or as late as age 70, subject to actuarial adjustments in the monthly benefit, and after age 70 with no further adjustment.[6] For workers born prior to 1917, the delayed retirement credit (DRC, the increase in benefits for those who delayed claiming past their FRA) was small, only 1% a year. But, the DRC increased across succeeding birth cohorts, reaching 8% a year for those born 1943 or later, so the possibility of adverse selection might not become apparent for earlier cohorts.[7] For workers with a FRA of 66 (those born in 1943-54), claiming at age 62 results in a 25% reduction in their monthly benefit (i.e., their benefit at age 62 is 75% of what they would have received at age 66) and claiming at age 70 results in an increase in benefit of 32% relative to claiming at the FRA.

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[6] Effective August 1, 1961, workers were able to claim reduced benefits at age 62. We restrict our analysis to workers born in 1900 and later, as previous birth cohorts lacked the option to claim early (Cohen and Mitchell 1961).

[7] https://www.ssa.gov/OP_Home/cfr20/404/404-0313.htm

The academic literature on the returns on delaying mostly assumes a 3% interest rate, considerably above current rates.[8] At that interest rate, the returns to delayed claiming are approximately actuarially fair to workers with population-average mortality (Heiland and Yin 2014).[9] For such workers, the choice of claiming age has only a small effect on the EPV of lifetime benefits. At a household level, delayed claiming by a higher earner will typically increase the EPV of lifetime household benefits. After the death of a worker eligible for retirement benefits, their spouse can receive a survivor benefit if that exceeds the spouse's own retired worker benefit. Subject to minor exceptions, the amount of the survivor benefit equals the retired worker's benefit, so that delayed claiming by a retired worker increases not only their own retired worker benefit but also their spouse's survivor benfit. Offsetting this, delayed claiming of retired worker benefit will reduce the expected value of the spousal benefit.

Although Social Security treats men and women identically, in the cohorts that we study most recipients of spousal benefits are women and most women claim survivor if not spousal benefits, reflecting disparities in lifetime earnings. A wife (or husband) can only claim spousal benefits once her husband (or wife) has claimed their

[8] While the 2020 Trustees Report (U.S. Social Security Administration 2020) has lowered it to 2.3%, we will continue to use a standard three percent discount rate because we do not want the very recent change in interest rates to change our accounting of the impact of changes in claiming ages and mortality.

[9] The calculations assume that workers cease work but delay claiming, perhaps using financial assets to bridge the gap between retirement and delayed claiming. In practice, workers who delay claiming very often continue to work and make Social Security contributions. However, they will only increase their retired worker benefit if their earnings count as part of their highest 35 years' earnings. As earnings typically decline at older ages, in many cases they will not, so that workers will pay additional contributions but not earn additional benefits, reducing the return to delay.

retired worker benefit, unless they have been divorced for at least two years. The spousal benefit amount is based on the wife's claiming age, not on that of her husband, and does not increase if the wife delays claiming beyond her FRA.[10] The spousal benefit ceases on the husband's death when the wife switches to a survivor benefit. Delayed claiming of the spousal benefit will typically reduce the benefit's EPV. But across succeeding birth cohorts, a decreasing minority of spouses earn so little as to be eligible for spousal benefits (Favreault and Steuerle 2007).

In this study, we focus solely on men's delayed claiming of the retired-worker benefit, given the more complicated incentives for women and also difficulties with observing dependent and survivor claim histories in the administrative data that we use. We defer to future research a study of women, which Waldron (2020a) covers in an analysis of claiming patterns, because women in this age group will typically switch to a survivor benefit after the death of their husbands. We also defer study of the impact of delayed claiming on spousal and survivor benefits.

2.2 Previous research

We review four strands of research relevant to our study. The first is research into our specific question, the relationship between claiming age and mortality. The second investigates the actuarial fairness of the actuarial reduction factor (ARF) and DRC. The third is research into claiming ages and the relationship between claiming age and socioeconomic status. The fourth is research into the relationship between mortality and socioeconomic status. To summarize, the literature shows strong

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[10] An exception for early claiming arises if the spouse is caring for the entitled child (who must be less than 18 years of age) of the retired worker.

relationships between socioeconomic status and both mortality and claiming age, leading us to hypothesize a correlation between claiming age and mortality, so that even if the return on delayed claiming is actuarially fair to those with population average mortality, it will be more than fair to those who actually delay.

2.2.1 The relationship between claiming age and mortality

Updating earlier studies (Wolfe 1983; Waldron 2001, 2002, 2004; Duggan and Soares 2002), Jaimes (2020) has recently analyzed the relationship between claiming age and mortality. Using Health and Retirement Study data linked to administrative data on claiming ages and date of death, the study finds that workers who claim a retired worker benefit at older ages have significantly and substantially lower mortality than those who claim at age 62. A limitation of the study is the small sample size. Our use of administrative data allows us to identify mortality differentials by single year of claiming ages and to investigate whether the relationship between claiming age and mortality has changed across birth cohorts.

2.2.2 The actuarial fairness of the return to delayed claiming

Heiland and Yin (2014) investigate whether the DRC and benefit reduction for early claiming are actuarially fair so that the EPV of benefits, discounted by a rate of interest and annual survival probabilities is the same at all claiming ages. Assuming population average mortality for the cohorts now entering retirement and a 3% long-term real interest rate, they conclude that the returns on delaying are approximately actuarially fair. At the lower real interest rates on Treasury Inflation Protected Securities prevailing today, the return to delay is more than actuarially fair. Similarly, Shoven and Slavov (2013) show that declines in interest rates, combined with increases in life expectancy and changes in program rules, have made delay actuarially advantageous, even for high mortality individuals. The analysis in both papers focuses solely on retired worker benefits and does not consider the impact on spousal and survivor benefits.

2.2.3 The relationship between claiming age and socioeconomic status

The dispersion of retired worker claiming ages has increased across succeeding birth cohorts (Munnell and Chen 2015). As we will show, the relationship between claiming age and lifetime earnings as measured by Average Indexed Monthly Earnings (AIME) has also changed across birth cohorts so that the findings of previous research are only applicable to the cohorts studied. Nonetheless, a consistent finding is that high socioeconomic status workers are more likely to delay claiming (Coile et al. 2002; Hurd et al. 2004; Waldron 2001, 2002, 2004; Sass et al. 2013; Waldron 2020; Armour and Knapp 2021).

2.2.4 The relationship between mortality and socioeconomic status

As Sanzenbacher et al. (2019) report, one of the earliest studies on documenting mortality differentials by socioeconomic status is Kitagawa and Hauser (1973). Brown et al. (2002) and Waldron (2013) confirmed the same pattern using later data. More recent studies using earnings (Waldron 2007; Cristia 2009; Isaacs and Choudury 2017) and especially education (Cutler et al. 2011; Olshansky et al. 2012; Case and Deaton 2015) — which, unlike earnings, is not affected by mid-life health shocks — document increasing disparities in mortality by SES, though in some studies relative rankings suggest less widening than do absolute measures (Bound et al. 2014; Kindig and Cheng 2013, Bosworth et al. 2015; Sanzenbacher et al. 2019). In our analysis, we do not have access to education data and use earnings as a proxy. We take the conservative approach of using relative earnings rank (quartiles, in our case) within each cohort.

3. Data and research methodology

Our analysis of mortality differences by claiming age and of claiming age and mortality differences by lifetime earnings consists of four steps. First, we quantify changes in claiming ages by birth cohort and by lifetime earnings. Second, we estimate a mortality model using administrative data from the SSA, in order to investigate life expectancy by claiming age. Third, we compute the expected present value of benefits for individuals claiming at different ages and under different assumptions about mortality by claiming age. Fourth, we repeat the analysis incorporating differences by lifetime earnings quartile.

3.1 Administrative data set

As we noted earlier, our focus is on male retired-worker beneficiaries who never claimed disability insurance and who did not die before age 62. We track their claiming ages and mortality, sometimes differentiated by lifetime earnings, in administrative data from SSA. We use the 10% sample of the SSA Master Beneficiary Record (MBR) file — a longitudinal data set selected randomly among issued Social Security numbers — and match it to the Master Earnings File (MEF) and NUMIDENT. The matched data files contain information on Social Security taxable wages from 1951 through 2019, Social Security benefits, date of birth, and date of death. Our analysis sample comprises those with a matched record in the MBR, MEF, and NUMIDENT files.

We start with a sample of primary beneficiaries in the 10% MBR file whom we can match in the MEF and NUMIDENT files (N=14,848,075), as detailed in Appendix Table 1. We restrict the analysis sample to keep only those born in 1925 to 1944 (N=4,108,723). We exclude anyone who ever received disability insurance (DI; N=3,382,747) since, if they remain on DI, they do not face a choice of when to claim the retired-worker benefit or, if they return to the workforce, they are still likely to face different retirement and claiming-age incentives while experiencing considerably higher mortality. [11] We keep only those who are fully insured at age 61 for OASI benefits (N=3,148,806).[12] We keep only those who are alive at age 62 (N=3,106,126) and exclude those who claimed benefits other than OASI/spousal/survivor benefits or who recorded an OASI claim before age 62 or after age 70 (neither of which is common nor relevant for our analysis), leaving a remaining sample of 3,047,368, of which 1,683,069 are men. [13] Among these, 1,506,679 have died, and the rest remain alive as of 2019, the latest year of available mortality data.

[11] Workers who claim disability benefits are automatically transferred to retired-worker benefit on attaining their FRA. Our sample includes a small number of men who earned less than their spouse and who claim or may later claim the survivor benefit upon their spouse's death, thus altering the claiming-age incentives they face for the retired-worker benefit. While this is infrequent, we are unable to determine some individuals who are in such a position, given the MBR's limited information on spouses.

[12] To be fully insured for OASI, workers born in 1929 and later must have at least 40 quarters of coverage or 10 years of work. Workers born earlier faced slightly less stringent eligibility rules.

[13] For our initial analysis documenting patterns in claiming ages, but before considering mortality differentials by claiming age, we consider a broader set of cohorts, born between 1900 and 1950 (N=7,411,518). However, when analyzing mortality, we use the narrower sample, limited at the beginning when average retirement ages first begin to rise and limited at the end by the short mortality history of the latest cohorts, for whom we can say little about mortality for those who claim at different ages.

Our measure of lifetime earnings is age-62 AIME. Rather than use AIME as reported for each individual when they claim benefits, we compute AIME for everyone as of age 62. In this way, it is independent of later work (and hence claiming-age) decisions.[14]

3.2 Estimation strategy

Because we are studying cohorts whose members have not all died, we need to estimate a mortality model in order to project cohort annual survival probabilities. We estimate a Gompertz survival model, a parametric demography model commonly used to analyze mortality, and we allow for mortality differences by cohort, claiming age, and, in some specifications, lifetime earnings quartile. By parameterizing how survival changes with age, the survival model has the advantage of accounting for both left-censoring of mortality (some individuals who are eligible for Social Security die before claiming) and also right-censoring (some deaths have not yet occurred in our data). The Gompertz model is a two-parameter distribution with a hazard that takes the form:

$$h(t) = e^{\lambda} e^{\gamma t} \tag{1}$$

The parameter λ captures individual characteristics X_{1i} that affect baseline mortality at age 62:

$$\lambda_i = e^{X_{1i}\beta_1} \tag{2}$$

and similarly the parameter γ captures individual characteristics X_{2i} that affect the exponential growth rate of mortality at subsequent ages t:

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[14] The taxable maximum rose over time, which systematically increased values of AIME for the highest earners in later cohorts. Thus, our approach will understate lifetime earnings inequality to some degree for earlier cohorts.

$$\gamma_i = e^{X_{2i}\beta_2\, t} \quad (3)$$

In our base case, we allow both baseline mortality λ and the annual rate of increase γ to vary with birth year. We then allow baseline mortality λ to also vary with claiming age, so we can test whether people who claim benefits later have systematically lower mortality, and whether the relationship between claiming age and mortality has changed across birth cohorts. We then estimate a model in which baseline mortality λ and the annual age-related increase in mortality γ are also allowed to vary by AIME quartile, a measure of lifetime earnings that we use to proxy for socioeconomic status. The disadvantage of our large administrative data sample size is that we lack detailed information on socioeconomic characteristics, such as educational attainment, that may be correlated with mortality. We use AIME quartile as a proxy for socioeconomic status (SES) and estimate the model separately for each quartile.

The earliest cohorts we study have essentially complete mortality histories. For example, 90.8% of men in the 1925 birth cohort who lived to age 62 had died by 2019, the date to which we have mortality data.[15] For incomplete cohorts, the model relies on the empirical regularity first reported by Gompertz (1825) that the annual percentage increase in mortality varies little with age up to quite advanced ages. So if a worker who claims at age 70 has, for example, the biological age of a 62-year-old, we might expect that the age-related increase in mortality does not vary with claiming age. On the other hand, if there is an upper limit to life expectancy common to both unhealthy early claimants and healthy late claimants, we might expect a higher age-related increase in

[15] Authors' calculations using SSA cohort life tables.

mortality among late claimants. We experimented with a model in which γ, the annual age-related increase in mortality, also varied with claiming age, in order to capture these differences. Even with our 10% sample, however, the sample sizes for individuals claiming at older ages are relatively small, and our results lacked any statistical significance. We also found that we could not increase the effective sample size by pooling across additional birth cohorts. For example, the annual mortality growth rate was 8.9% for men in the 1925-26 birth cohort, compared with 5.9% for the 1943-44 birth cohort.[16] Imposing the restriction that the rate of increase is the same for all participants in the sample would bias estimates of the expected present value of lifetime benefits. Therefore, we allow the age-related increase in mortality to vary with birth year.

