The Effect of Annuities on Longevity

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Abstract

We study the effect of annuities on longevity, using payout data on approximately 600,000 Chilean retirees from 2004 to 2022. To address selection effects, we rely on the fact that annuity sales vary with recent market returns. We find that the decision to annuitize—instrumented by recent market returns—has a positive, economically meaningful effect on longevity. Annuitants also report fewer disability symptoms than nonannuitants several years after retirement. Additional analyses suggest that annuities may shield retirees from investment-related stress and provide incentives to live longer and healthier lives.

Keywords: annuities; retirement; longevity; post-retirement health; extrapolative beliefs.

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1 Introduction

Facing an aging population, many countries are cutting back on public pension benefits and healthcare spending. To tackle pension shortfalls, governments have promoted employer-sponsored plans and individual private pensions. Corporations confronting similar demographic challenges are shifting from defined benefit plans to defined contribution plans. Public pension systems and defined benefit plans typically provide benefits through annuities, while individual retirement accounts and defined contribution plans offer lump-sum payouts. In frictionless markets, retirees could offset a decrease in their annuitized retirement wealth by purchasing annuities in the private market. However, annuity sales have historically been low, a puzzling phenomenon noted since Yaari (1965) and Modigliani (1986).

Given these trends, many retirees may experience a drastic reduction in the portion of their retirement wealth automatically converted into an annuity. How does this reduction in annuities affect retirees' health and longevity? What are the implications for older people of losing a steady income stream for life, especially as governments are also reducing public healthcare funding? In this paper, we aim to address these questions by providing evidence on the impact of annuities on retirees' longevity.

Previous studies have documented how annuitants live longer than non-annuitants (Finkelstein and Poterba 2002, and Brown, Mitchell, and Poterba 2002). This evidence is generally interpreted through the lenses of adverse selection models, consistent with individuals having private information about their longevity and making annuitization choices accordingly (e.g., Finkelstein and Poterba 2004). Our paper complements the existing literature on selection effects in annuitization by examining whether annuities have direct effects on longevity.

Annuities can affect longevity through several interconnected channels. To begin, annuities provide a stable source of lifetime income. Higher earnings and lower earnings variability can increase both immediate and long-term longevity, consistent with evidence on job displacements in Sullivan and von Wachter (2009b). Next, annuity payments shield retirees from negative stock market movements, which can lead to increased stress, diminished mental health, and ultimately higher short-term mortality (Engelberg and Parsons 2016, Schwandt 2018). Moreover, life-contingent payments from annuities can create incentives to investment in health (Philipson and Becker 1998), thereby reducing mortality rates.

We use administrative payout data from approximately 600,000 Chilean retirees between 2004 and 2022. These retirees face a choice between annuities and phased withdrawals (PW). While annuity payments are inflation-adjusted, payouts from phased withdrawals vary with recent market returns. To account for selection effects, we use the returns on the most common pension fund in the six months before retirement as an instrument for the decision to annuitize. Our approach relies on the empirical regularity that demand for annuities tends to increase following poor stock market returns and decrease after good returns, a fact observed in both retirement plans and fixed annuity sales from insurance companies (Chalmers and Reuter 2012, Previtero 2014). In our preferred specification, a two-stage least squares (2SLS) regression with retirement-year and birth-cohort fixed effects among other controls, we document that annuities increase longevity by 2.55% at the five-year horizon and by 3.62% at the ten-year horizon. This estimate indicates a positive and economically significant direct effect of annuities on longevity.

Studying the Chilean public pension system offers several advantages. In 1980, Chile replaced its public pay-as-you-go pension system with privately managed defined contribution retirement accounts. Therefore, we can study Chilean retirees' payout choices over

a period long enough to detect their effects on longevity. Additionally, we can access administrative data on payout choices and longevity, thereby minimizing measurement error from self-reported data. Next, the payout options within the Chilean system differentially provide resources in the years after retirement. PW payments are more front-loaded and volatile. They start at a higher level but vary with stock market returns and residual life span—meaning that the longer someone lives, the lower the payments become. In contrast, annuity payments are more stable and back-loaded as they adjust for inflation and are life-contingent. Consequently, differences in volatility and timing of resources can impact retirees' health investments and, ultimately, their longevity. Lastly, annuities are popular among Chilean retirees, with approximately two-thirds choosing one. A long time series of administrative data, the differential timeline of payout options (front-loaded vs. back-loaded), and the popularity of annuities make the Chilean pension system a unique laboratory for studying the effects of annuities on longevity.

We report three sets of results. We begin by testing the relevance of our instrument, the recent pension-fund returns. We first document a strong, significant negative correlation between annuitization and the pension fund returns in the raw data (-0.55). In our (first-stage) regressions, we find that a one-standard-deviation increase in returns reduces the likelihood of choosing an annuity by 2.7%. Given that we include retirement-year fixed effects, our specification exploits within-year variation in exposure to recent fund returns. While, through fixed effects and other control variables (e.g., previous income, total savings), we partial out a substantial fraction of the variation in the demand for annuities, the first-stage F-test is comfortably above the threshold that would suggest a weak-instrument problem.

Why do retirees become more likely to select annuities following past negative returns (and vice versa)? Using data from 113 different DB plans, Previtero (2014) provides

evidence consistent with extrapolative beliefs. Extrapolating from past returns into the future, households' demand for annuities—a fixed-income product—is lower following high stock market returns. Conversely, annuities become more appealing following bad stock returns. The tendency to extrapolate is stronger among less sophisticated investors and financial nonprofessionals (Da, Huang, and Jin 2021) and among older investors, who are more cognitively impaired and are more likely to suffer biases (Previtero 2014). Consistent with evidence in these two studies and, more generally, with an extrapolation explanation, the compliers in our setup are less likely to be sophisticated (i.e., they have lower balances, fewer years of contribution, and lower replacement rates) and more likely to be older.

Next, we regress mortality on the instrumented annuity decision. At the 5-year horizon, we find that the 2SLS coefficient on annuities is -2.55%. Similarly, at the ten-year horizon, the IV coefficient is equal to -3.62%. These results suggest that annuities reduce short and long-term mortality. This effect is comparable with other findings in the literature. For example, Dobbie and Song (2015) documents that personal bankruptcy protection reduces five-year mortality by 10.9% among individuals 60 and older.

In our setting, the exclusion restriction implies that recent pension fund returns affect longevity only through the annuitization decision, not directly or through other omitted variables. One potential concern is that pension fund returns can correlate with the business cycle, and that economic conditions around retirement can directly affect mortality. Coile, Levine, and McKnight (2014) show that employees approaching retirement during a recession suffer long-lasting negative consequences due to higher unemployment and reduced access to health care. We document that annuitization is higher following poor pension fund returns and, hence, during recessions. Therefore, the nexus between recessions and long-run mortality works *against* finding a positive effect of annuitization on longevity. Moreover, we control for the business cycle around retirement by using

retirement-year fixed effects. Therefore, our estimates rely on within-year variation in pension fund returns.

To investigate further potential violations of the exclusion restriction, we run a placebo test using pension fund returns *immediately after* the retirement date (i.e., the six months following retirement). Detecting a correlation between future returns and longevity might signal an omitted-variable bias in our specifications. In these analyses, we find no relation between future returns and longevity. Since future returns are adjacent in time to the past returns used as our instrument, it is hard to argue that the macroeconomic conditions and the business cycle change abruptly at the date of retirement. Overall, this evidence supports the viability of our instrument.