Besides that, we checked the assumption of constant exponential increases in mortality in SSA lifetables using a five-year moving average to smooth out substantial annual fluctuations in mortality. The annual percentage increase in mortality for the 1925 birth cohort rose with age until 90, and then declined, although at ages past 93, the decline is an actuarial projection. Given that benefits payable at very advanced ages are subject to substantial time and mortality discounting, we consider our assumption of exponentially increasing mortality a reasonable approximation.

3.3 Impact of claiming age differences on benefits

Once we estimate whether claiming age and subsequent mortality are correlated, we use the estimates to evaluate the impact on lifetime benefit payouts. We use our estimated coefficients to construct life tables and use those life tables for two sets of

[16] We curtail our analysis at the 1943-44 birth cohort and ages 74 to 75 because mortalities at older ages for more recent birth cohorts h yet to be observed.

calculations. First, we compare expected lifetime benefits for early and late claimers, showing how these calculations vary depending on what assumptions about life expectancy we use. Second, we calculate the gain to delaying claiming, calculated from differences in expected lifetime benefits. The key is that our mortality model yields estimates of mortality differences for early and late claimers. Therefore, we compare each metric assuming that claimers at each age have population-average mortality (from SSA life tables); average mortality of all beneficiaries whose initial claim is for retired-worker beneficiaries (our estimation sample); or average mortality of beneficiaries who claim at particular ages. This reveals the extent to which differences in mortality of early versus late claimers influences benefit payout inequality. We then do the same calculations, but allow claiming behavior and mortality to differ by lifetime earnings quartile.

For both metrics, we begin with the EPV of lifetime benefits per dollar of annualized PIA (the benefit payable at the FRA), payable at the claiming age and adjusted for early claiming or the DRC, as appropriate, and discounted back to age 62. For example, a worker born 1931-32 who was entitled to $1 a year of benefits at their age 65 FRA, but who claimed at age 70 would receive $1.25 a year. For that worker, we report that value, discounted back to age 62. We assume a 3% real interest rate. Some individuals who delay claiming do not survive to collect benefits, and our EPV for those who delay is averaged over those who survive to delay and those who we estimate, based on our mortality model, planned to delay but died before claiming.

4. Results

4.1 Claiming age trends

We begin by reporting claiming age patterns across cohorts for our sample of male retired-worker beneficiaries who never received DI. Claiming ages have diverged considerably in recent years. Figure 1 reports the median and the interquartile ranges of retired-worker claiming ages by single-year birth cohort for men born between 1900 and 1950.[17] As Figure 1 shows, claiming ages became more compressed for a while, with the median claiming age declining from 64.9 to 62.3 years between the 1900 and 1932 birth cohorts, who turned 62 in 1962 (when the early retirement age of 62 was first established) and 1994, respectively. More recently, this trend has reversed, with the median claiming age passing 63 for the 1941 cohort and 64.3 years for the 1950 birth cohort, which turned 62 in 2012. The 25th percentile of claiming ages was 62.6 years for the 1900 birth cohort and declined to fractionally over 62 years by the 1909 birth cohort, where it has remained. The 75th percentile closely tracks the FRA, which was 65 for those born 1937 and earlier, increasing by stages to age 66 for those born 1943-44. The prevailing trend in the most recent period of focus has been an increasing disparity in claiming ages, potentially exposing the program to adverse selection.

We then document how claiming age varies by socioeconomic status. Figure 2 reports the median retired-worker claiming age, by single-year birth cohort and by age-62 AIME quartile, which represents lifetime earnings groups. In all birth cohorts, the median claiming age was later in higher AIME quartiles. Meanwhile, the pattern of

[17] Although not all of the 1950 birth cohort have claimed yet, more than 75% have, and we are therefore able to report an interquartile range for all birth cohorts in our sample.

increasing compression for early birth cohorts and increasing divergence for recent cohorts is mirrored here across quartiles. From around the 1920 to 1937 birth cohorts, the median claiming age in the lowest three AIME quartiles hovered around age 62, reaching a low with the 1932 cohort, and doing so for the highest AIME quartile one to two years later. Starting with cohorts born in the late 1930s, median claiming ages began to increase for all AIME quartiles. The increase started earlier and has been larger thus far for those in the highest AIME quartile, although we now see a separation of median claiming ages between the lowest three AIME quartiles as well. Figure 3 reports the 75th percentile of claiming ages for each of the four AIME quartiles. The 75th percentile of those in the highest quartile have always delayed until their FRA. Those in the lower three quartiles used to claiming earlier, but by the 1950 birth cohort had converged with the highest earnings quartile.

The overall trend, therefore, has been increasing inequality in claiming ages both by socioeconomic status and also within groups of similar status. The impact of diverging claiming ages on trust fund payouts and on lifetime benefit inequality will depend on both life expectancy and lifetime earnings of early versus late claimants.

4.2 Mortality estimates

In order to investigate life expectancy by claiming age for cohorts whose members have not all died, we estimate a Gompertz survival model, while allowing for mortality differences by cohort, claiming age, and, in some specification, lifetime earnings quartile. This allows us to formally test whether early versus late claimants have differing mortality patterns and whether this pattern is related to socioeconomic status. We report the estimated values of baseline mortality at age 62, as derived from

Equation (2), and the estimated values of the growth rate of mortality, as derived from Equation (3). We report these from the specification that allows them to differ by birth cohort, then also allows baseline mortality to differ by claiming age, and then further allows baseline mortality and mortality growth to differ by age-62 AIME quartile. We also present the resulting value of remaining life expectancy at age 62, again differing by birth cohort, claiming age, and AIME quartile.[18]

Throughout, we compare our results to SSA cohort life tables, partly to investigate the difference between population-average life expectancy and life expectancy for our sample, which is relatively healthy because we exclude beneficiaries with a previous DI claim, and partly to gauge whether our cross-cohort changes in life-expectancy seem reasonable. Overall, we find that the model with the simplest set of covariates appears to overstate longevity for the recent (and most incomplete) cohorts. In comparison, richer models that include claiming-age dummies do a better job of capturing heterogeneity in mortality trajectories when those trajectories are relatively short. The latter yield reasonable estimates of baseline mortality, age-related mortality increases and, consequently, life expectancy, even for incomplete cohorts.

In the simplest model we allow both age-62 mortality λ and the annual growth rate in mortality γ to vary with two-year birth cohort (Table 1a). We find, unsurprisingly, that estimates of age-62 mortality for our sample of retired-worker beneficiaries without

[18] The raw coefficient estimates show how much log mortality at each age changes as a result of the covariate in question. To illustrate, in the specification for men born in 1931-32, λ, γ, and the age-66 claiming-age coefficient are estimated to be -4.298, 0.083, and -0.240 respectively. Age-70 log mortality of an age-66 claimant equals -4.298 + 0.083*(70-62)-0.240, or -3.874, which when exponentiated equals 2.08%.

any DI claim (who are, therefore, relatively healthy) are significantly lower than reported by SSA cohort life tables, decreasing from 1.42% for the 1925-26 birth cohort to 1.15% for the 1943-44 cohort. These values are reported in the second row and are the exponent of the estimated value of λ reported in the first row. The comparable population rates are 2% and 1.39%, respectively.

We further find that the estimated γ, the annual percentage increase in mortality with age, falls substantially for recent cohorts, decreasing from an 8.88% annual growth rate for the 1925-26 cohort to around 7% for cohorts born around 1940. These values are reported in the fourth row, as the exponent of the estimated value of γ reported in the third row. Such a substantial decline in the growth rate of mortality (which is statistically significant when comparing, for example, the 1931-32 and 1941-42 cohorts in Table 1b) may reflect a poor fit for later cohorts in our data. This concern is reflected when we use our estimated coefficients to calculate remaining life expectancy at age 62 for each cohort (Table 2). The estimates suggest that life expectancy increased from about 19 years for the 1925 cohort to 23 years for cohorts born around 1940, with the gap between mortality for this group of retired-workers with no prior DI claim and population mortality projected by SSA cohort life tables rising from 1.22 years for the 1925-26 cohort to around three years for cohorts born around 1940. Our values of γ for more recent cohorts are estimated only from deaths at younger ages (for example, below ages 74 to 75 for the 1943-44 cohort) and the resulting right-censoring biases these estimates because high-mortality individuals are observed to die but low-mortality individuals are not.[19] This subset of estimates for more recent cohorts lie below the range reported in the literature and is lower than the increase implied by Social Security cohort life tables, yielding quite high life expectancy estimates for these last cohorts. Consequently, we view mortality estimates for these very incomplete cohorts with caution.

Our second model includes claiming-age dummies that are allowed to vary with birth cohort, which accomplishes two things. First, this lets us answer our key question: Does mortality of early versus late claimants differ, and has that relationship changed over time? We find that mortality has declined across the board for our sample; that later claimants have persistently lower mortality; and that there is little clear evidence of any change in this disparity, though estimates are noisy. Second, it allows us to better fit mortality trajectories for recent incomplete cohorts, compared to the previous model without claiming-age dummies, by adjusting for the bias arising from incomplete cohorts. These issues will come to the fore later when we project the impact of selective claiming on the trust fund and on inequality in lifetime resources. For those purposes, we will consider an adjustment to the model without claiming-age dummies.

Estimates from the model with claiming-age dummies appear in Table 3a, which shows the estimated coefficients on the claiming-age dummies in both the λ term, which

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[19] A model without claiming-age dummies understates the age-related increase in mortality because the sample comprises only high-mortality early claimants at younger ages and only becomes fully balanced after age 70. Prior to that age, the data are subject to left-censoring at claiming age, with the censoring more severe for the low-mortality risk types who delay claiming. The bias is more pronounced when the unbalanced sample comprises a larger share of all ages observed, as is the case with, say, the 1943-44 birth cohort, which is only observed to ages 74-75 (so that the eight years from 62 to 70 are unbalanced, but only four years, from 70 to 74, are a fully balanced sample).

allows baseline mortality at age 62 to differ relative to age-62 claimants. Table 3b shows the percentage change in estimated mortality by claiming age, relative to age 62, as implied by the claiming-age coefficients in Table 3a, and Table 4 shows the implied effect on remaining expected life expectancy by claiming age. At younger claiming ages, the claiming-age coefficients are generally statistically significant, although they vary considerably in magnitude from cohort to cohort. At older claiming ages, the claiming-age coefficients generally lack statistical significance, reflecting small number of claimants. In this model, γ increases slightly across birth cohorts but always lies within the range of 0.068-0.086, so the estimates are more stable than in the model without claiming-age dummies. Moreover, estimates of both λ and γ exhibit a steady downward trend, and γ lies within the range implied by Social Security cohort life tables, unlike with the model without claiming-age dummies. While it would be unwieldy to test whether every cohort's parameter estimates differ from each other, in Table 3c we test equality of each of the parameters (baseline mortality λ, claiming-age dummies for ages 63 to 70, and age-related growth in mortality γ) for the 1931-32 and the 1941-42 cohorts. Estimates of λ and γ are significantly smaller in the later cohort, while the estimates of claiming-age dummies are in some cases significantly different but not systematically so.[20]

We discuss resulting mortality expectations from the model estimated with claiming-age dummies for men in the 1931-32 birth cohort, a cohort for which we

[20] While the age-69 and age-70 coefficients are significantly different between the cohorts, we do not place much store by this test because it lacks power. Age-69 and age-70 claimants in the 1941-42 cohort are only observed for six to eight years, few people claim at these ages, and even fewer of those late claimants have died.

observe mortality for many of its members and, therefore, have a high degree of confidence in estimates of the relationship between claiming age and subsequent mortality. In the 1931-32 birth cohort, men who claim at age 62 have an age-62 mortality rate of 1.36% (the exponent of -4.298, the λ coefficient estimate). Even though age-62 claimants have higher mortality than those who claim at older ages, their mortality is still lower than population-average mortality of 1.78%, based on SSA life tables, which reflect the much higher mortality of Social Security disabled worker benefit recipients. Delayed claiming is associated with significant and substantially lower mortality. Mortality among age-66 claimants is 21.3% lower than among those who claim at age 62. These differences in mortality are reflected in differences in life expectancy (Table 4). Counting those who die prior to age 66, age-62 life expectancy among age-66 claimers is 22.0 years, compared with 19.8 years among age-62 claimants, a gap of 2.2 years.[21]

Lastly, we examine mortality differences by socioeconomic status, allowing both baseline mortality at age 62 and mortality growth to differ by age-62 AIME quartile. In Tables 5a and 6 we confirm, as has been widely documented (including by Sanzenbacher et al. 2019, Waldron 2013), that men in the highest lifetime-earnings quartile have substantially lower mortality than men in lower lifetime-earnings quartiles even in our sample that excludes higher-mortality beneficiaries who initially claim DI. This results from a significantly more negative estimated value of λ in higher AIME

[21] As we noted earlier, we do not observe the claiming age of men who would have claimed at age 66 but died before that age, but we are able to calculate the age-62 life expectancy of age-66 claimants by reason of our assumption of a constant percentage increase in mortality with age.

quartiles. However, we also find that γ is significantly higher in higher quartiles, demonstrating the mortality rates between quartiles converge at older ages. The claiming-age coefficients are somewhat noisy given our relatively small sample size, and some lack statistical significance, but they generally show that the coefficients tend to be smaller for the higher AIME quartiles, suggesting less selection in claiming than within the lower AIME quartiles. A full set of parameter tests across cohorts and AIME quartiles is even more unwieldy than for the previous model, so we once again limit ourselves to testing significance across AIME quartiles within the 1931-32 and 1941-42 birth cohorts and for the same AIME quartiles across these cohorts (Table 5b). The same pattern generally holds across AIME quartiles within the 1941-42 birth cohort as discussed above. It is also the case that many of these parameters are significantly different when comparing the two birth cohorts, quartile by quartile, with significant differences for all values of λ and γ and for some of the claiming-age dummies, especially at younger ages from 63 to 65. When the differences in claiming-age dummies are significant, they are generally more negative (implying lower baseline mortality) for the later cohort.