Turning to the mechanisms behind the effects of annuity, we first examine the effects of post-retirement income levels and volatility. Lower and more volatile income can be a source of stress and, consequently, mortality (see Sullivan and von Wachter 2009a,b, and Engelberg and Parsons 2016). Even after controlling for post-retirement income levels and volatility in our regressions, we still find economically significant effects of annuities on longevity. These results suggest that the impact of annuities is not simply about higher disposable income in the later years or a more stable income.

Last, we test for the possibility that annuities increase longevity by promoting more investments in health and, hence, better health (Philipson and Becker, 1998). We first use data from the Health and Retirement Study (HRS) to investigate the plausibility of this mechanism. We compute cross-sectional measures of health status and expenses for all retirees across the 2002-2020 waves. Retirees who receive significant income from annuities are more likely to exercise, less likely to smoke, and have a lower weight.[1] Moreover, they self-report higher life satisfaction, better health status, fewer depression and disability

[1] We investigate retirees who report any annuity income or annual annuity income higher than $18,000.

symptoms. All this evidence is purely correlational and consistent with selection effects. Nonetheless, we also find that annuitants have higher annual health-related expenses. It is worth noting that pure selection effects might imply better expected health of annuitants and, possibly, lower expenses.

To examine this evidence further and address the obvious selection effects in the HRS, we analyze data from CASEN, a biannual survey conducted by the Chilean Ministry of Development. This survey collects detailed disability information on challenges with day-to-day activities such as eating, dressing, or communicating. Interestingly, this question about disability is modeled after a similar one in the HRS. This data helps to advance our analyses in two different ways. First, this survey data is different from the administrative data used in our main analyses on longevity. Therefore, these analyses can serve as an out-of-sample test of our previous evidence. Second, in CASEN, we do not observe retirement dates. Thus, as an instrument, we use pension fund returns prior to the standard retirement age (i.e., age 60 for women and 65 for men). Even with noisy retirement dates, we still find that past returns significantly affect the likelihood of choosing an annuity (our first stage estimates). In the second stage, we confirm that annuities significantly reduce the average disability index by 0.98 on a five-point scale. Notably, the disability status of annuitants and non-annuitants is remarkably similar for the first decade post-retirement, but diverges afterwards. Overall, this evidence is consistent with annuities improving retirees' health and well-being and, consequently, reducing mortality.

Our study contributes to three streams of literature. A first strand investigates adverse selection in annuity markets. Prior studies suggest that individuals act on private information about their longevity. For example, Finkelstein and Poterba (2004) documents that in the UK, individuals who live longer choose back-loaded annuities. More recent evidence on subjective survival beliefs, however, seems to contradict this interpretation.

Using data from the English Longitudinal Study of Ageing (ELSA), O'Dea and Sturrock (2023) show that individuals underestimate their longevity. Similarly, Heimer, Myrseth, and Schoenle (2019) find that individuals exhibit survival pessimism well into their 60s. How can retirees systematically underestimate their life expectancy yet make annuity choices that reflect realized mortality? Our evidence that annuities themselves influence longevity can help reconcile these seemingly contradictory findings in the literature.

A second strand focuses on the reasons behind the annuity puzzle. Prior work proposes a variety of rational explanations—bequest motives, precautionary savings, adverse selection, fees, and intra-family longevity hedging (for a review, see Brown 2007). Additionally, researchers have proposed behavioral explanations such as framing, trend-chasing, present-biased preferences, and regret aversion (for a review, see Benartzi, Previtero, and Thaler 2011). We add to this literature by documenting how annuities could shape both health and longevity. If annuities lead to improved longevity, they are more valuable than previously estimated, which makes the annuity puzzle even more stark. These findings also have implications for the pricing of annuities in private insurance markets.

A third strand examines how economic conditions affect longevity. Several studies link recessions and financial crises to mortality (see Ruhm 2016, Coile, Levine, and McKnight 2014, and Finkelstein, Notowidigdo, Schilbach, and Zhang 2024). Other research connects financial shocks to individual health: Sullivan and von Wachter (2009b) find that displaced workers experience persistently higher mortality, Dobbie and Song (2015) document that bankruptcy protection reduces mortality, and Engelberg and Parsons (2016) show negative health effects from stock market downturns. We contribute to this literature by showing that the payout choice at retirement—specifically, annuitization—has both short and long-term consequences for retirees' health and longevity. These findings have implications for the design of payout options in employer-sponsored and private pen-

sion saving plans, and highlight the potentially negative welfare consequences for retirees of declining annuitization.

2 The Pension System in Chile

2.1 DC Pension Plans

The Chilean pension system was privatized in 1980 through the creation of a DC system that replaced the public pay-as-you-go system. All workers contribute 10% of their monthly taxable income (with a cap) to individual retirement accounts that are managed by pension fund administrators (PFAs). PFAs charge a fee out of the contributions. Individuals can choose among different PFAs and transfer between them over time.

Since 2002, individuals can choose between five types of funds that each PFA is mandated to offer. The five funds (labeled A through E) are subject by law to different investment limits. Fund A has the highest limit for equity, up to 80% of the portfolio, and is considered the riskiest. Fund E is almost entirely invested in domestic fixed-income securities. Funds B, C, and D are designated as age-dependent default options. Investors are automatically shifted to the less risky funds, moving from B to D, as they get older, unless they explicitly express their preference for other funds.

In 2010-2020, average assets under management in the system are approximately USD175 billion, or close to 65% of Chilean GDP. Fund C, which was the only fund available between 1980 and 2002, is the largest, with USD65 billion in assets under management. At the system level, close to 42% of the funds are invested in foreign assets. On average, 84.5% of the population between 20 and 65 years contributes to individual accounts in the pension fund system. Overall, there are more than 10 million accounts in

the system.

2.2 Retirement Choices in the Chilean System

Given the start in 1980, there are already many retirees from the Chilean pension system. The legal age of retirement is 60 for women and 65 for men. Most people retire at the legal age or shortly thereafter as seen in Figure 1. We call old-age retirees those women and men who retire after 60 and 65, respectively. Individuals can retire earlier than the legal age under two conditions: (i) having sufficient funds to obtain a pension above 70% of the average wage received by the individual in the last 10 years, and (ii) that the first monthly pension is at least UF12 (around USD1,050).[2] In practice, individuals who classify for early retirement are in their late 50s and early 60s. Besides old-age and early retirement, individuals can retire if they are declared fully or partially disabled by a medical committee of the pension regulator.[3]

Insert Figure 1 here

Retirees under any of the three retirement modalities (old-age, early, or disability) can choose between three payout mechanisms: annuity, phased withdrawal (PW), or a combination of the previous two.

In the first case, the retiree takes her accumulated pension balance and buys an annuity from an insurance company. The insurance company must pay the retiree an inflation-adjusted (otherwise fixed) amount per month until death. Hence, longevity risk is passed

[2]The Chilean UF is an inflation-adjusted unit of account used for most financial contracts in the country (e.g., mortgages, leasing, college tuition, etc.). For our calculations, we use a conversion rate of UF1 = 37,015 Chilean pesos (CLP), and then adjust for purchasing power using USD1 = CLP426 from the OECD. For comparison purposes, the monthly legal minimum wage in Chile increased from UF6.56 in 2002 to UF11.39 in 2022.

[3]We exclude from the analysis survivorship pensions that are allocated to the spouse or dependents of a deceased retiree.

on to the insurance company. Annuity payments can start immediately or on a future date (e.g., three years after retirement). In the case of the deferred annuity, the retiree can draw from her remaining balance a temporary income between retirement and the beginning of the annuity. The monthly temporary income cannot be more than twice the future monthly annuity. Annuities can also have a guaranteed period (e.g., 20 or 30 years), during which, if the person dies, her beneficiaries continue to receive payments. Without the guaranteed period, the spouse or children of the retiree do not receive payments after the retiree's death. The annuity decision is irreversible. For most of our analysis, we group together retirees with immediate and deferred annuities.

Under PW, the PFA pays the retiree out of her individual capitalization account. Retirees under PW are exposed to yearly fluctuations in the returns of their portfolios. Retirees can choose to allocate their money between funds C, D, or E, but they cannot choose the more risky funds (A or B). The amount of the payment under PW is reset each year based on the balance of the individual account, the life expectancy of the retiree, the number of beneficiaries, and assumptions about future returns. In particular, the monthly payout under PW is:

$$PW = \frac{AccountBalance}{12 \times NUC},$$

where NUC or Necessary Unit of Capital is given by the following formula (up to a constant):

$$NUC = \sum_{n=age}^{110} \frac{l(n, age, gender, beneficiaries)}{(1 + r_{pw})^{n-age}}$$

The NUC is the present value of one unit of annual pension, taking into account the likelihood of survival ($l(.)$) and future returns (r_{pw}). Survival probabilities are a function of age, gender, and they take into account beneficiaries. The probability of being alive at 110 is assumed to be zero. Since 2014, future returns are assumed to be constant, and they are computed as a combination of current annuity yields and the average returns of the pension funds over the previous 120 months. The pension regulator sets the rules and parameters for computing the NUC. There is no leeway for the individual or PFA in determining the amount of PW.

PW is reversible, and retirees can transfer to annuities if they choose to do so later on. Beneficiaries of a retiree under PW receive any balance left after her death. A final possibility is a combination of PW and annuity. The annuity amount, in this case, must be larger than the state-funded basic pension. We exclude from our analysis retirees with a mix of PW and annuity, although these are extremely few cases (less than half of one percent of all retirees in our sample).

Based on the limited survey evidence that we have, the main trade-off that retirees see when deciding between annuities and PW is that annuities protect against longevity risk, but PW provides higher pensions at the start of retirement. For example, 60% of annuitants mention that longevity is their main reason for choosing annuities, while only 20% of those under PW mention longevity as their main concern. At the same time, 24% (19%) of those under PW (annuities) cite higher pensions in the beginning as the main reason for choosing PW (annuities). The bequest motive seems secondary for both annuities and PW: less than 3% of retirees cite leaving money to heirs as a relevant concern.[4]

[4]This evidence is based on a sample of 4,349 Chilean retirees in the Encuesta Proteccion Social for whom we know their retirement choice. The longevity concern is identified as the retiree citing as main concern for their pension decision one of the following "I wanted a life-long pension", or "I didn't want

2.3 The SCOMP Exchange

Since 2004, the choice between annuities and PW has been implemented through an exchange called SCOMP (Sistema de Consultas y Ofertas de Montos de Pensión). The purpose of this exchange is to increase market transparency by reducing the asymmetries of information between retirees and insurance companies. Access to SCOMP is limited to individuals with pension savings that are large enough to buy a monthly annuity equal to or greater than UF3 (about USD250). For those above UF3 it is compulsory to use SCOMP. PW is the only option for those without access to SCOMP, although they also get pension supplements from the government. Sales agents from insurance companies and financial advisors help retirees access SCOMP, and charge fees for their services that are tilted towards recommending annuities (Boehm, 2024). Through SCOMP, retirees receive offers from insurance companies regarding different annuity contracts, and different PW offers, as illustrated with an example in Figure 2. The table at the top of the figure shows the first-year monthly payment offered by different PFAs (one can move to a different administrator at retirement). Fees are the only difference between offers since future PW payments are determined under the parameters set by the regulator. The graph below the table shows a simulation of future PW payments.

Insert Figure 2 here

Our main dataset corresponds to all retirees who have accepted an offer (annuity or PW) from the SCOMP exchange in 2004-2022. Table 1 shows averages of different variables for our sample of 591,909 retirees with full data. Almost two thirds of retirees choose annuities. The average value of the annuity bought at retirement or the initial balance under PW is UF2,600 or around USD225,000. The monthly payment in the

my pension to decline in time", or "I was scared of running out of money".

first year is on average UF16.3. The mean (median) ratio of this initial payment to the individual's last income before retirement is 93% (59%), which indicates a relatively high replacement rate in this sample. Individuals retire on average at 63, after saving for more than 26 years. There are more men (66%) than women (34%) in our sample, as the SCOMP database is biased toward higher incomes. The deceased represent 8% of the sample and their average age of death is 68.6 years. This average lifetime is higher than the life expectancy at birth for Chilean cohorts in the 1950s and 1960s (below 65 years).

Insert Table 1 here

3 Empirical Design

3.1 Main Regression

We are interested in estimating the effect of annuities on mortality. A starting point is the following OLS regression, which mimics Dobbie and Song (2015)'s study of the impact of bankruptcy protection on mortality:

$$Dead_{i,t+j} = \beta Annuity_{i,t} + \Gamma' X_{i,t} + \Omega_{i,t} + \epsilon_{i,t+j} \tag{1}$$

The variable $Dead_{i,t+j}$ takes a value of 1 if the individual i who retired at time t has passed away in year $t+j$ or before, and 0 otherwise. We form a balanced panel where each individual is present for $j = T$ years, where T can be 5 or 10. The panel is truncated for retirees at the end of the sample for which we do not observe the full T years (e.g., we observe an individual who retires in 2020 only up to 2022). We can also estimate a different β for each post-retirement period j, although this is not shown in equation 1 for simplicity.

This way of studying mortality has several advantages over alternative specifications. First, it allows us to include all retirees, independent of whether they are deceased or not. Conditioning on death, i.e., on observing the event of interest as in a duration-type analysis, would reduce the sample to 8% of retirees who are already deceased. This would also assign a disproportionate weight on the early cohorts that we observe for a longer period. We still put more weight on the early cohorts since we do not observe the later cohorts for the full T years, but the issue is less of a problem under our specification than if we condition on death. Second, the panel structure allows us to put more weight on those who live longer. An alternative would be to run a purely cross-sectional regression with the cumulative mortality rate, i.e., a variable that takes a value of 1 if the retiree is deceased after T periods, and 0 if the retiree is still alive. This would reduce the number of observations and, more importantly, it would obscure the timing of death within the time spell under study. If $T = 10$, this would mean that a retiree who dies in year $j = 2$ is treated the same as a retiree who dies in year $j = 9$. Our setup uses the extra information provided by the longer life span of the retiree who dies in year $j = 9$. At the same time, by considering a common panel horizon for all retirees (i.e., a balanced panel) instead of cutting the panel at death for each individual (at $j = 2$ or $j = 9$ respectively), the sample does not over-represent individuals that live longer. Third, as it becomes clear in the next section, the linear structure of equation 1, as opposed to non-linear models such as with duration analysis, makes the setup easier to combine with instrumental variables. Our specification retains the flexibility of the linear probability model, but adds the hazard-rate intuition of the non-linear models.