Notably, conditioning on AIME quartile reveals almost as strong a relationship between claiming age and mortality within AIME quartiles as between them. Comparing age-62 claimants versus age-66 claimants within the four AIME quartiles in the 1931-32 birth cohort, age-62 mortality is lower by 25.9%, 13.7%, 13.2%, and 15.0% for the later claimants than for the early claimants, compared with the overall reduction of 21.3% for all quartiles combined. Therefore, some of the selection in claiming is related to, and may be accounted for by, socioeconomic status, but considerable selection remains even within earnings groups.

Now that we have established that later claimants have lower mortality, and especially that high-earning later claimants have even lower mortality, we will consider the impact of selective claiming on benefits. We compare expected lifetime benefits and the gain to delaying claiming under different mortality assumptions, first assuming that beneficiaries have population-average mortality (from SSA life tables) and then based on estimates from the model that incorporates mortality differences by claiming age and then by claiming age and AIME quartile.

4.3 Impact of delayed claiming on expected lifetime benefits

To understand how delayed claiming affects benefit payouts, Table 7 shows how the EPV of lifetime benefits depends on life expectancy. We report the EPV of benefits per dollar of annualized PIA, the benefit payable at the FRA, discounted back to age 62, by birth cohort and claiming age, calculated with a 3% interest rate.

The first panel of Table 7 uses population-average mortality (from SSA life tables) to compute the EPV, while the second panel instead uses claiming-age specific mortality, which incorporates systematic differences in mortality for early versus late claimers. The third panel reports percentage differences in EPVs of individuals who claimed at 62, given the mortality of age-62 claimants, with, say, individuals who claimed at 63 and had the mortality of age-63 claimants, and so on. These are not equivalent to the individual return to delay, which we discuss later, but rather show the impact of mortality differences by claiming age. Thus, for the 1931-32 birth cohort in the first column (reaching FRA in 1996-97), each $1 of annualized PIA for those who claim at age 62 yields $10.89 in expected lifetime benefits, assuming population-average mortality for men of that birth cohort (in the first panel), and $11.36 assuming average mortality of men who actually claim at age 62 (in the second panel), reflecting the slightly lower-than-population-average mortality of age-62 claimants.[22] In comparison, for those who claim at age 66, each $1 of PIA yields $10.47 assuming population-average mortality. This is *lower* than the $10.89 available if the same individuals claimed at age 62 (as reported in the third panel) because of the actuarial unfairness of the DRC for that cohort. On the other hand, assuming average mortality of actual age-66 claimers yields expected lifetime benefits of $12.23 per dollar of PIA, exceeding their age-62 benefit (as reported in the fourth panel). But, even the low mortality of age-66 claimants is insufficient to offset the meager DRC faced by this cohort, and their EPV plateaus and then declines after age 66.

Assuming population mortality, men who delayed claiming used to receive substantially lower expected present values per dollar of PIA, in spite of their longer life expectancy, than those who claimed early (Panel 3), especially for claiming at late ages. These differences remained negative even with the increase in the DRC for later cohorts in our sample. Assuming claiming-age specific mortality, however, yields a different picture. Even with a disadvantageous DRC, only the earliest cohorts had lower EPVs for late claiming ages. For cohorts born by the early 1930s, those who delayed

[22] When using population-average mortality, the value at age 62 is a little lower because it implicitly includes mortality experiences of men whose first claim is for disability insurance. In our estimation, we exclude them, in order to focus solely on men whose first claim is for retired-worker beneficiaries. Thus, when we instead use expected mortality for our full estimation sample (as shown in the final panel of Table 4), expected lifetime benefits for age-62 claimers are a little higher.

generally had higher EPVs than those who claimed early. While small sample sizes lead to considerable variability in these differences for later cohorts retiring at older ages, the difference in EPVs for late claimants has generally increased. Again, these percent differences in EPVs by claiming age do not measure an individual's return on delaying, a topic we address in the next section.

4.4 Impact of delayed claiming on the return on delaying claiming

The analysis above combines two effects induced by mortality differences associated with delayed claiming, the first arising by virtue of life expectancy disparities, and the second through the operation of actuarial adjustments. Here, we evaluate whether the adjustments are, in practice, actuarially fair for late claimants, who have systematically longer life expectancy than early claimants.

Table 8 shows the return on delaying claiming, which is computed as the percentage change in the EPV of lifetime benefits as a result of claiming at each year after age 62, under different mortality assumptions and, again, calculated with a 3% interest rate. The first panel shows, similar to the previous section, the EPV of lifetime benefits per $1 of annualized PIA, but now computed using the average mortality of age-62 claimants, for each claiming age from 62 to 70. The second panel shows the same, but computed using the average mortality of age-66 claimants. The third and fourth panels show the return to delaying claiming as the percentage difference between the expected lifetime benefit of claiming at each age after 62, using age-62 and age-66 expected mortality, respectively.

While Table 7 showed that mortality differences caused late claimants to have higher expected lifetime benefits from about the 1927 birth cohort on, Table 8 shows that the actuarial adjustments did not begin to reward late claiming until, perhaps, the 1939 birth cohort, when the return on delaying becomes consistently positive among claiming ages for men with age-66 claimant mortality expectations. For example, for the 1931-32 birth cohort, the return to delaying claiming from age 62 to 66 is -0.32% when using age-66 claimant mortality (it is more negative for age-62 claimants at -2.63%). In comparison, it reaches 4.53% for the 1941-42 birth cohort and 6.42% for the 1943-44 birth cohort.

These shifts toward a reward for delaying claiming among those who delay reflect increases in the DRC as well as increasingly selective claiming. The upshot is the emergence of fiscal consequences from adverse selection about 15 years ago. Moving forward, it seems likely that adverse selection will increase further if cohort-wide reductions in mortality continue.

4.5 The role of socioeconomic disparities

We now examine the extent to which differences in expected lifetime benefits persist once we control for mortality differences in lifetime earnings, as measured by age-62 AIME quartile. We report results for models estimated separately for men in each AIME quartile that also include claiming-age dummies. Unfortunately, the sample sizes are small enough that the latter does not yield very precise estimates.

Table 9 reports the EPV of benefits (per dollar of PIA, by AIME quartile, birth cohort, and claiming age) and the percentage by which the EPV of the benefits of workers who delay claiming exceeds the benefits of those who claim at age 62. As previously, these percentages are not a claimant’s return on delaying. We also calculated the EPV of lifetime benefits and the return on delaying for workers with the mortality of age-62 or of age-66 claimants in each of the four AIME quartiles, a total of eight cases. We report the polar cases, the EPV of age-62 claimants in AIME quartile one, and of age-66 claimants in AIME quartile four (Table 10).

The data are noisy, but several patterns emerge. First, as we noted earlier, the within-AIME quartile relationship between claiming age and EPV is of a similar order of magnitude to the overall relationship. However, the share who claim late is lower in lower AIME quartiles. In the 1943-44 birth cohort, 17.6% claim at age 66 or later in the lowest quartile, compared to 34.3% in the highest quartile. Second, conditional on claiming age (in addition to unconditionally), workers in higher AIME quartiles have higher EPVs, reflecting their greater longevity relative to workers in lower AIME quartiles. Third, selective claiming increases EPVs for high earners by more than for low earners because it is more prevalent and because the returns on delaying for later-claiming high earners exceed actuarially fair amounts by larger margins. For example, in the 1943-44 birth cohort, age-66 claimants have a return to delay of 5.6% in the lowest quartile (not reported in the table, but available on request), compared to 7.4% in the highest quartile. This is an economically significant but not a dramatic increase. Fourth, the dollar gains in EPVs are larger for higher earners, who have higher PIAs, which will matter for the trust fund calculations that we undertake next.

5. Impact on the Social Security trust fund

While our research suggests that the returns on delayed claiming became positive for those who delay about 15 years ago, over a longer period, adverse selection in claiming has increased trust fund payouts relative to what they would have been. Nevertheless, for the cohorts we study, the impact on the trust fund has been modest.

We define the adverse impact on the trust fund of adverse selection in claiming as the excess of the rate of return on delay of those who actually delay over the rate of return they would have earned had they experienced population-average mortality, weighted by the share who delay claiming. This disregards the offsetting benefit to the trust fund derived from offering a DRC that was less than actuarially fair to workers with population average mortality. In other words, the return on delaying may be negative, but selective claiming may make it less negative than it would be if all claimants had the same life expectancy.

To illustrate, those in the 1931-32 birth cohort who delayed to age 66 earned a -0.32% return (as shown in the fourth panel of Table 8), compared with a population average return of -3.81% (in the third panel of Table 7), a gap of 3.49 percentage points. About half of this gap arises because even men who claim the retired-worker benefit at age 62 have lower-than-population average mortality, reflecting the exclusion of high mortality risk, DI-benefit claimants from the retired-worker benefit risk pool. The other half of the gap in the return on delaying claiming until age 66 comes from age-66 claimants having even lower mortality than age-62 claimants. These shares should be regarded as rough orders of magnitude as even with the 10% sample, the return gaps fluctuate across cohorts and claiming ages.

As only 1.4% of workers in the 1931-32 cohort delayed to age 66, however, the impact of age-66 claimants on the trust fund was a mere 0.05%. By the 1943-44 cohort, the share of workers claiming at age 66 had increased to 19.6%, in large part due to a shift from claiming at age 65, and the gap between population-average and age-66 claiming age returns on delaying had widened to 6.80 percentage points (6.42% minus -

0.38%), although some of the increase in the gap, which reflects an increasing divergence between population and retired worker mortality, may reflect the tentative nature of our estimates for very incomplete cohorts.

To measure the full trust fund impact, we make four calculations of the EPV of each worker's benefit, given their claiming age and PIA, assuming that they have 1) population-average mortality; 2) sample-average mortality of retired-worker benefit claimants; 3) mortality of claimants in the same age-62 AIME quartile; and 4) mortality specific to their claiming age along with their AIME quartile.[23] We sum across all workers in each birth cohort to arrive at mortality differentials' overall impact on aggregate trust fund liabilities for the cohort. The fourth step delivers the impact of selective claiming on benefits but, as with the earlier steps, we face the problem arising because of bias in estimating how mortality differs between our sample and the population if we ignore claiming-age differences. As we noted in Section 4.2, incorporating claiming-age differences in mortality allows us to fit mortality trajectories better for recent incomplete cohorts, delivering estimates of age-related increases in mortality that were not decreasing substantially (and, perhaps, unrealistically) for the most recent cohorts. Therefore, for the second and third steps above, we try an adjusted calculation as well, in order to correct for this bias.[24] For this adjustment we

[23] As we noted earlier, the calculations assume that beneficiaries who delay claiming cease work, since we are not modeling the impact of delayed claiming on work decisions. Therefore, we do not calculate the impact of additional work on either taxes paid to the trust fund or on benefit recalculations.

[24] The adjustments that we make in the intermediate steps do not affect the total trust fund costs, but rather their attribution to the differences in mortality between our sample of non-DI claimants and population-average mortality on the one hand and to the role of selective claiming on the other. We note that population-level SSA cohort mortality tables, which we use

use a value of λ, baseline mortality at age 62, computed as the weighted average of the age-62 mortality rates of age 62 to age 70 claimants derived from the model with claiming-age dummies. We use the value of γ, the age-related increase in mortality, estimated in the same model with claiming-age dummies.[25]

The differences between the successive calculations of the trust fund impact capture three ways in which mortality differentials increase trust fund expenditures: Non-DI claimants have longer life expectancy than DI claimants; higher earners have longer life expectancy and higher benefits than lower earners; and, finally, late claimants have longer life expectancy than early claimants, which is the selective claiming that is our focus. The adjustment that we just mentioned shifts the allocation among these factors, principally from the first to the third, by modest amounts for recent cohorts. All numbers are reported in millions of current dollars per two-year birth cohort.

The result of all three factors, as shown in Table 11, is an increase in Trust Fund liabilities of around 9% for cohorts born in the mid-1920s to as high as 21% for cohorts born in the mid-1940s. For the early cohorts, whether considering the unadjusted mortality estimates or the estimates adjusted for bias, about 6 percentage points were due to greater longevity among retired-worker beneficiaries without a DI claim in our sample relative to the population average. About 1.7-1.8 percentage points were due to

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for this comparison, are constructed using historical data for prior years and actuarial forecasts for future years, whereas our models for retired workers are estimated parametrically.

[25] The weights are the shares of workers claiming at each age. Recall that the model with claiming-age dummies had more realistic life expectancy at late-claiming ages for recent cohorts compared to the model without claiming-age dummies. The weighted average approach thus uses these better estimates but averages over differences in mortality by claiming age.

longer life expectancy of higher earners, and about 0.2-0.3 percentage points were due to selective claiming by the longer-lived within our sample. In more recent cohorts, our capacity to attribute the shares resulting from each factor depends modestly on how we treat the mortality results from the model without claiming-age dummies. The first and second comparisons, between trust fund liabilities assuming retired-worker versus population-average mortality, rests on those estimates, which we believe overestimate longevity and, therefore, overstate liabilities. By the same token, then, they would understate liabilities attributable to the third comparison, between retired-worker mortality and claiming-age specific mortality. If we ignore these caveats, it appears that the first factor increases trust fund liabilities to almost 19%, with the role of lower mortality by high earners declining very slightly among later cohorts to 1.4-1.6 percentage points and the role of selective claiming rising very slightly to 0.3-0.4 percentage points. If, instead, we adjust our estimates, those amounts shift a little, with the role of the first factor reaching almost 18% instead of almost 19%, the second factor remaining essentially unchanged, and the third factor, selective claiming, rising to 0.5-0.7 percentage points for the most recent cohorts we consider.

Overall, our calculations demonstrate that the increase in trust fund payouts due to adverse selection in claiming are, unsurprisingly, modest. While someone with a PIA of $1,000 who delays claiming from age 66 to 67 gets a monthly benefit of $1,080 instead of $1,000, the impact on payouts of greater longevity is the impact of paying the additional $80 for longer, not the impact of paying $1,080 for longer.[26]

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[26] Besides the possibility that the model without claiming age dummies overstates longevity attributable to the difference between all claimants and retired-worker claimants and understates the difference between retired-worker claimants and age-specific claiming, it may

Moving forward, the impact on the trust fund of the very substantial increases in claiming age being observed as the FRA rises will depend on the longevity of those who now delay. Those who delay from, say, 62 to 63 may have similar longevity to those who previously claimed at age 62 and earn a return that is only slightly more than actuarially fair, so that selection will diminish. Or, later claimants may continue to be a select group with mortality similar to those who currently delay, so that selection will increase, with age-62 claimants becoming an even higher mortality group. Meanwhile, those who delay from 69 to 70 may have much greater longevity, but their cost to the trust fund will be mitigated by the decreasing actuarial fairness of the DRC at very advanced claiming ages.[27]

6. Impact on inequality in benefit payouts

Lastly, we consider the role of selective claiming in increasing benefit payout inequality. As we pointed out earlier, late claiming has risen faster for those in higher age-62 AIME quartiles, and late claiming by beneficiaries with longer life expectancy occurs both within and across AIME quartiles. The result is that workers in higher AIME quartiles have higher EPVs and a greater return to delaying claiming because of their longer life expectancy.

To quantify the resulting redistribution, we undertake similar calculations as when we consider the impact on the trust fund as a whole. We focus our comparisons on the

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also be possible that workers who delay have become a less select group. An F-test does not lend support for this hypothesis, however.

[27] An adjustment that is truly actuarially fair (even without selective claiming) should increase with age, as remaining life expectancy gets shorter.

highest and lowest lifetime earnings quartiles (as measured by AIME calculated at age 62), and we show the impact of using different life expectancy assumptions in order to highlight the interaction of selective claiming and lifetime earnings differentials. Using data on mean PIA by claiming age and AIME quartile, the shares claiming at each age in each quartile, and the EPV of lifetime benefits by claiming age and AIME quartile, we calculate the mean EPV of lifetime benefits by AIME quartile and claiming age. We then recalculate the mean EPV for the highest quartile assuming that they 1) had the claiming age pattern of workers in the lowest AIME quartile, while retaining the mortality appropriate to their original claiming age, then 2) had the mortality rates and claiming age distribution of workers in the lowest AIME quartile, and then 3) also had the AIME of workers in the lowest AIME quartile (Table 12). To illustrate, for the 1931-32 birth cohort, the mean EPV of lifetime benefits was $115,360 for those in the highest quartile and $43,170 for those in the lowest quartile, a ratio of 2.68:1. But, the mean EPV of those in the highest quartile would have been $115,207 if they had claimed at the same ages as those in the lowest quartile (so that differences in the extent of selective claiming increased benefits by 0.4%) and $96,653 if they also had the lowest quartile mortality (so that mortality differentials increased benefits by 19.2%). The rest of the difference is accounted for by differences in AIME.

We find that inequality in the EPV of benefits has increased considerably from the 1925-26 to 1943-44 cohorts. The ratio of the mean EPVs of highest to lowest quartile workers has increased from 2.62 to 3.09 over the period. Differences in earnings continue to make the largest contribution to differences in EPVs, almost three-quarters of the total. Differences in mortality account for close to a quarter.[28] Differences in claiming ages account for a small but increasing share, increasing from 0.2% of the total to 2.8%. Relative to a base case of highest quartile men having the mortality and claiming ages of lowest quartile men, lower mortality increases trust fund liabilities by 21.3% and selective claiming increases liabilities by 1.9% in the most recent cohort. While these values are not directly comparable with our earlier calculations for the trust fund, which assume a base case of all men having the average mortality of their earnings quartile irrespective of claiming age, they indicate somewhat greater consequences of selective claiming for redistribution within cohorts than on the trust fund as a whole.

7. Conclusions

Our results demonstrate that adverse selection in benefit claiming has become more prevalent. Late claiming of Social Security benefits by individuals with both relatively high lifetime earnings and relatively high life expectancy undermines the neutrality of the actuarial adjustments as well as elements of redistribution that are built into the benefit payout formula.

In future research, we plan to extend this analysis. By incorporating the complicated claiming-age incentives that couples face, we can analyze how household-level inequality is influenced by claiming age, mortality, and earnings patterns. Also, by determining how the COVID-19 pandemic has affected both mortality and retirement

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[28] The relative magnitudes depend on the order in which the adjustments are made. We first give AIME Q4 men the claimomg ages of AIME Q1 and then also give them the mortality of AIME Q1.

and claiming ages, we can evaluate the consequences for the trust fund moving forward.

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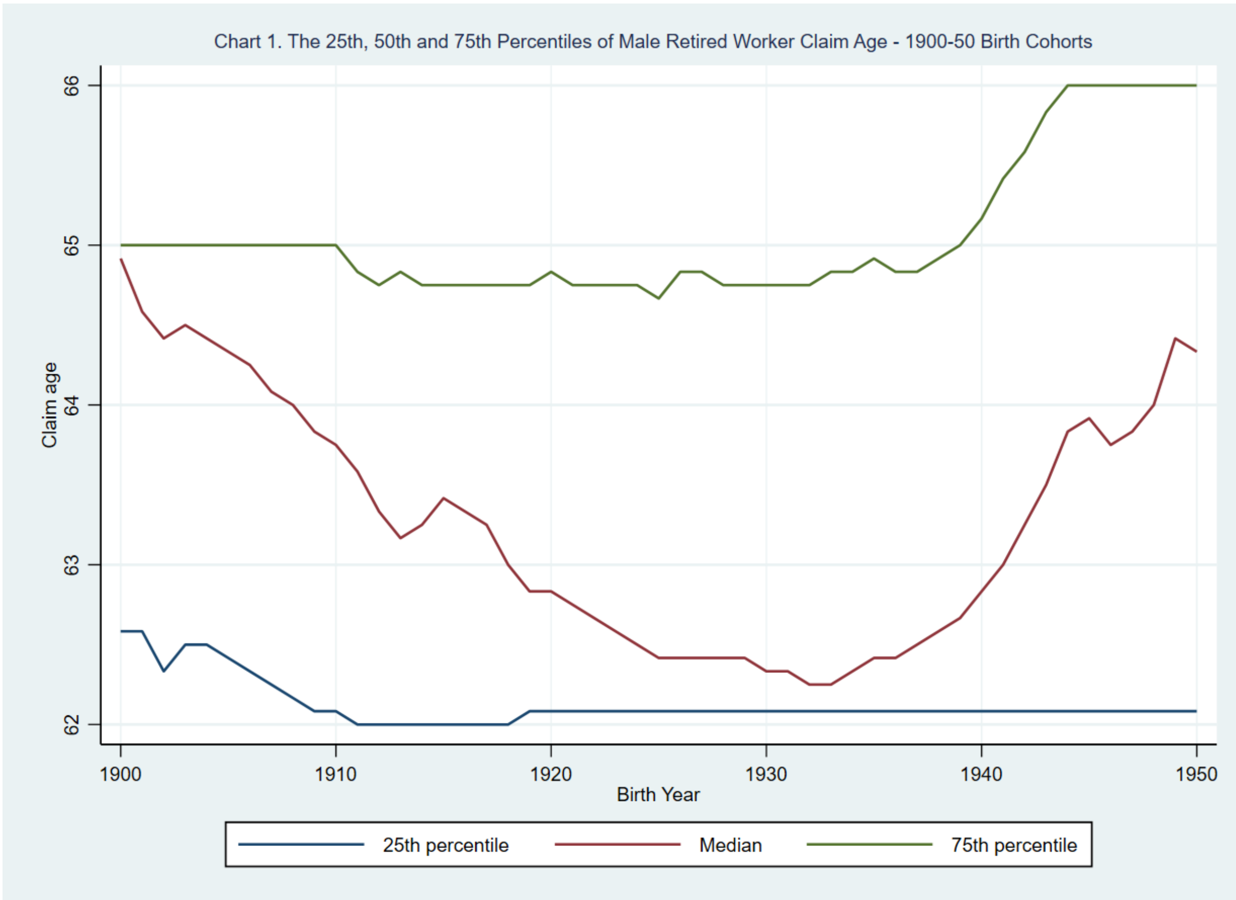
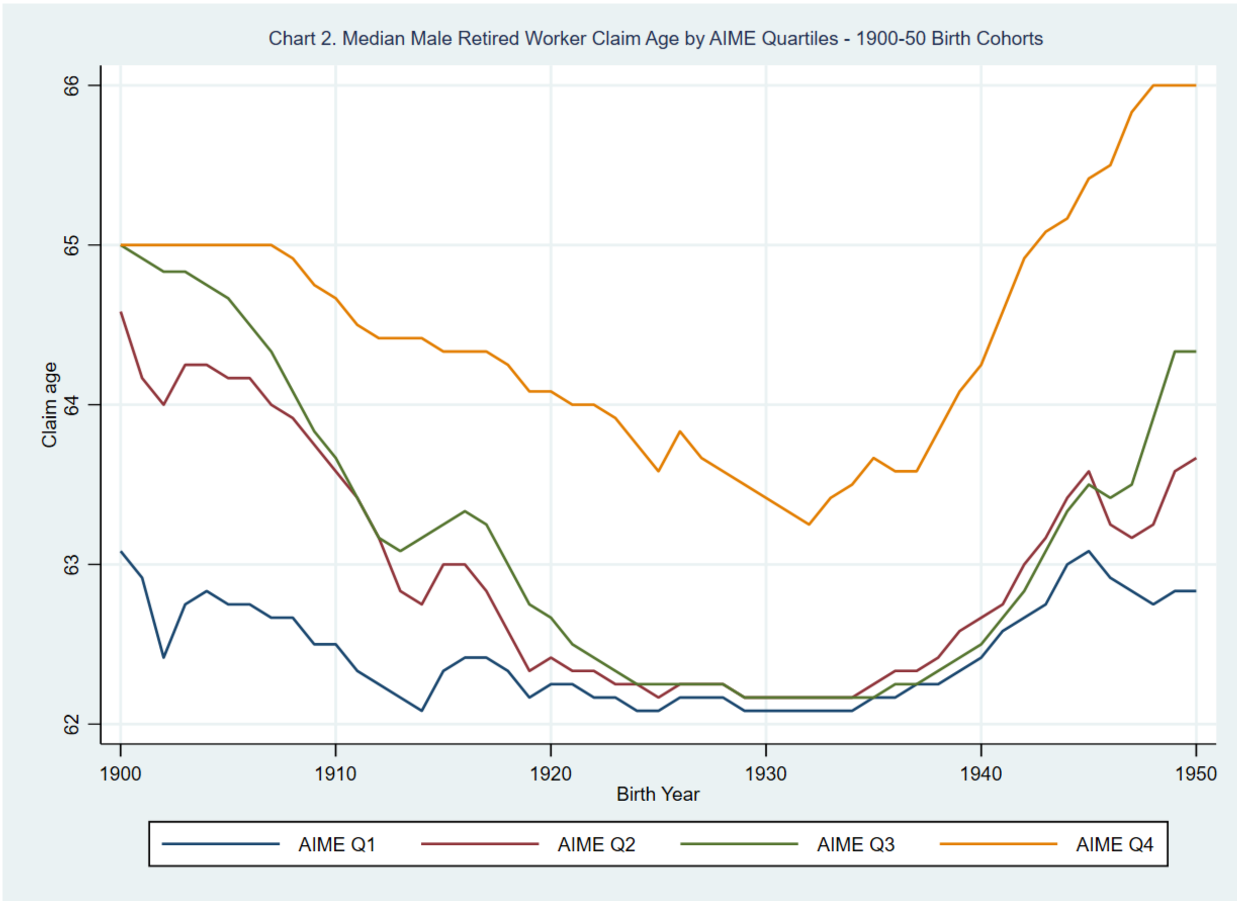
Figure 1: The 25th, 50th, and 75th percentiles of male, retired worker claiming ages, 1900 to 1950 birth cohorts