We are interested in estimating the coefficient β, which captures the impact of retiring with an annuity (instead of PW) on the future likelihood of death. The magnitude of β corresponds to the fraction of life years gained (or lost) over the horizon T by taking

annuities. For example, imagine we have a sample with 2 retirees: an annuitant who is still alive after $T = 10$ years, and a PW-retiree who died at the end of year 8. The annuitant lives for 2 more years out of 10, and thus there is 20% lower mortality for annuitants in this sample ($\beta = -20\%$).[5]

The vector $X_{i,t}$ includes continuous variables measured at retirement for each individual: accumulated pension savings, last monthly income before retirement, and years with contributions to pension funds. Differences in observable characteristics between annuitants and PW retirees suggest that these control variables are necessary to estimate a clean effect of annuities on mortality. As seen in the last column of Table 1, annuitants are more likely to be women, who retire earlier, and after shorter work lives (proxied by the number of years with pension contributions). Annuitants retire with larger balances, receive larger initial payments, and have higher replacement rates than retirees with PW. This is just a reflection of annuitants' higher pre-retirement income (as in Finkelstein and Poterba 2002). Both women and high-income individuals live longer lives, on average, so we can expect to find a negative effect of annuities on mortality if we do not control for such characteristics.

The set of fixed effects $\Omega_{i,t}$ includes dummy variables for each type of retirement (old-age, early, and disability), retirement month dummies for seasonal effects (i.e., January, February, etc.), and, more importantly, birth-year and retirement-year fixed effects interacted with gender dummies. Hence, a woman born in 1950 and who retired in 2010 has a different fixed effect than a man born in 1950, and a different fixed effect than a woman born in 1950 but who retired in 2011. Birth-year effects control for cohort differences

[5]Since the panel structure is linear, life years are treated the same irrespective of who gets to live longer: 10 more years for one person are the same as one more year for 10 people. For example, imagine we have a single cross-section (i.e., $T = 1$) where 3 out of 10 (30%) annuitants are dead and 5 out of 10 (50%) PW-retirees are dead. In this case, we also get a regression estimate of $\beta = -20\%$.

in life expectancy. Life expectancy in Chile has increased from 55 years for those born in the 1950s to 80 years for those born in the 2020s. Retirement-year dummies control for business cycle effects in future mortality as documented by Coile, Levine, and McKnight (2014), and Finkelstein, Notowidigdo, Schilbach, and Zhang (2024). Variation in retirement age around the standard ages of 60 for women and 65 for men (see Figure 1), gives us power to disentangle birth-year (i.e., cohort) and retirement-year fixed effects. We cluster standard errors at the birth-year level.

Even after controlling for observables, the OLS estimate for β is unlikely to capture the true causal effect of annuities on mortality. Previous literature speaks of selection effects in annuity markets that support this suspicion. Finkelstein and Poterba (2004) argue that individuals who expect to live longer take annuities, and therefore that insurance companies face adverse selection. In this case, β would be biased downwards since annuitants, for reasons unobservable to the econometrician, would have lower mortality rates than the rest of the population.

On the other hand, Heimer, Myrseth, and Schoenle (2019), and O'Dea and Sturrock (2023) show that mortality expectations are frequently biased and that such biases affect savings and consumption decisions. Heimer, Myrseth, and Schoenle (2019) find that beliefs turn optimistic as individuals approach retirement age. Optimistic individuals flock to annuities since their subjective survival probabilities are above the fair or objective probabilities used to price annuities. Pessimistic individuals, on the other hand, should have a stronger preference for PW. If optimism is related to behavioral traits that increase mortality (e.g., recklessness), or to decisions that increase mortality (e.g., paying fewer visits to the doctor), then β would be biased upwards. For example, Puri and Robinson (2007) show that extreme optimists have self-control problems (e.g., they are more likely to be smokers and hold smaller fractions of their wealth in liquid assets).

Overall, the bias in OLS compared to the true causal effect can be positive or negative, depending on the distribution of beliefs in the population, but it is unlikely to be zero.[6]

3.2 IV Strategy

The ideal experiment (for the econometrician) to estimate the true causal effect of annuities on mortality would be to run a lottery in which some retirees are randomly assigned annuities and others PW. Short of that, we need an instrument for annuitization. This instrument needs to affect mortality only through the annuitization decision, and not directly or through other channels. This does not mean that the instrument has to be exogenous to all market forces, but that the instrument is uncorrelated with other mechanisms that potentially impact mortality.

We propose to use as instrument the returns faced by individuals in the 6 months before retirement. For example, if someone retires in July of 2010, our instrument is the return from January 1st, 2010 to June 30th, 2010. We focus on the returns of fund C, which is the largest and oldest of the five funds available. It was the only fund available in the first two decades of the system. As a moderate portfolio (close to 40% equity and 60% fixed income), fund C is a good summary of the returns faced by investors near retirement. For retirees with PW, fund C is the riskiest of the options available to them (funds A and B are not allowed under PW).

Our choice of instrument is motivated by previous research showing that the demand for annuities is inversely related to past stock returns. Chalmers and Reuter (2012), and Previtero (2014) document this relationship in the context of U.S. retirees. Figure 3 shows that there is a similar relationship among Chilean retirees. There is significant time-series

[6] In addition to omitted variables such as private mortality expectations, measurement error and heterogeneous treatment effects can also contribute to the difference between OLS and IV estimates (Pancost and Schaller, 2025).

variation in the aggregate annuitization rate and the returns of fund C. The annuity take-up steadily increases from a low point of 51% in early 2007 to a peak of 86% in January 2009 during the Great Recession. Then, it falls to 43% (December 2010) following the strong returns in the aftermath of the recession. During the rest of the 2010's we also see a clear inverse relationship between returns and annuitization. The overall correlation between the two series is strongly negative (-0.51). The standard explanation for this inverse relationship in the literature is that past returns proxy for investor sentiment. Previtero (2014) argues that retirees extrapolate future returns from previous returns.

Insert Figure 3 here

The first stage of the IV setup is:

$$Annuity_{i,t} = \lambda Returns_{i,t-6-t-1} + \Psi' X_{i,t} + \Omega_{i,t} + \upsilon_{i,t} \tag{2}$$

Notice that the instrument $Returns_{i,t-6-t-1}$ retains within-year variation. For example, an individual who retires in December is exposed to returns that have only 1 out of 6 months in common with the returns faced by someone who retired in July of the same year. This is important since the retirement-year fixed effects absorb an important fraction of the calendar time variation in the sample. Given the preliminary evidence in Figure 3, we expect to find a negative λ from equation 2. With the predicted value $\widehat{Annuity}_{i,t}$ we can run the second stage of the IV setup:

$$Dead_{i,t+j} = \beta \widehat{Annuity}_{i,t} + \Gamma' X_{i,t} + \Omega_{i,t} + \nu_{i,t+j} \tag{3}$$

Given the discussion above about potential biases in OLS, we expect to find $\beta_{OLS} \neq \beta_{IV}$. The IV estimate for β corresponds to the causal effect of annuities on mortality, if

the IV assumptions hold. We now examine in detail the IV assumptions applied to our particular setup.

3.3 Balance

In Table 2 we show summary statistics for individuals who retire after periods of high and low returns compared to the sample median of 6-month returns for fund C. Except for returns, which are different by construction, we find no significant difference in the observable characteristics of the two populations. Those who retire after high returns have higher balances on average (UF2,627) than those who retire after low returns (UF2,574), but this difference is insignificant and smaller than the difference in balance between annuitants and those with PW (Table 1). Overall, the evidence seems consistent with returns providing an as-random assignment of retirees.