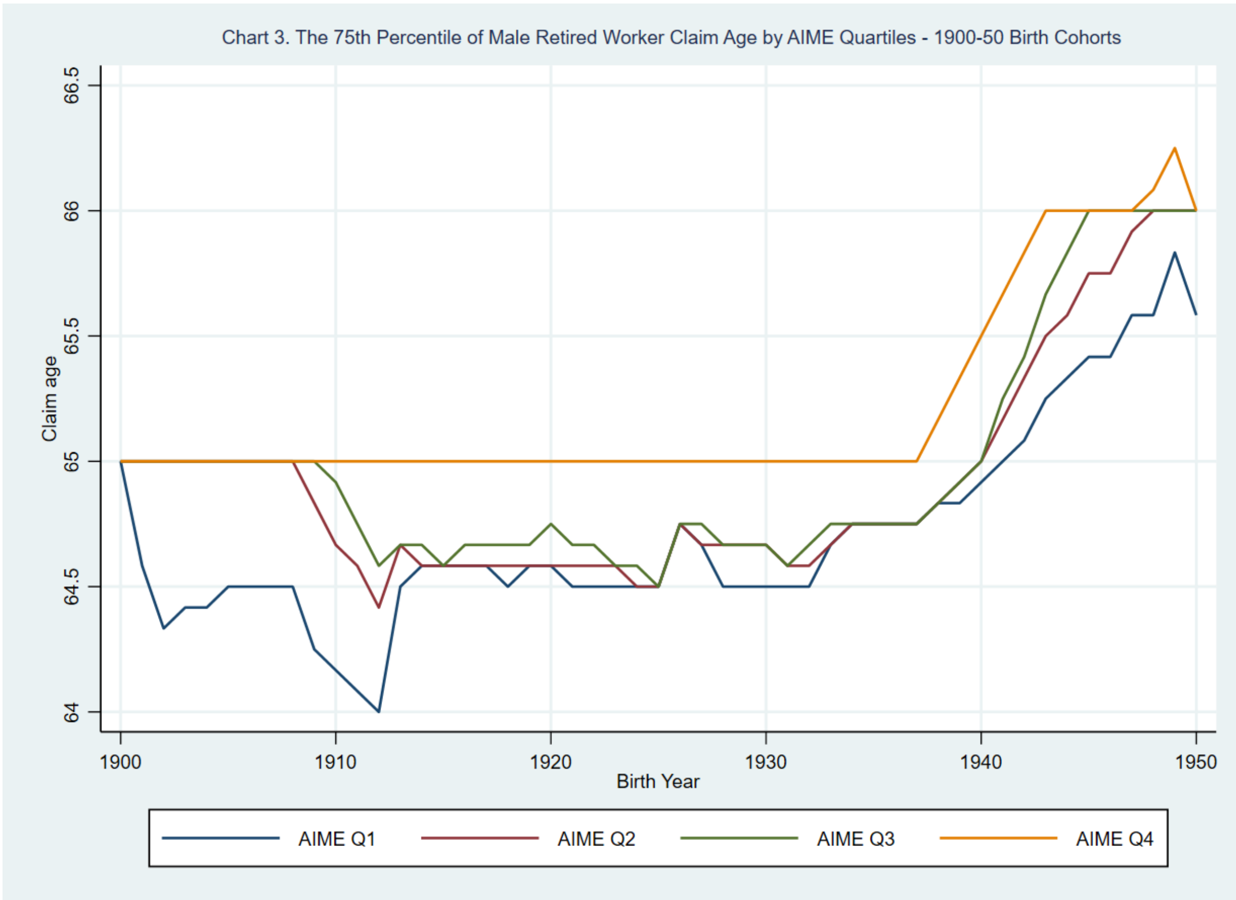
Source: Authors' calculations using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Figure 2: Median male retired worker claiming ages by AIME quartiles, 1900 to 1950 cohorts



Source: Authors' calculations using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Figure 3: The 75th percentile of male retired worker claiming ages by AIME quartiles, 1900 to 1950 birth cohorts



Source: Authors' calculations using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 1a: Mortality model estimates, no additional controls

Birth cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
Estimated λ	-4.254***	-4.267***	-4.304***	-4.352***	-4.403***	-4.453***	-4.487***	-4.497***	-4.509***	-4.469***
(standard errors)	(0.00633)	(0.00654)	(0.00699)	(0.00754)	(0.00819)	(0.00871)	(0.00929)	(0.0101)	(0.0107)	(0.0118)
Implied age-62 mortality	0.0142	0.0140	0.0135	0.0129	0.0122	0.0116	0.0113	0.0111	0.0110	0.0115
Estimated γ	0.0851***	0.0837***	0.0824***	0.0816***	0.0805***	0.0797***	0.0775***	0.0738***	0.0687***	0.0577***
(standard errors)	(0.00032)	(0.00034)	(0.00038)	(0.00043)	(0.00050)	(0.00058)	(0.00068)	(0.00081)	(0.00097)	(0.00120)
Implied annual growth rate In mortality	8.88%	8.73%	8.59%	8.50%	8.38%	8.30%	8.06%	7.66%	7.11%	5.94%
Observations	157,916	159,952	156,200	152,836	151,023	157,620	166,343	171,603	196,323	209,129

Source: Authors' calculations, based on estimates of a Gompertz mortality model with no additional controls, using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims. Notes: λ is the natural log of age 62-mortality, and γ is the natural log of the annual growth rate in mortality. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 1b: Parameter tests, mortality model estimates with no additional controls

	coefficient	signif. diff. than:	coefficient	significantly different than:	
Birth cohort	1931-32	0	1941-42	0	1931-32
Estimated λ	-4.352	***	-4.509	***	***
Estimated γ	0.082	***	0.069	***	***

Notes: Estimates from Table 1a. Columns with stars indicate whether estimates are significantly different from zero or across cohorts, respectively.
*** p<0.01, ** p<0.05, * p<0.1.

Table 2: Implied life expectancy at age 62 from mortality model estimates, no additional controls

Birth cohort	**1925-26**	**1927-28**	**1929-30**	**1931-32**	**1933-34**	**1935-36**	**1937-38**	**1939-40**	**1941-42**	**1943-44**
Estimated from model, Table 1	19.13	19.40	19.88	20.40	20.99	21.54	22.14	22.73	23.53	24.67
SSA cohort life tables	17.91	18.19	18.48	18.79	19.11	19.43	19.70	19.92	20.12	20.31
Difference	1.22	1.21	1.40	1.61	1.88	2.11	2.44	2.81	3.41	4.36

Source: Authors' calculations, based on Table 1a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims

Table 3a: Mortality model estimates, including claiming-age dummies

Birth cohort	**1925-26**	**1927-28**	**1929-30**	**1931-32**	**1933-34**	**1935-36**	**1937-38**	**1939-40**	**1941-42**	**1943-44**
Estimated λ	-4.199***	-4.212***	-4.248***	-4.298***	-4.345***	-4.387***	-4.411***	-4.424***	-4.439***	-4.414***
claim-age 62	(0.00657)	(0.00678)	(0.00720)	(0.00775)	(0.00842)	(0.00897)	(0.00952)	(0.0104)	(0.0109)	(0.0120)
Dummy, age 63	-0.0516***	-0.0517***	-0.0691***	-0.0799***	-0.0490***	-0.0511***	-0.0435***	-0.0388**	-0.00560	-0.00514
	(0.00980)	(0.00976)	(0.0104)	(0.0113)	(0.0128)	(0.0131)	(0.0143)	(0.0153)	(0.0159)	(0.0173)
64	-0.147***	-0.153***	-0.164***	-0.160***	-0.162***	-0.172***	-0.217***	-0.156***	-0.132***	-0.0791***
	(0.00729)	(0.00767)	(0.00835)	(0.00925)	(0.0100)	(0.0105)	(0.0110)	(0.0132)	(0.0152)	(0.0166)
65	-0.239***	-0.242***	-0.245***	-0.228***	-0.267***	-0.314***	-0.372***	-0.375***	-0.394***	-0.284***
	(0.00776)	(0.00786)	(0.00852)	(0.00915)	(0.00939)	(0.00949)	(0.0104)	(0.0105)	(0.0107)	(0.0149)
66	-0.194***	-0.195***	-0.181***	-0.240***	-0.280***	-0.0553	-0.113**	-0.218***	-0.320***	-0.539***
	(0.0219)	(0.0247)	(0.0262)	(0.0272)	(0.0219)	(0.0484)	(0.0482)	(0.0436)	(0.0364)	(0.0148)
67	-0.138***	-0.199***	-0.201***	-0.307***	-0.193***	-0.0285	-0.178***	-0.228***	-0.331***	-0.478***
	(0.0295)	(0.0321)	(0.0339)	(0.0249)	(0.0456)	(0.0664)	(0.0661)	(0.0613)	(0.0520)	(0.0503)
68	-0.211***	-0.164***	-0.153***	-0.329***	-0.0704	-0.122	-0.0947	-0.182**	-0.246***	-0.559***
	(0.0375)	(0.0397)	(0.0388)	(0.0306)	(0.0735)	(0.0840)	(0.0800)	(0.0733)	(0.0662)	(0.0716)
69	-0.336***	-0.316***	-0.348***	-0.118**	-0.265***	-0.125	-0.152*	-0.417***	-0.493***	-0.630***
	(0.0336)	(0.0353)	(0.0312)	(0.0534)	(0.0804)	(0.0832)	(0.0818)	(0.0856)	(0.0791)	(0.0764)
70	-0.324***	-0.384***	-0.420***	-0.287**	-0.444***	-0.585***	-0.662***	-0.892***	-0.896***	-1.063***
	(0.0464)	(0.0418)	(0.0476)	(0.123)	(0.127)	(0.139)	(0.126)	(0.102)	(0.0761)	(0.0686)
Estimated γ	0.0863***	0.0849***	0.0837***	0.0830***	0.0820***	0.0815***	0.0800***	0.0774***	0.0745***	0.0679***
	(0.000321)	(0.000343)	(0.000382)	(0.000435)	(0.000504)	(0.000578)	(0.000674)	(0.000813)	(0.000965)	(0.00121)
Observations	157,916	159,952	156,200	152,836	151,023	157,620	166,343	171,603	196,323	209,129

Source: Authors' calculations, based on estimates of a Gompertz mortality model with claiming-age dummies interacted with λ, using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims. Notes: λ is the natural log of age 62-mortality, and γ is the natural log of the annual growth rate in mortality. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3b: Mortality model estimates, including claiming-age dummies

Birth cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
Estimated reduction in mortality vs. age 62										
63	-5.0%	-5.0%	-6.7%	-7.7%	-4.8%	-5.0%	-4.3%	-3.8%	-0.6%	-0.5%
64	-13.7%	-14.2%	-15.1%	-14.8%	-15.0%	-15.8%	-19.5%	-14.4%	-12.4%	-7.6%
65	-21.3%	-21.5%	-21.7%	-20.4%	-23.4%	-26.9%	-31.1%	-31.3%	-32.6%	-24.7%
66	-17.6%	-17.7%	-16.6%	-21.3%	-24.4%	-5.4%	-10.7%	-19.6%	-27.4%	-41.7%
67	-12.9%	-18.0%	-18.2%	-26.4%	-17.6%	-2.8%	-16.3%	-20.4%	-28.2%	-38.0%
68	-19.0%	-15.1%	-14.2%	-28.0%	-6.8%	-11.5%	-9.0%	-16.6%	-21.8%	-42.8%
69	-28.5%	-27.1%	-29.4%	-11.1%	-23.3%	-11.8%	-14.1%	-34.1%	-38.9%	-46.7%
70	-27.7%	-31.9%	-34.3%	-24.9%	-35.9%	-44.3%	-48.4%	-59.0%	-59.2%	-65.5%

Source: Authors' calculations. Each entry equals one minus the exponent of the claiming-age dummies reported in Table 3a.

Table 3c: Parameter tests, mortality model estimates including claiming-age dummies

Birth cohort	**coefficient 1931-32**	**signif. diff. than: 0**	**coefficient 1941-42**	**significantly different than: 0**	**1931-32**
Estimated λ, claim-age 62	-4.298	***	-4.439	***	***
Dummy, age 63	-0.080	***	-0.006		***
64	-0.160	***	-0.132	***	
65	-0.228	***	-0.394	***	***
66	-0.240	***	-0.320	***	*
67	-0.307	***	-0.331	***	
68	-0.329	***	-0.246	***	
69	-0.118	**	-0.493	***	***
70	-0.287	**	-0.896	***	***
Estimated γ	0.083	***	0.075	***	***

Notes: Estimates from Table 3a. Columns with stars indicate whether estimates are significantly different from zero or across cohorts, respectively. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Implied life expectancy at age 62 from mortality model estimates, including claiming-age dummies

		Birth cohort									
		1925-26	**1927-28**	**1929-30**	**1931-32**	**1933-34**	**1935-36**	**1937-38**	**1939-40**	**1941-42**	**1943-44**
Claim age	**62**	18.5	18.8	19.3	19.8	20.4	20.8	21.3	21.8	22.4	23.3
	63	19.0	19.3	19.9	20.5	20.8	21.3	21.7	22.1	22.4	23.3
	64	19.8	20.2	20.7	21.3	21.9	22.4	23.3	23.3	23.7	24.1
	65	20.6	20.9	21.5	21.9	22.8	23.8	24.8	25.5	26.4	26.3
	66	20.2	20.5	20.9	22.0	23.0	21.3	22.3	23.9	25.6	29.1
	67	19.7	20.6	21.1	22.6	22.1	21.1	22.9	24.0	25.8	28.4
	68	20.4	20.2	20.6	22.8	21.0	21.9	22.1	23.6	24.9	29.3
	69	21.5	21.6	22.4	20.9	22.8	22.0	22.7	25.9	27.4	30.0
	70	21.4	22.2	23.1	22.4	24.6	26.4	27.8	30.8	31.6	34.4

Source: Authors' calculations, based on Table 3a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 5a: Mortality model estimates, including claiming-age & AIME quartile dummies

Cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
					AIME quartile 1					
Estimated λ, age-62 claimants										
	-3.856	-3.863	-3.860	-3.893	-3.951	-3.972	-3.963	-3.980	-3.973	-3.944
claim-age dummies										
63	-0.025	-0.020	-0.054	-0.065	-0.011	-0.007	-0.081	-0.084	0.069	-0.057
64	-0.182	-0.183	-0.208	-0.189	-0.188	-0.289	-0.345	-0.276	-0.276	-0.273
65	-0.205	-0.227	-0.261	-0.225	-0.252	-0.358	-0.437	-0.464	-0.496	-0.465
66	-0.233	-0.192	-0.129	-0.300	-0.256	-0.091	-0.219	-0.184	-0.336	-0.631
67	-0.101	-0.129	-0.091	-0.288	-0.113	-0.033	-0.188	-0.251	-0.278	-0.292
68	-0.096	-0.134	-0.158	-0.208	-0.008	-0.162	-0.051	-0.065	-0.225	-0.350
69	-0.164	-0.301	-0.397	-0.145	-0.231	-0.254	-0.196	-0.371	-0.611	-0.489
70	-0.446	-0.339	-0.484	0.003	-0.294	-0.387	-0.803	-0.695	-0.795	-1.120
Est'd γ	0.074	0.073	0.070	0.068	0.068	0.067	0.065	0.062	0.057	0.053
					AIME quartile 2					
Estimated λ, age-62 claimants										
	-4.105	-4.125	-4.173	-4.215	-4.254	-4.301	-4.349	-4.368	-4.402	-4.415
										claim-age dummies
63	-0.022	-0.052	-0.026	-0.051	-0.025	-0.029	-0.029	-0.015	-0.019	0.018
64	-0.159	-0.189	-0.152	-0.193	-0.169	-0.179	-0.208	-0.158	-0.130	-0.010
65	-0.228	-0.206	-0.197	-0.201	-0.206	-0.260	-0.305	-0.280	-0.319	-0.235
66	-0.120	-0.236	-0.226	-0.147	-0.211	-0.092	0.007	-0.359	-0.329	-0.421
67	-0.158	-0.099	-0.276	-0.395	-0.100	-0.209	-0.301	-0.214	-0.199	-0.744
68	-0.310	-0.120	-0.056	-0.307	-0.146	-0.024	-0.074	-0.455	-0.132	-0.570
69	-0.459	-0.215	-0.279	0.208	-0.223	-0.123	0.012	-0.843	-0.438	-0.598
70	-0.359	-0.364	-0.264	-0.552	-0.399	-0.130	-0.586	-1.182	-1.206	-0.766
Est'd γ	0.085	0.085	0.084	0.084	0.083	0.084	0.083	0.082	0.082	0.076
					AIME quartile 3					
Estimated λ, age-62 claimants										
	-4.358	-4.396	-4.434	-4.499	-4.565	-4.612	-4.655	-4.692	-4.728	-4.703
										claim-age dummies
63	-0.354	-0.330	-0.404	-0.377	-0.392	-0.420	-0.445	-0.356	-0.336	-0.284
64	-0.451	-0.417	-0.475	-0.460	-0.488	-0.530	-0.588	-0.559	-0.567	-0.435
65	-0.439	-0.375	-0.386	-0.486	-0.460	-0.625	-0.766	-0.444	-0.602	-0.655
66	-0.346	-0.461	-0.454	-0.478	-0.586	-0.333	-0.601	-0.617	-0.756	-0.695
67	-0.406	-0.340	-0.381	-0.574	-0.546	-0.874	-0.754	-0.739	-0.517	-0.924
68	-0.521	-0.520	-0.533	-0.525	-0.865	-0.589	-0.502	-0.428	-0.686	-0.834
69	-0.451	-0.509	-0.550	-1.081	-0.910	-1.284	-0.916	-0.996	-0.946	-1.214
70	4.358	4.396	4.434	4.968	4.565	4.612	4.655	4.692	4.728	4.703
Est'd γ	0.091	0.091	0.091	0.091	0.091	0.090	0.089	0.089	0.087	0.080

	AIME quartile 4									
Estimated λ, age-62 claimants										
	-4.633	-4.634	-4.741	-4.823	-4.866	-4.959	-5.004	-4.993	-5.051	-5.050
Claim-age dummies										
63	-0.025	-0.042	-0.060	-0.051	-0.059	-0.008	-0.017	-0.011	0.005	0.098
64	-0.079	-0.092	-0.097	-0.053	-0.091	-0.073	-0.096	-0.055	-0.013	0.063
65	-0.176	-0.179	-0.168	-0.136	-0.187	-0.183	-0.239	-0.258	-0.244	-0.088
66	-0.164	-0.137	-0.079	-0.162	-0.159	-0.278	-0.417	-0.143	-0.279	-0.308
67	-0.071	-0.223	-0.147	-0.154	-0.285	0.014	-0.252	-0.316	-0.433	-0.348
68	-0.131	-0.102	-0.074	-0.250	-0.245	-0.527	-0.405	-0.438	-0.194	-0.577
69	-0.246	-0.282	-0.226	-0.201	-0.564	-0.242	-0.153	-0.127	-0.363	-0.487
70	-0.176	-0.271	-0.243	-0.757	-0.609	-0.937	-0.567	-0.695	-0.623	-0.867
Est'd γ	0.099	0.097	0.098	0.098	0.097	0.097	0.097	0.091	0.090	0.080

Source: Authors' calculations, based on estimates of a Gompertz mortality model with claiming-age dummies interacted with λ, estimated separately by age-62 AIME quartile, using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims. Notes: λ is the natural log of age 62-mortality, and γ is the natural log of the annual growth rate in mortality. Standard errors omitted from the table.

Table 5b: Test of mortality model estimates including claiming-age dummies, by AIME quartiles

Birth cohort	1931-32										
	coeffi -cient	signifi cantly diff. than:	coeffi -cient	signify-cantly different than:		coeffi -cient	signify-cantly different than:		coeffi -cient	signify-cantly different than:	
AIME quartile	**Q1**	**0**	**Q2**	**0**	**Q1**	**Q3**	**0**	**Q1**	**Q4**	**0**	**Q1**
Estimated λ, claim-age 62	-3.893	***	-4.215	***	***	-4.499	***	***	-4.823	***	***
Dummy, age 63	-0.065	***	-0.051	**		-0.031			-0.051	**	
64	-0.189	***	-0.193	***		-0.125	***	**	-0.053	***	***
65	-0.225	***	-0.201	***		-0.119	***	***	-0.136	***	***
66	-0.300	***	-0.147	**	*	-0.141	**	**	-0.162	***	*
67	-0.288	***	-0.395	***		-0.191	***		-0.154	***	**
68	-0.208	***	-0.307	***		-0.191	**		-0.250	***	
69	-0.145	*	0.208	*	**	-0.106			-0.201	*	
70	0.003		-0.552	**	*	0.049			-0.757	**	**
Estimated γ	0.068	***	0.084	***	***	0.091	***	***	0.098	***	***

Birth cohort	1941-42														
	coeffi-cient	significantly different than:		coeffi -cient	significantly different than:			coeffi -cient	significantly different than:			coeffi -cient	significantly different than:		
AIME quartile	**Q1**	**0**	**31-32**	**Q2**	**0**	**Q1**	**31-32**	**Q3**	**0**	**Q1**	**31-32**	**Q4**	**0**	**Q1**	**31-32**
Estimated λ, claim-age 62	-3.973	***	***	-4.402	***	***	***	-4.728	***	***	***	-5.051	***	***	***
Dummy, age 63	0.0687	***	***	-0.019		**		-0.071	**	**		0.005 3			

64	-0.276	***	***	-0.130	***	***	*	-0.033		***	**	-0.013		***	
65	-0.496	***	***	-0.319	***	***	***	-0.223	***	***	***	-0.244	***	***	***
66	-0.336	***		-0.329	***		*	-0.142	*	*		-0.279	***		
67	-0.278	***		-0.199	*			-0.270	**			-0.433	***		**
68	-0.225	**		-0.132				-0.265				-0.194			
69	-0.611	***	***	-0.438	**		***	-0.192		*		-0.363	**		
70	-0.795	***	***	-1.206	***		*	-0.647	***		**	-0.623	***		
Estimated γ	0.0574	***	***	0.082	***	***		0.087	***	***	*	0.09	***	***	***

Notes: Estimates from Table 5a. Columns with stars indicate whether estimates are significantly different from zero, relative to AIME quartile 1, or across cohorts, respectively. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Implied life expectancy at age 62 from mortality model estimates, including claiming-age & AIME quartile dummies

Birth cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
	AIME Quartile 1									
62	16.9	17.1	17.4	18.0	18.5	18.7	18.9	19.5	20.0	20.3
63	17.1	17.3	17.9	18.6	18.6	18.8	19.7	20.3	19.4	20.8
64	18.5	18.7	19.3	19.7	20.3	21.4	22.2	22.1	22.7	22.9
65	18.7	19.1	19.8	20.1	20.9	22.1	23.0	23.8	24.7	24.7
66	19.0	18.8	18.6	20.8	20.9	19.6	21.0	21.2	23.2	26.2
67	17.8	18.2	18.2	20.6	19.6	19.1	20.7	21.9	22.7	23.1
68	17.7	18.3	18.8	19.9	18.6	20.3	19.4	20.1	22.2	23.6
69	18.3	19.8	21.0	19.3	20.7	21.1	20.8	23.0	25.7	24.9
70	20.9	20.1	21.8	17.9	21.3	22.3	26.3	25.9	27.3	29.9
	AIME Quartile 2									
62	17.9	18.1	18.5	18.9	19.4	19.7	20.2	20.5	20.9	21.7
63	18.1	18.5	18.8	19.4	19.6	19.9	20.4	20.6	21.0	21.6
64	19.2	19.7	19.8	20.6	20.9	21.2	22.0	21.9	22.0	21.8
65	19.8	19.8	20.2	20.7	21.2	21.9	22.8	23.0	23.6	23.8
66	18.9	20.1	20.5	20.2	21.2	20.5	20.1	23.6	23.7	25.4
67	19.2	18.9	20.9	22.4	20.3	21.5	22.8	22.4	22.6	28.0
68	20.5	19.1	19.0	21.6	20.7	19.9	20.8	24.5	22.0	26.6
69	21.8	19.9	20.9	17.2	21.3	20.7	20.1	27.6	24.6	26.8
70	20.9	21.2	20.8	23.7	22.9	20.8	25.2	29.9	30.3	28.1
	AIME Quartile 3									
62	19.3	19.6	20.0	20.5	21.0	21.5	22.0	22.4	23.0	23.7
63	19.4	19.4	20.1	20.8	20.8	22.0	21.6	22.2	23.6	23.3
64	20.1	20.2	21.0	21.6	22.0	22.1	23.1	23.0	23.3	23.7
65	20.6	21.0	21.1	21.5	22.4	23.0	23.7	24.2	24.9	24.9
66	19.9	20.4	21.4	21.7	22.7	21.5	20.5	24.1	24.2	26.3
67	20.6	20.7	21.2	22.1	23.0	23.6	22.3	22.8	25.2	26.4
68	21.6	21.1	21.0	22.1	21.4	20.6	22.3	22.5	25.2	27.6
69	22.3	21.3	22.0	21.4	23.6	18.7	24.9	26.7	24.6	28.6

70	21.2	21.6	24.0	20.1	24.8	30.0	24.3	29.1	28.1	30.3
	AIME Quartile 4									
62	20.6	20.9	21.7	22.2	22.8	23.6	23.9	24.6	25.2	26.6
63	20.8	21.2	22.1	22.6	23.3	23.6	24.1	24.7	25.2	25.8
64	21.2	21.6	22.4	22.7	23.6	24.1	24.7	25.0	25.3	26.1
65	22.0	22.4	23.0	23.3	24.3	25.0	25.8	26.6	27.1	27.2
66	21.9	22.0	22.3	23.5	24.1	25.8	27.2	25.7	27.4	28.8
67	21.2	22.7	22.9	23.5	25.1	23.4	25.9	27.1	28.5	29.1
68	21.6	21.7	22.3	24.3	24.8	27.6	27.1	28.0	26.7	30.6
69	22.6	23.2	23.5	23.9	27.2	25.5	25.2	25.6	28.0	30.0
70	22.0	23.1	23.6	28.1	27.6	30.3	28.2	29.7	29.7	32.2

Source: Authors' calculations, based on Table 5a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 7: Expected present value of benefits, assuming population or claiming-age specific mortality, implied by mortality model estimates