Insert Table 2 here

The balanced nature of the instrument is important to minimize concerns with the partly endogenous timing of retirement. Retirees retain some (not full) flexibility to delay or bring forward their retirement as seen in Figure 1. If such flexibility is correlated with returns and the choice of annuities, or to some omitted variable that directly affects longevity, then it could invalidate the IV setup. For example, imagine a situation where low prior returns prompt rich individuals to retire and choose annuities. Their future longevity can be explained by income levels, more than by the choice of annuities. The results in Table 2 suggest that such manipulation in the timing of retirement is not apparent in the data. In other words, although retirees retain some flexibility, the timing of retirement is unrelated to returns. In fact, the fraction of early retirees is not statistically different across return samples.

3.4 Exclusion Restriction

The exclusion restriction requires that the instrument has an effect on future mortality only through the choice of annuities. One immediate concern is that 6-month returns are correlated to the business cycle, and therefore potentially to long-term mortality. Coile, Levine, and McKnight (2014) show that individuals who are approaching retirement when a recession hits are particularly likely to suffer long-lasting negative consequences due to higher unemployment and worse access to health care.[7]

The observations with extremely low returns (below -10%) that we see in Figure 3 correspond to the Great Recession. Three things are important to note. First, the Great Recession in Chile was a relatively mild recession in terms of unemployment rates, consumption growth, and other macro outcomes. It was a valuation shock as seen in returns, more than a traditional recession. Second, annuitization peaked at the time, so, if anything, the alleged positive nexus between recessions and long-run-mortality works *against* a negative association between annuities and mortality like we find. Third, our setup (regressions 2 and 3) includes retirement-year fixed effects precisely to control for potential long-run effects of business cycles on mortality. Adding these fixed effects allows us to be agnostic about the underlying relationship between recessions and mortality, which is important given the recent evidence in Finkelstein, Notowidigdo, Schilbach, and Zhang (2024) showing a negative, instead of positive, impact of the Great Recession on long-term mortality in the U.S.

A placebo test can allow us to study the plausibility of the exclusion restriction. The test we propose uses returns immediately following the retirement decision (e.g., the next 6 months). If the returns occur after retirement, then by construction they cannot have

[7] This long-term effect is separate from the also documented *contemporaneous* and negative association between recessions and mortality (Ruhm, 2016).

an impact on the already fixed pension choice. Any remaining influence of returns on future mortality would be an indication of omitted variables. If we find no relationship between these post-retirement returns and future mortality then it is evidence in favor of the exclusion restriction holding. Since these returns are adjacent to our instrument, it is hard to argue that the macro channel discontinuously disappears at the date of retirement.

Besides ruling out a direct channel of influence of returns on mortality, the exclusion restriction requires that returns do not induce selection effects that correlate with mortality. It is not enough to show that there is a relationship between a behavioral trait and annuitization *on average* to argue that there is a violation of the exclusion restriction. For example, it may be the case that "strong" people –with better mental or physical health– prefer annuities on average. Similarly, risk preferences are not enough to violate the exclusion restriction. Maybe risk-averse individuals prefer annuities on average and at the same time live longer since they avoid reckless activities.

A violation of the exclusion restriction requires a time-varying relationship because otherwise the instrument does not pick it up. For example, if strong individuals have a more marked preference for annuities after low returns, then the correlation between annuities and longevity would simply be a signal of the underlying health of the return-induced annuitants.

Ultimately, a violation of the exclusion restriction should explain why individuals who take annuities after low returns are in some way stronger than individuals who take PW after high returns. This is a much taller order to meet. Moreover, the underlying trait along which there is selection needs to affect mortality years away from the returns that we use as instrument.

The flexibility that individuals have about whether to retire earlier or later than the legal age can potentially work against the exclusion restriction. However, similarly to

the example above, the endogenous timing of retirement needs to correlate with the instrument and with traits that affect longevity to invalidate our setup. For example, it may be the case that strong people rush to take annuities after poor returns. Strong people would cluster after poor returns, some of them retiring early and others late with respect to the legal age. Conversely, weak people, may rush to take PW after good returns, and thus cluster after good returns. Again, the empirical relevance of such a selection story is far from obvious.

4 Results

4.1 Main Results

Table 3 presents the main results for horizons (T) of 5 and 10 years. For each horizon under consideration we show the OLS regression (equation 1), the reduced-form regression of $Dead_{i,t+j}$ directly on the instrument $Returns_{i,t-6-t-1}$, the first stage regression (equation 2) and the second stage regression (equation 3) of the IV setup.

Insert Table 3 here

The variable $Dead_{i,t+j}$ is multiplied by 100, so the coefficients are interpreted as percentage points. The negative OLS coefficient in column 1 implies that annuitants have 0.69% lower mortality over the next five years.

The positive reduced-form coefficient (columns 2 and 6) means that retirees exposed to positive returns before retirement have higher mortality going forward. A one-standard-deviation shock to returns (4.9%) implies a 0.07% (0.08%) higher mortality at the 5-year (10-year) horizon. The effects are small, but strongly significant. The reduced-form regression is inconsistent with a mechanical wealth effect of returns, whereby individuals

retire with larger balances after high returns. Since higher wealth is negatively related to mortality we should find negative instead of positive coefficients for returns.

The first-stage coefficient relates the variation in returns to the annuitization decision. The coefficient of -0.55 (column 3) implies that a one-standard-deviation shock to returns reduces the likelihood of taking annuities by 2.7% ($-0.55 \times 4.9\%$). The unconditional annuitization rate is 66%, so the effect may appear small, but note that we are already partialling out a substantial fraction of the variation in annuitization through control variables and fixed effects. The Kleibergen-Paap robust F-test for the first stage regression is comfortably above 10, so we are not concerned about weak instruments.[8]

The second-stage coefficient shows a strongly negative effect of annuities on mortality. Mortality is reduced by 2.55% at the 5-year horizon (column 4), and 3.62% at the 10-year horizon (column 8). The effects are not statistically different from each other.

4.2 The magnitude of IV coefficients

The magnitude of the effect of annuitization on mortality is plausible in comparison to other estimates in the literature. For instance, our estimate is smaller than the difference in mortality between annuitants and nonannuitants in other settings. Using data from the U.K., Finkelstein and Poterba (2002) report that the cumulative mortality rate from 65 to 82 for a voluntary male annuitant is 15% lower than for the average male, which represents a rough upper bound for our estimates.[9] Our panel estimate reflects the average difference in cumulative mortality rates during the first T years after retirement. As such, it should be smaller than the difference in cumulative mortality at age 82 reported by

[8]When there is one endogenous regressor and one instrument, the Kleibergen-Paap F-statistic is numerically equivalent to the Montiel-Olea and Pflueger effective F-statistic (Andrews, Stock, and Sun, 2019).

[9]Finkelstein and Poterba (2002) report cumulative survival probabilities, which are simply one minus the cumulative mortality rate that we report above.

Finkelstein and Poterba (2002). Moreover, their estimates combine both selection and treatment effects, while ours arguably capture only the treatment component.

In terms of the mortality impact of other financial decisions, Dobbie and Song (2015) find that bankruptcy protection among individuals 60 and older in the U.S. reduces 5-year mortality by 10.9%. This corresponds to close to three times the impact of annuities in our sample. To our knowledge, there is no comparable evidence of the impact on mortality for other financial decisions and products (e.g., fixed-rate vs. adjustable-rate mortgages).