Birth cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
	Population mortality									
62	10.48	10.61	10.74	10.89	11.04	11.19	11.32	11.18	11.03	10.88
63	10.51	10.65	10.79	10.94	11.11	11.27	11.41	11.23	11.03	10.82
64	10.45	10.60	10.76	10.92	11.09	11.27	11.42	11.26	11.09	10.91
65	10.32	10.47	10.64	10.81	11.00	11.19	11.34	11.21	11.07	10.91
66	9.81	10.02	10.24	10.47	10.72	10.96	11.17	11.11	11.00	10.83
67	9.30	9.55	9.81	10.09	10.38	10.68	10.94	10.95	10.90	10.82
68	8.78	9.06	9.36	9.68	10.01	10.35	10.65	10.72	10.74	10.72
69	8.25	8.56	8.90	9.24	9.61	9.97	10.31	10.43	10.50	10.54
70	7.73	8.06	8.41	8.79	9.18	9.56	9.93	10.09	10.20	10.29
	Claim age specific mortality									
62	10.83	10.95	11.14	11.36	11.59	11.78	11.94	11.88	11.84	11.85
63	11.10	11.22	11.50	11.79	11.91	12.12	12.27	12.14	11.91	11.87
64	11.49	11.65	11.93	12.17	12.44	12.70	13.10	12.75	12.59	12.37
65	11.84	12.00	12.26	12.45	12.92	13.37	13.85	13.81	13.86	13.42
66	11.15	11.36	11.60	12.23	12.78	11.98	12.55	13.10	13.62	14.70
67	10.38	10.93	11.30	12.23	12.08	11.60	12.72	13.10	13.75	14.67
68	10.21	10.28	10.63	11.99	11.11	11.79	12.05	12.73	13.28	15.24
69	10.31	10.56	11.19	10.48	11.78	11.48	12.08	13.85	14.56	15.71
70	9.72	10.41	11.11	10.95	12.38	13.70	14.68	16.30	16.68	17.99
	Percentage change relative to age 62 - population average mortality									
63	0.27%	0.36%	0.46%	0.55%	0.66%	0.75%	0.84%	0.41%	-0.05%	-0.53%
64	-0.29%	-0.10%	0.10%	0.31%	0.52%	0.72%	0.89%	0.72%	0.52%	0.28%
65	-1.56%	-1.28%	-0.98%	-0.66%	-0.33%	-0.03%	0.22%	0.28%	0.31%	0.32%
66	-6.37%	-5.55%	-4.70%	-3.81%	-2.91%	-2.05%	-1.26%	-0.62%	-0.33%	-0.38%
67	-11.27%	-9.99%	-8.67%	-7.30%	-5.91%	-4.57%	-3.31%	-2.08%	-1.15%	-0.52%
68	-16.24%	-14.58%	-12.85%	-11.07%	-9.27%	-7.52%	-5.86%	-4.14%	-2.67%	-1.45%
69	-21.25%	-19.27%	-17.21%	-15.08%	-12.94%	-10.85%	-8.87%	-6.73%	-4.81%	-3.10%
70	-26.25%	-24.02%	-21.69%	-19.28%	-16.87%	-14.51%	-12.26%	-9.79%	-7.51%	-5.39%

	Percentage change relative to age 62 - claim age specific mortality									
63	2.44%	2.52%	3.26%	3.75%	2.76%	2.92%	2.74%	2.17%	0.63%	0.23%
64	6.06%	6.45%	7.07%	7.11%	7.38%	7.89%	9.70%	7.34%	6.36%	4.43%
65	9.26%	9.61%	10.03%	9.62%	11.49%	13.52%	15.98%	16.22%	17.06%	13.31%
66	2.91%	3.77%	4.12%	7.62%	10.26%	1.74%	5.06%	10.28%	15.02%	24.13%
67	-4.20%	-0.16%	1.45%	7.68%	4.25%	-1.51%	6.48%	10.27%	16.13%	23.84%
68	-5.79%	-6.08%	-4.56%	5.53%	-4.12%	0.17%	0.86%	7.10%	12.18%	28.65%
69	-4.83%	-3.53%	0.44%	-7.78%	1.67%	-2.53%	1.12%	16.56%	23.00%	32.58%
70	-10.26%	-4.87%	-0.26%	-3.66%	6.84%	16.32%	22.90%	37.16%	40.88%	51.87%

Source: Authors' calculations, based on Table 3a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 8: Expected present value of benefits, age-62 versus age-66 claimant mortality by claiming age

Birth cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
Claim age	**Age-62 claimant mortality**									
62	10.83	10.95	11.14	11.36	11.59	11.78	11.94	11.88	11.84	11.85
63	10.89	11.01	11.22	11.46	11.71	11.91	12.09	11.98	11.89	11.85
64	10.85	10.98	11.21	11.47	11.73	11.95	12.14	12.07	12.02	12.02
65	10.74	10.88	11.11	11.39	11.67	11.90	12.11	12.07	12.06	12.11
66	10.23	10.43	10.72	11.06	11.41	11.71	11.98	12.02	12.05	12.12
67	9.71	9.95	10.30	10.69	11.10	11.45	11.79	11.91	12.03	12.20
68	9.17	9.46	9.85	10.29	10.74	11.14	11.53	11.73	11.93	12.19
69	8.65	8.95	9.38	9.85	10.34	10.78	11.22	11.48	11.75	12.10
70	8.10	8.44	8.88	9.39	9.91	10.39	10.85	11.17	11.51	11.94
	Age-66 claimant mortality									
62	11.56	11.68	11.82	12.27	12.65	11.99	12.38	12.70	13.03	13.82
63	11.67	11.80	11.96	12.44	12.85	12.14	12.56	12.87	13.16	13.95
64	11.69	11.83	12.00	12.52	12.96	12.19	12.65	13.02	13.39	14.29
65	11.63	11.78	11.96	12.51	12.98	12.16	12.65	13.09	13.53	14.54
66	11.15	11.36	11.60	12.23	12.78	11.98	12.55	13.10	13.62	14.70
67	10.65	10.91	11.20	11.90	12.52	11.74	12.38	13.05	13.69	14.97
68	10.12	10.44	10.77	11.53	12.22	11.44	12.15	12.92	13.68	15.14
69	9.61	9.94	10.32	11.13	11.86	11.09	11.86	12.73	13.59	15.21
70	9.07	9.44	9.84	10.69	11.47	10.70	11.52	12.47	13.43	15.20
	Percentage change relative to age 62 - age-62 claimant mortality									
63	0.51%	0.59%	0.72%	0.87%	1.02%	1.13%	1.23%	0.84%	0.44%	0.05%
64	0.18%	0.35%	0.62%	0.93%	1.23%	1.46%	1.67%	1.60%	1.53%	1.51%
65	-0.89%	-0.63%	-0.21%	0.26%	0.72%	1.08%	1.41%	1.63%	1.88%	2.24%
66	-5.54%	-4.74%	-3.72%	-2.63%	-1.54%	-0.59%	0.33%	1.21%	1.83%	2.27%
67	-10.33%	-9.06%	-7.52%	-5.89%	-4.24%	-2.76%	-1.31%	0.24%	1.63%	2.95%
68	-15.31%	-13.56%	-11.57%	-9.46%	-7.33%	-5.39%	-3.48%	-1.31%	0.75%	2.88%
69	-20.20%	-18.20%	-15.82%	-13.30%	-10.75%	-8.41%	-6.10%	-3.40%	-0.74%	2.13%

70	-25.20%	-22.94%	-20.24%	-17.38%	-14.47%	-11.79%	-9.14%	-5.97%	-2.77%	0.77%
	Percentage change relative to age 62 - age-66 claimant mortality									
63	0.99%	1.07%	1.16%	1.41%	1.62%	1.25%	1.47%	1.28%	1.05%	0.98%
64	1.17%	1.33%	1.51%	2.04%	2.47%	1.72%	2.18%	2.52%	2.80%	3.45%
65	0.63%	0.88%	1.16%	1.98%	2.64%	1.48%	2.19%	3.05%	3.85%	5.26%
66	-3.54%	-2.74%	-1.90%	-0.32%	1.05%	-0.05%	1.39%	3.15%	4.53%	6.42%
67	-7.87%	-6.59%	-5.25%	-3.00%	-0.98%	-2.08%	0.03%	2.73%	5.11%	8.34%
68	-12.41%	-10.64%	-8.87%	-6.00%	-3.41%	-4.57%	-1.85%	1.72%	5.03%	9.54%
69	-16.89%	-14.85%	-12.72%	-9.30%	-6.19%	-7.46%	-4.20%	0.18%	4.35%	10.10%
70	-21.52%	-19.19%	-16.75%	-12.86%	-9.28%	-10.71%	-6.96%	-1.85%	3.11%	10.04%

Source: Authors' calculations, based on Table 3a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 9: Expected present value of benefits, from model estimated by claiming age & AIME by claiming age

Birth cohort	**1925-26**	**1927-28**	**1929-30**	**1931-32**	**1933-34**	**1935-36**	**1937-38**	**1939-40**	**1941-42**	**1943-44**
Claim age					**AIME Quartile 1**					
62	10.04	10.12	10.25	10.49	10.75	10.84	10.92	10.91	10.90	10.76
63	10.14	10.21	10.49	10.81	10.85	10.92	11.35	11.31	10.58	10.95
64	10.78	10.89	11.17	11.37	11.66	12.26	12.64	12.29	12.28	12.09
65	10.77	11.00	11.34	11.48	11.93	12.59	13.12	13.26	13.45	13.15
66	10.42	10.38	10.28	11.56	11.71	11.00	11.87	11.78	12.69	14.07
67	9.24	9.59	9.65	11.16	10.63	10.40	11.50	12.05	12.38	12.41
68	8.68	9.12	9.57	10.33	9.67	10.82	10.43	10.77	11.99	12.78
69	8.51	9.53	10.44	9.54	10.57	11.02	10.99	12.41	14.25	13.62
70	9.48	9.24	10.48	8.24	10.55	11.46	14.45	14.22	15.28	17.32
					AIME Quartile 2					
62	10.53	10.63	10.83	11.00	11.20	11.33	11.54	11.44	11.34	11.42
63	10.66	10.88	10.99	11.28	11.39	11.54	11.78	11.56	11.43	11.33
64	11.20	11.45	11.51	11.90	12.02	12.21	12.59	12.24	11.99	11.58
65	11.43	11.45	11.65	11.89	12.15	12.56	13.03	12.80	12.86	12.64
66	10.43	11.16	11.41	11.32	11.94	11.58	11.42	13.17	12.95	13.54
67	10.10	10.03	11.26	12.19	11.08	11.91	12.78	12.39	12.33	15.26
68	10.31	9.65	9.71	11.38	10.96	10.63	11.35	13.50	11.88	14.57
69	10.54	9.62	10.39	8.26	10.99	10.80	10.55	15.41	13.39	14.76
70	9.51	9.88	9.84	11.85	11.55	10.44	13.58	17.03	17.34	15.66
					AIME Quartile 3					
62	11.19	11.34	11.51	11.73	11.94	12.16	12.38	12.28	12.24	12.24
63	11.33	11.35	11.65	11.98	12.00	12.54	12.34	12.28	12.58	12.11
64	11.66	11.75	12.12	12.42	12.63	12.68	13.17	12.81	12.61	12.47
65	11.89	12.08	12.15	12.37	12.82	13.12	13.51	13.45	13.49	13.18
66	11.03	11.37	11.98	12.18	12.77	12.19	11.67	13.44	13.21	14.05
67	10.89	11.07	11.45	12.09	12.68	13.13	12.51	12.67	13.86	14.29
68	10.93	10.82	10.90	11.72	11.44	11.09	12.30	12.33	13.82	15.22
69	10.82	10.46	11.04	10.88	12.43	9.53	13.63	14.81	13.35	15.98

70	9.65	10.12	11.82	9.62	12.78	16.67	12.98	16.33	15.63	17.29
					AIME Quartile 4					
62	11.80	11.92	12.25	12.49	12.73	13.04	13.19	13.17	13.15	13.42
63	12.02	12.22	12.64	12.87	13.16	13.30	13.51	13.41	13.28	13.18
64	12.28	12.48	12.88	12.99	13.41	13.69	13.97	13.78	13.58	13.59
65	12.67	12.84	13.19	13.35	13.86	14.22	14.64	14.73	14.65	14.41
66	12.15	12.26	12.47	13.21	13.58	14.55	15.40	14.34	14.96	15.48
67	11.26	12.22	12.41	12.88	13.92	13.08	14.64	15.15	15.79	15.97
68	11.00	11.21	11.66	12.98	13.47	15.37	15.22	15.70	14.77	17.21
69	11.02	11.57	11.95	12.37	14.68	13.79	13.80	14.06	15.57	16.99
70	10.16	11.03	11.57	14.63	14.58	16.85	15.63	16.76	16.80	18.81
					Percentage change relative to age 62 - AIME Quartile 1					
63	1.00%	0.84%	2.41%	3.07%	0.93%	0.80%	3.97%	3.70%	-2.97%	1.77%
64	7.37%	7.56%	8.97%	8.40%	8.54%	13.08%	15.76%	12.62%	12.63%	12.40%
65	7.35%	8.64%	10.71%	9.43%	11.06%	16.15%	20.14%	21.57%	23.38%	22.22%
66	3.81%	2.54%	0.34%	10.22%	9.01%	1.52%	8.71%	8.00%	16.41%	30.86%
67	-7.97%	-5.29%	-5.82%	6.34%	-1.07%	-4.02%	5.33%	10.47%	13.61%	15.38%
68	-13.55%	-9.85%	-6.63%	-1.57%	-9.99%	-0.19%	-4.50%	-1.26%	10.03%	18.83%
69	-15.20%	-5.89%	1.91%	-9.02%	-1.61%	1.66%	0.63%	13.77%	30.76%	26.59%
70	-5.54%	-8.75%	2.29%	-21.46%	-1.85%	5.78%	32.35%	30.32%	40.20%	61.03%
					Percentage change relative to age 62 - AIME Quartile 2					
63	1.16%	2.38%	1.50%	2.52%	1.67%	1.89%	2.03%	1.09%	0.79%	-0.80%
64	6.33%	7.67%	6.33%	8.12%	7.35%	7.78%	9.04%	6.97%	5.71%	1.34%
65	8.47%	7.68%	7.58%	8.01%	8.53%	10.83%	12.88%	11.93%	13.42%	10.64%
66	-1.01%	4.95%	5.42%	2.83%	6.60%	2.18%	-1.05%	15.17%	14.20%	18.53%
67	-4.15%	-5.63%	3.99%	10.80%	-1.05%	5.10%	10.72%	8.28%	8.71%	33.60%
68	-2.10%	-9.27%	-10.29%	3.42%	-2.10%	-6.16%	-1.72%	18.03%	4.75%	27.53%
69	0.09%	-9.47%	-4.00%	-24.95%	-1.87%	-4.67%	-8.66%	34.73%	18.06%	29.18%
70	-9.68%	-7.03%	-9.13%	7.71%	3.13%	-7.86%	17.65%	48.91%	52.91%	37.04%
					Percentage change relative to age 62 - AIME Quartile 3					
63	1.24%	0.07%	1.28%	2.13%	0.50%	3.09%	-0.28%	0.04%	2.81%	-1.08%
64	4.20%	3.67%	5.33%	5.84%	5.81%	4.22%	6.46%	4.32%	3.04%	1.86%
65	6.28%	6.54%	5.60%	5.47%	7.37%	7.87%	9.19%	9.50%	10.25%	7.63%