The IV coefficient for $Annuity_{i,t}$ is larger (in magnitude) than the OLS coefficient. This situation is common in IV setups (see Jiang 2017, and Pancost and Schaller 2025). The standard explanation is that selection effects (i.e., omitted variables) account for the difference between OLS and IV. In the case of annuities, the literature typically speaks of adverse selection, or that individuals who expect to live longer are more likely to choose annuities. Thus, the OLS coefficient should be larger than the IV coefficient.

Instead, the OLS bias that we find is consistent with advantageous selection. Several stories can explain this second type of selection. First, survival optimism, which increases the demand for annuities, can be correlated with reckless behavior and higher mortality. Second, Boehm (2024) shows that intermediaries in the Chilean market have financial incentives to steer consumers towards annuities. Poor (i.e., high-mortality) individuals may be more prone to follow the recommendations of advisors, and thus lead to advantageous selection.[10] Besides alternative selection effects like these, Pancost and Schaller (2025) argue that measurement error and heterogeneous treatment effects can also be related to differences between OLS and IV coefficients.[11]

[10] See also Illanes and Padi (2025) on the industrial organization of the Chilean annuity market.

[11] For example, there can be measurement error in the annuity variable since we do not observe non-pension wealth for each individual.

4.3 Robustness

In Figure 4, we show the second-stage coefficients for the year-by-year estimation in the post-retirement period. The regression specification is, otherwise, the same as our baseline panel. This is basically the cross-sectional specification with the cumulative mortality rate up that we mentioned in section 3. We find that the point estimates for the effect of annuities on mortality grow with time. In particular, after year $t = 5$ the effect roughly doubles in magnitude. The estimates are still smaller than the differences between annuitants and non-annuitants reported in Finkelstein and Poterba (2002). In part because of the smaller sample size for each regression, the effects are noisier than in the panel specification. Thus, we cannot reject that coefficients across post-retirement years are statistically different from one another.

Insert Figure 4 here

In Table 4 we show the reduced-form and the second-stage results for 10-year mortality using returns at various horizons. Returns between months $t-12$ and $t-1$ before retirement provide similar increases in mortality than returns between $t-6$ and $t-1$. The second stage coefficient for $Annuity_{i,t}$ is almost twice as large when using 12-month returns (-7.22 vs. -3.62 using 6-month returns), and it is strongly significant. There is little power of 3-month returns to predict future mortality, and also smaller and insignificant coefficient for $Annuity_{i,t}$ in the second stage regression. Longer returns, say between months $t-36$ and $t-1$ or $t-24$ and $t-1$, also have little predictive power for mortality, as well as in the second stage. This can be expected since recent experiences, e.g., the last 6 or 12 months, have more weight in the formation of beliefs than old experiences (Malmendier and Nagel, 2011). Consequently, long returns are less likely to influence the demand for annuities.

Insert Table 4 here

Returns in the post-retirement period provide a useful placebo exercise. The reduced-form regressions show that there is no significant relationship between post-retirement returns and future mortality. This is the case although post-retirement returns are only a few months away from the pre-retirement returns we used before. In the second stage we find an insignificant effect of annuities on mortality, and even that the sign of the effect flips. This is support for the exclusion restriction since, if returns have an impact on mortality through the business cycle, then we should not expect the effect to drop or flip at retirement.

Insert Figure 5 here

Strategic retirement timing induced by returns poses a potential challenge to the exclusion restriction. If timing is related to traits that affect future mortality, then it can violate the exclusion restriction. One possibility would be that strong people (those who know that will live longer lives) rush to retire with annuities after poor recent returns, and weak people (those who know that will live shorter lives) rush to retire with PW after good returns. The argument is symmetric for delayed retirement. Strong people should delay retiring with annuities after good returns, and weak people should delay retiring with PW after poor returns.

We tackle the issue of strategic retirement by looking at subsamples of individuals who retire in a given window around the legal retirement age of 60 for women and 65 for men. We set windows starting with $\pm$ 0 years and up to $\pm$ 5 years around the legal age. As seen in Figure 5, we cannot reject that the effects of annuities are the same in the narrow subsamples and in the full sample. In other words, strategic retirement does not appear to drive our results. In the sample with individuals that retire exactly at the legal age

(i.e., ± 0 years), the residual variation after birth-year and retirement-year fixed effects is much smaller than in the full sample. We still have variation in 6-month returns since some individuals retire early in the year and others late in the year, but we can expect smaller and noisy estimates.

4.4 Compliers

The IV setup leverages on compliers, which in our case correspond to individuals whose pension choices depend on past returns. Compliers are more (less) likely to take annuities when past returns are low (high). Simply put, compliers are return "extrapolators". There is ample evidence of extrapolation in investor expectations. Greenwood and Shleifer (2014) show that survey-based expectations of future stock returns are positively correlated with recent returns. Extrapolation can be particularly relevant for pension choices, since bias is likely to increase with age. For example, Besedeš, Deck, Sarangi, and Shor (2012) report that old investors rely more on heuristics, which can lead to extrapolation. In the same vein, Previtero (2014) shows that the inverse relationship between annuity demand and recent returns is stronger for older investors.

The IV estimation does not require that all individuals in the sample are compliers or extrapolators. Some individuals will take annuities regardless of past returns ("always takers" in IV language), and others will take PW regardless of past returns ("never takers" in IV language).[12] Compliers are individuals at the margin, or individuals for whom the cost and benefits of annuities are close. For them, past returns can be a small nudge to take annuities or PW.

The idea that compliers are extrapolators does not violate the exclusion restriction.

[12]The monotonicity assumption in IV is consistent with the existence of compliers, always takers, and never takers. In other words, returns either decrease annuity take-up (compliers), or do not affect annuity take-up (always and never takers), but returns never increase annuity take-up (defiers).

In general, differences between compliers and the general population do not violate the exclusion restriction because all comparisons in the IV setup are made within compliers. The IV estimation is still valid, in the sense of comparing a marginal retiree who takes annuities with a marginal retiree who takes PW. It is simply the case that both marginal retirees are extrapolators, and hence that the comparison is made within extrapolators. This argument can be extended to any other complier characteristic.

Still, the particular characteristics of compliers are relevant for external validity since they speak of the population from which our results are derived. In fact, it can be shown that β_{IV} is the local average treatment effect (LATE) for the complier population, which is not necessarily the same as the treatment effect for the entire population. Following Angrist and Pischke (2009), we study the prevalence of a characteristic in the complier population compared to the general population. We compute the ratio of the first-stage coefficient in a given subsample divided by the full-sample first-stage coefficient (from Table 3). Sub-samples are defined using a categorical variable (e.g., men) or observations above the median of a continuous characteristic (e.g., pension balance). If the ratio of first-stage coefficients is above (below) 1, then the compliers are more (less) likely to have that characteristic than the full sample.

Insert Table 5 here

Table 5 shows that compliers are as likely to be men as the general sample (which is already two-thirds men). Compliers are significantly less likely to retire with large balances, after more years of contributions, and with a high replacement rate. Pension savings are positively correlated with financial literacy (see Hastings and Mitchell (2020) for Chilean evidence), suggesting that compliers in our sample are less financially literate and, thus, more prone to extrapolation. We also find that compliers are more (less) likely

to retire late (early), again indicating that compliers might be extrapolators given the higher prevalence of extrapolation among older investors (Previtero, 2014). The split by age sub-samples is also consistent with the higher prevalence of extrapolation in old age. Finally, compliers are more likely to employ financial advisors, which suggests that compliers are aware of their lack of financial sophistication. However, financial advisors are often subject to behavioral biasses, such as extrapolation, just like their clients (Linnainmaa, Melzer, and Previtero, 2021).

Extrapolation is a unifying theme for compliers in our sample. The literature shows that extrapolation is prevalent among many investors and large segments of the population (Greenwood and Shleifer, 2014). Thus, instead of raising concerns about the external validity of our setup, it suggests that our results are potentially relevant for many retirees around the world.

5 Why do annuities reduce mortality?

Annuities provide a constant income stream in purchasing power terms, since payments are adjusted for inflation. Phased withdrawals (PWs), by contrast, have payments that might decline later in life (Figure 2). PWs are recalculated annually, and retirement income also depends on pension fund returns: with high returns, income may increase, whereas with negative returns, income may decline faster than initially anticipated. We begin by investigating heterogeneity in the annuity effects by income levels to test if annuities increase longevity because they prevent retirees from running out of money. We then investigate heterogeneity by return differentials between annuities and phased withdrawals to study if annuities are effective because they provide a stable income, independent from stock market fluctuations. Last, we study if annuities provide incentives

to live longer and healthier lives.

5.1 Do annuities prevent retirees from running out of money?

Living expenses can decrease with age as children leave the home. However, medical expenses typically increase later in life. Using data from the Health and Retirement Study, Fahle, McGarry, and Skinner (2016) show that out-of-pocket medical expenses rise sharply with age and even more near the end of life. Therefore, annuitants are less likely to run out of money when facing higher medical costs later in life.[13]

If annuities prevent individuals from running out of money, we would expect the effect of annuities to be stronger among individuals with lower income levels and fewer resources to cover health care expenses. We investigate this possibility in Table 6. Given that annuities determine the post-retirement income, and to avoid a bad control problem (Angrist and Pischke 2009), instead of controlling for post-retirement income, we re-run our main specification in equation Table 3 separately for sub-samples of retirees with above or below median post-retirement resources.

Insert Table 6 here

In Table 6, we begin by analyzing the effects of annuities on the sample of retirees with high (above median) and low (below median) post-retirement income.[14] Contrary to the notion that running out of money drives the effect of annuities, we find that the effect of annuities is not stronger in the low post-retirement income. If anything, our estimates are

[13]Expected health costs can be a first-order determinant of the demand for annuities and portfolio choice. For a treatment of this topic, see De Nardi, French, and Jones (2010), Peijnenburg, Nijman, and Werker (2017), and Yogo (2016).

[14]The post-retirement real income for annuitants is constant and equal to the first payment. For retirees with PW, we compute the post-retirement real income with the Stata module `cnu` provided by the pension regulator, and assuming the retiree selects fund C after retirement.

larger for the sample with high post-retirement income (-7.36) than for retirees with low income (-1.41). While economically meaningful in magnitude, this difference is imprecisely estimated (p = 0.172).

We obtain qualitatively similar results when we split the sample by pension balance or income replacement ratio (see Columns 3-7). Taken together, our evidence suggests that the effect of annuities on longevity is not limited to retirees with low income, low pension balances, or low pension replacement ratios. Therefore, the possibility that a non-annuitant could run out of money is unlikely to be the primary determinant of our results.

5.2 Do annuities shield retirees from investment-related stress?

Another possibility is that phased withdrawals expose retirees to greater income volatility, as their payments fluctuate with the returns of the selected pension funds. Higher income volatility can negatively impact longevity (Sullivan and von Wachter 2009a). Analogously, fluctuations in financial markets that affect retirement wealth can increase stress, diminish mental health, and ultimately lead to higher short-term mortality (Engelberg and Parsons 2016, Schwandt 2018).

To address this possibility, in Table 7 we rerun our main specification in Table 3, splitting the sample by post-retirement returns. More specifically, we compute the one-year return differential between the chosen payout form and the alternative (non-chosen) option.[15] The intuition in running these tests is that annuitants—who receive a stable income—are insensitive to ex-post return differentials. In contrast, non-annuitants might be more attentive to Fund C performance and experience stress or anxiety if their return

[15]For an annuitant, we compute the difference between the annuity yield and the return on the most popular pension fund, Fund C. Conversely, for a non-annuitant, we compute the differential between the returns of Fund C and the annuity yield.

differentials are negative. That is, for example, if they select phase withdrawals and the performance of the fund C is low or negative. If this intuition is correct, we would expect the effect of annuities to be stronger in the subsample of retirees who experience negative return differentials. In other words, when we compare samples of annuitants and non-annuitants who both experience positive return differentials, then the effect of annuities on longevity might be muted. Conversely, when we compare retirees who experience negative return differentials, the impact of annuities is stronger, as non-annuitants experience higher stress or anxiety than annuitants because they face poor pension fund returns.

We begin by investigating return differentials above or below our sample median in Table 7, Columns 1 and 2). Consistent with the idea that annuity might mitigate stress about pension fund returns, our estimates are stronger when retirees face negative (below median) return differentials (-2.26) as opposed to positive (above median) differential (0.50). This difference is marginally statistically significant (p = 0.098). In Columns 3 and 4, we repeat a similar analysis, changing the definition of negative vs. positive return differentials. When we focus on return differentials below the bottom quartile of the differential distribution in our sample, our results become economically stronger (-4.01 vs. 0.04) and their difference is highly statistically significant (p-value = 0.007). This evidence is consistent annuitants experiencing a more sizable reduction in mortality when non-annuitants face strong negative pension fund returns in the year following their payout decision.

In Columns 5 to 8 of Table 7, we repeat similar analyses focusing on return differentials computed in the two years post retirement. Consistent with the evidence in Columns 1 to 4, We find stronger annuity effects for negative differentials with these differences economically and statistically significant with p-values of 0.032 for the median split and 0.024 for the top/ bottom quartile split.

Overall, this evidence show that the effect of annuities is particularly strong when retirees face negative return differentials in the one or two-years post-retirement. We interpret these findings as consistent with annuities limiting the stress and anxiety associated with bad financial returns.

5.3 Do annuities provide stronger incentives to invest in health?

Last, we explore the idea that annuities might provide stronger incentives to live longer and healthier lives (Philipson and Becker 1998). By setting up life-contingent payments, annuities introduce a classical moral-hazard problem, whereby those insured do more of what they are insured against, in this case, living. Evidence in Table 6 suggests that the effect of annuities is potentially stronger for retirees who have higher retirement wealth (post-retirement income, pension balance, or replacement rate) and, hence, larger financial incentives.

In Appendix Table A2 we study heterogeneity across two additional subsamples, which could potentially speaks about the intensity of the incentive effect. In Columns 1 and 2, we split the sample by whether annuities have a guaranteed period. In column 1, we compare guaranteed annuities with programmed withdrawals (PW), and in column 2, we compare non-guaranteed annuities with PW. We find stronger effects for guaranteed annuities, although the difference relative to other annuities is not statistically significant. It is important to note that the vast majority of annuities in our sample are guaranteed (see Table 1), and most guarantees extend over a long horizon (typically 10 years). Thus, we interpret the presence of a guarantee as a proxy for households with dependents, such as a spouse or other beneficiaries. The incentive to continue living can be greater when retirees are less lonely.

In Columns 3 and 4 of Table A2, we split the sample by gender. The effect is much stronger (in magnitude) in men than women (-6.56% vs. 0.57), and the difference is highly significant (p-value 1.65%). Men are expected to respond more to monetary incentives (Croson and Gneezy, 2009). These sample splits are not definitive evidence for the incentive effect, but they point in that direction.