66	-1.49%	0.24%	4.13%	3.84%	6.97%	0.21%	-5.67%	9.49%	7.94%	14.80%
67	-2.72%	-2.35%	-0.45%	3.03%	6.17%	7.98%	1.06%	3.22%	13.27%	16.71%
68	-2.32%	-4.61%	-5.26%	-0.11%	-4.21%	-8.84%	-0.63%	0.45%	12.99%	24.30%
69	-3.34%	-7.72%	-4.01%	-7.26%	4.13%	-21.63%	10.18%	20.63%	9.08%	30.53%
70	-13.75%	-10.77%	2.74%	-17.98%	7.01%	37.07%	4.89%	33.01%	27.71%	41.23%
	Percentage change relative to age 62 - AIME Quartile 4									
63	1.92%	2.52%	3.20%	3.03%	3.37%	2.04%	2.36%	1.80%	0.96%	-1.82%
64	4.11%	4.71%	5.15%	3.95%	5.37%	5.04%	5.87%	4.60%	3.26%	1.28%
65	7.35%	7.71%	7.68%	6.87%	8.89%	9.05%	10.93%	11.80%	11.42%	7.36%
66	3.01%	2.85%	1.86%	5.75%	6.63%	11.57%	16.75%	8.87%	13.74%	15.33%
67	-4.59%	2.49%	1.32%	3.07%	9.32%	0.34%	10.95%	14.98%	20.06%	18.97%
68	-6.73%	-5.99%	-4.76%	3.88%	5.78%	17.93%	15.37%	19.15%	12.34%	28.25%
69	-6.60%	-2.92%	-2.46%	-1.00%	15.31%	5.78%	4.60%	6.72%	18.41%	26.60%
70	-13.86%	-7.48%	-5.51%	17.07%	14.56%	29.22%	18.43%	27.24%	27.72%	40.20%

Source: Authors' calculations, based on Table 5a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 10: Expected present value of benefits and the return to delay, from model estimated by claiming age & AIME by claiming age

Birth cohort	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
Claim age	**Expected present value, AIME Quartile One - Mortality of age 62 claimants**									
62	10.04	10.12	10.25	10.49	10.75	10.84	10.92	10.91	10.90	10.76
63	10.03	10.12	10.25	10.52	10.80	10.90	10.98	10.94	10.89	10.69
64	9.93	10.03	10.18	10.46	10.76	10.87	10.96	10.95	10.94	10.78
65	9.77	9.87	10.03	10.33	10.64	10.76	10.86	10.89	10.92	10.78
66	9.25	9.40	9.61	9.97	10.35	10.51	10.67	10.78	10.85	10.71
67	8.72	8.92	9.17	9.58	10.01	10.22	10.42	10.61	10.77	10.71
68	8.18	8.42	8.71	9.16	9.63	9.88	10.13	10.38	10.62	10.63
69	7.66	7.91	8.23	8.71	9.22	9.50	9.78	10.10	10.40	10.49
70	7.13	7.40	7.74	8.25	8.78	9.09	9.40	9.77	10.14	10.27
	Expected present value, AIME Quartile Four - Mortality of age 66 claimants									
62	12.36	12.39	12.52	13.04	13.27	13.96	14.56	13.65	14.05	14.41
63	12.54	12.58	12.71	13.28	13.53	14.27	14.92	13.89	14.26	14.58
64	12.62	12.66	12.80	13.41	13.68	14.49	15.18	14.12	14.57	14.97
65	12.61	12.66	12.81	13.46	13.75	14.61	15.35	14.26	14.79	15.27
66	12.15	12.26	12.47	13.21	13.58	14.55	15.40	14.34	14.96	15.48
67	11.67	11.83	12.10	12.91	13.34	14.42	15.38	14.35	15.11	15.79
68	11.15	11.37	11.68	12.57	13.06	14.22	15.28	14.28	15.18	16.01
69	10.64	10.88	11.24	12.18	12.73	13.97	15.11	14.14	15.16	16.12
70	10.11	10.38	10.77	11.76	12.35	13.66	14.87	13.93	15.06	16.16
	Return to delay, AIME Quartile One - Mortality of age 62 claimants									
63	-0.08%	-0.01%	0.09%	0.28%	0.46%	0.53%	0.59%	0.24%	-0.12%	-0.59%
64	-1.02%	-0.87%	-0.66%	-0.27%	0.12%	0.25%	0.37%	0.39%	0.40%	0.20%
65	-2.69%	-2.46%	-2.13%	-1.53%	-0.94%	-0.74%	-0.54%	-0.19%	0.18%	0.25%
66	-7.85%	-7.10%	-6.20%	-4.95%	-3.71%	-2.98%	-2.26%	-1.21%	-0.43%	-0.38%
67	-13.09%	-11.90%	-10.52%	-8.69%	-6.89%	-5.71%	-4.52%	-2.75%	-1.19%	-0.39%
68	-18.45%	-16.82%	-15.02%	-12.70%	-10.41%	-8.84%	-7.25%	-4.86%	-2.58%	-1.13%

69	-23.68%	-21.83%	-19.68%	-16.92%	-14.21%	-12.33%	-10.40%	-7.45%	-4.54%	-2.51%
70	-28.96%	-26.87%	-24.43%	-21.32%	-18.26%	-16.12%	-13.90%	-10.48%	-7.01%	-4.47%
	Return to delay, AIME Quartile Four - Mortality of age 66 claimants									
63	1.46%	1.48%	1.54%	1.81%	1.92%	2.24%	2.48%	1.72%	1.49%	1.21%
64	2.12%	2.16%	2.30%	2.86%	3.09%	3.75%	4.27%	3.43%	3.72%	3.92%
65	2.07%	2.14%	2.35%	3.22%	3.59%	4.61%	5.42%	4.45%	5.26%	5.98%
66	-1.67%	-1.09%	-0.34%	1.31%	2.30%	4.18%	5.79%	5.05%	6.45%	7.41%
67	-5.59%	-4.57%	-3.34%	-0.98%	0.56%	3.25%	5.61%	5.14%	7.56%	9.60%
68	-9.76%	-8.28%	-6.64%	-3.63%	-1.58%	1.86%	4.92%	4.63%	8.02%	11.08%
69	-13.90%	-12.18%	-10.19%	-6.59%	-4.11%	0.04%	3.76%	3.58%	7.87%	11.91%
70	-18.23%	-16.25%	-13.97%	-9.84%	-6.97%	-2.17%	2.15%	2.02%	7.15%	12.12%

Source: Authors' calculations, based on Table 5a estimates of Gompertz mortality model using the 10% CWHS, on a sample of male retired-worker beneficiaries with no DI claims.

Table 11: Impact of differential mortality and selective claiming on Trust Fund liabilities, in current millions of US dollars

Assumptions about mortality:	1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
population	69,879	85,108	100,162	116,206	129,217	155,178	192,157	225,152	282,383	324,454
retired-worker	74,409	90,496	107,053	125,003	140,153	169,432	211,955	251,327	321,621	382,220
varies with AIME	75,669	92,026	108,989	127,163	142,534	172,273	215,331	255,467	326,266	388,758
also varies with claim age	75,858	92,257	109,256	127,517	142,895	172,720	216,031	256,458	327,788	391,440
Total % increase, above population mortality	8.6%	8.4%	9.1%	9.7%	10.6%	11.3%	12.4%	13.9%	16.1%	20.6%
% of increase due to mortality assumptions:										
retired-worker	6.5%	6.3%	6.9%	7.6%	8.5%	9.2%	10.3%	11.6%	13.9%	17.8%
varies with AIME	1.7%	1.7%	1.8%	1.7%	1.7%	1.7%	1.6%	1.6%	1.4%	1.7%
also varies with claim age	0.2%	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	0.4%	0.5%	0.7%

Source: Authors' calculations. Note: All amounts are discounted back to age 62 for the relevant cohort. The percentage increases do not sum because the denominator changes from population to retired-worker claimant mortality when calculating the impact of the relationship between longevity and AIME and claiming age.

Table 12: Impact of differential mortality, differential earnings, and selective claiming on retired-worker benefits, for AIME Quartile 1 versus 4

		1925-26	1927-28	1929-30	1931-32	1933-34	1935-36	1937-38	1939-40	1941-42	1943-44
Average EPV of AIME Q4	**(1)**	$65,836	$78,863	$96,554	$115,630	$132,558	$154,933	$184,165	$215,195	$241,583	$277,774
Average EPV of AIME Q1	**(2)**	$25,123	$30,349	$36,668	$43,170	$48,570	$55,959	$65,455	$74,153	$82,432	$89,869
Ratio EPVs,Q4 to Q1	**(1)/(2)**	2.62	2.60	2.63	2.68	2.73	2.77	2.81	2.90	2.93	3.09
EPV of AIME Q4, with Q1 claim ages	**(3)**	$65,766	$78,753	$96,351	$115,207	$131,739	$153,851	$182,775	$213,383	$239,076	$272,566
% increase ⇐ Q1 claim ages	**[(1)-(3)] /(3)**	0.1%	0.1%	0.2%	0.4%	0.6%	0.7%	0.8%	0.8%	1.0%	1.9%
EPV of AIME Q4, with Q1 claim ages & mortality	**(4)**	$55,510	$66,305	$80,346	$96,653	$110,371	$128,912	$153,299	$179,007	$201,538	$224,754
% increase ⇐ Q1 mortality	**[(3)-(4)] /(4)**	18.5%	18.8%	19.9%	19.2%	19.4%	19.3%	19.2%	19.2%	18.6%	21.3%
% increase ⇐ Q1 claim age & mortality	**[(1)-(4)] /(4)**	18.6%	18.9%	20.2%	19.6%	20.1%	20.2%	20.1%	20.2%	19.9%	23.6%
Shares attributable to:											
Earnings	**[(4)-(2)]/ [(1)-(2)]**	74.6%	74.1%	72.9%	73.8%	73.6%	73.7%	74.0%	74.3%	74.8%	71.8%
Claim ages	**[(1)-(3)]/ [(1)-(2)]**	0.2%	0.2%	0.3%	0.6%	1.0%	1.1%	1.2%	1.3%	1.6%	2.8%
Mortality	**[(3)-(4)]/ [(1)-(2)]**	25.2%	25.7%	26.7%	25.6%	25.4%	25.2%	24.8%	24.4%	23.6%	25.4%

Source: Authors' calculations. Note: All amounts are discounted back to age 62 for the relevant cohort.

Appendix Table 1: Sample Restrictions

	Total	Male	Female
Sample is in NUMIDENT, MEF, and MBR file of primary beneficiaries[1]	14,848,075	8,268,923	6,579,152
Remaining sample after exclusions:			
Keep those born in 1925-1944, inclusive	4,108,723	2,247,954	1,860,769
Exclude DI beneficiaries[2]	3,382,747	1,788,865	1,593,882
Keep only those Fully insured at age 61 for OASI[3]	3,148,806	1,727,537	1,421,269
Keep only those Alive at age 62	3,106,126	1,697,305	1,408,821
Keep only OASI retirement beneficiaries (i.e. exclude all other benefit types)	3,063,464	1,688,788	1,374,676
Exclude those with OASI claim prior to age 62	3,061,299	1,687,350	1,373,949
Exclude those with OASI claim after age 70	3,047,368	1,683,069	1,364,299
Final Sample	3,047,368	1,683,069	1,364,299
Remaining alive	1,540,689	753,899	786,790
Deceased	1,506,679	929,170	577,509

[1] We start with the 10% sample of MBR file (restricting it to primary beneficiaries), that we could match with the NUMIDENT and the MEF file (those with at least a year of positive earnings).

[2] Those excluded in this step are observation for which the type of benefits in the data file is denoted as DI denied or disallowed.

[3] To be fully insured for OASI, workers born in 1929+ must have at least 40 quarters of coverage or 10 year of work.