A potential interpretation of the incentive effect is that annuities reduce mortality by allowing retirees to invest in a healthier lifestyle. The stable income that annuities provide can facilitate planning and, in general, enable commitments to recurring expenditures, such as medical insurance or healthier eating. We do not have a way to test this hypothesis directly with our main sample, although we provide suggestive evidence consistent with it in the next section.

As preliminary evidence for this channel, we collect data on the lifestyles of fully retired individuals in the 2002-2020 U.S. Health and Retirement Study (HRS). For each individual, we compute the average of each response across the multiple surveys where the individual appears. Then, we average across across individuals with and without annuities. In Table 8 we show that annuitants are more likely to exercise, are less likely to smoke, and have lower weight. Annuitants have higher health expenses, which can be related to the income channel as well. The differences are mostly stronger when we compare with annuitants that receive at least USD18,000 annually (1,500 monthly).

Insert Table 8 here

We cannot claim this as definitive evidence of behavioral changes induced by annuities, since it can also reflect selection effects. In other words, individuals with healthier lifestyles may choose annuities in the first place, instead of deciding to live healthier lives because of life-contingent payments. Unfortunately, there is not enough data in the HRS to apply

our identification strategy with returns.

6 Annuities and well-being in retirement

In this final section we explore well-being in retirees as another indication of the long-term effects of annuities. In this section we use different data sources, so the results can serve as an out-of-sample check of the previous evidence.

In Table 8 we begin by confirming Panis (2004)'s finding with previous HRS surveys that U.S. annuitants are, on average, more satisfied with retirement and have fewer depression symptoms. Annuitants report to be in better health than non-annuitants, and have less difficulty with day-to-day activities such as eating, going to the bathroom, getting dressed, going out of the house, communicating, and others. Again, this can be due to selection effects and not a treatment effect related to annuities.

The advantage of health outcomes, measured in similar ways as the HRS, is that they are part of the Chilean CASEN, a survey that the Chilean Ministry of Development runs every two years. This survey reports information about income, work, education, health, household composition, and living standards for a representative sample of thousands of households across the country. The sample is different each year, so it is a repeated cross-sectional survey. Questions regarding sources of retirement income (e.g., PW or annuity) start with the 2011 survey. In the rest of our analysis we focus on retired men (women) who are older than 65 (60), and who are receiving non-disability pension income from either PW or an annuity.

Insert Table 9 here

Table 9 reports summary statistics for the CASEN sample: 49% of retirees have annuities, they are 71.5 years old on average, and 57% are men. Annuitization is lower

than in our main sample (Table 1) since the CASEN includes retirees who do not qualify for SCOMP and for whom PW is the only available option. This can also be seen in the much lower income of the CASEN respondents than those in SCOMP (Table 1). When comparing retirees with PW and annuities, we find that annuitants have higher post-retirement income, as also in Table 1.

Consistent with annuities allowing retirees to invest in health, we find that annuitants are 4.1% more likely to have private mandatory health insurance, and 1.9% more likely to have private supplementary health insurance. They are 4.7% more likely to have a preventive health check-up in the last 12 months, and to get that check-up with a private health provider.

Like the HRS, the CASEN survey includes a set of questions about day-to-day disabilities. Each response can go from 1 (no difficulty) to 5 (severe difficulty). Mean disability is the average over ten disability questions and has an overall average of 1.178. Max disability is the highest number across the ten responses for an individual and has an average of 1.385. Thus, annuitants suffer from fewer disabilities (both mean and max disability) than retirees under PW.

Unlike our main SCOMP sample, we do not know the exact date of retirement for individuals in the CASEN sample. However, we know their age, and when the field work for the survey was conducted. With this information we can estimate when women (men) in the sample turned 60 (65), and hence their likely retirement date. This is a noisy proxy for the exact retirement date, given the flexibility of individuals to retire ahead of or after their 60th (65th) birthday (see Figure 1). Still, we estimate our IV setup using returns in the 6 months before this pseudo-retirement date.

Insert Table 10 here

In column 1 of Table 10 we run the first stage of the IV setup in the CASEN sample. Returns before the psedo-retirement date predict annuitization with a negative sign as in our main results in Table 3. The coefficient for returns is less than half the coefficient we find in the main sample, which is consistent with attenuation bias due to noise in the retirement date. The first-stage F-statistic is 7.79, suggesting a potential problem of weak instruments (more on this below).

In columns 2 through 4 we show the OLS, reduced form, and second stage when the dependent variable is the mean disability for each individual. We find a negative OLS coefficient for annuity. The second stage coefficient is larger (-0.985), and equivalent to almost two standard deviations of mean disability in the sample (0.51). The coefficient for annuity is significant under standard inference. In the case of a potentially weak instrument, Andrews, Stock, and Sun (2019) recommend using Anderson-Rubin (AR) confidence intervals instead. The AR weak-instrument–robust 95% confidence interval is $[-3.54; -0.33]$, so our conclusion that there is a significant negative impact of annuities on disability remains valid even if our instrument is weak. The effects for max disability in columns 5 through 7 are analogous, although the statistical significance in the second stage is marginal (p-value of 7.2%).

Insert Figure 6 here

To further alleviate concerns about selection into treatment, we document the differences in these disability measures by annuitants and PW-retirees, looking at the differences by year after reaching retirement age (60 or 65 for women and men). Figure 6 shows the mean disability residual (after controlling for survey year, income, age, and gender) in 5-year intervals. In the first panel (OLS) we split individuals by their annuity decision, and in the second panel by pseudo pre-retirement returns. The panel with returns can be

interpreted as the reduced-form relationship between returns and disability measures. We find that retirees who likely faced high and low returns before retirement are similar for the first 20 years after retirement. Differences arise beyond 20 years: low-return retirees, associated with higher annuity take-up, have lower disability in the last few years of their lives.

Our evidence on disabilities is consistent with annuities improving health during retirement years. This serves as a complement to the previous evidence on mortality from a different sample and individuals. Overall, annuities appear to have a strong impact on well-being for retirees.

7 Conclusions

What is the relationship between annuities and longevity? By providing a stable income stream for as long as someone lives, annuities can provide retirees a simple way to manage their finances later in life when individuals face cognitive decline and high health expenses.

Using data from over 600,000 Chilean retirees, we investigate whether annuities directly affect longevity. For our identification, we rely on the fact that recent stock market returns provide a plausibly exogenous shock to the propensity to annuitize. In other words, the stock market return in the six months before turning 65 (or 60) should be exogenous and unrelated to mortality rates several years later. Our instrumental variable approach shows that annuities have a positive, economically meaningful impact on longevity.

We analyze a survey of Chilean retirees to investigate the mechanism behind our results. Our IV estimates confirm that annuitants are in better health and are less likely to report disability status than non-annuitants. Notably, the health status of annuitants

and non-annuitants is remarkably similar for the first decade post-retirement, but diverges afterwards.

Identifying the treatment effect of annuities is important for the correct design and functioning of pension systems. Philipson and Becker (1998) highlight how introducing mandatory annuity programs such as Social Security has been associated with a rapid rise in life expectancy at older ages, potentially due to the incentives provided by annuities. Many countries have reduced the generosity of annuitized public pensions and nudged citizens to rely more on private or employer-sponsored retirement plans that do not provide longevity insurance. This trend can potentially reverse the longevity gains introduced by the Social Security system.

A further consideration concerns the correct pricing of annuities. Insurance companies rely on annuitants' mortality projections to price annuities. Understanding annuity selection and treatment effects can help improve this pricing process (Koijen and Yogo, 2023).

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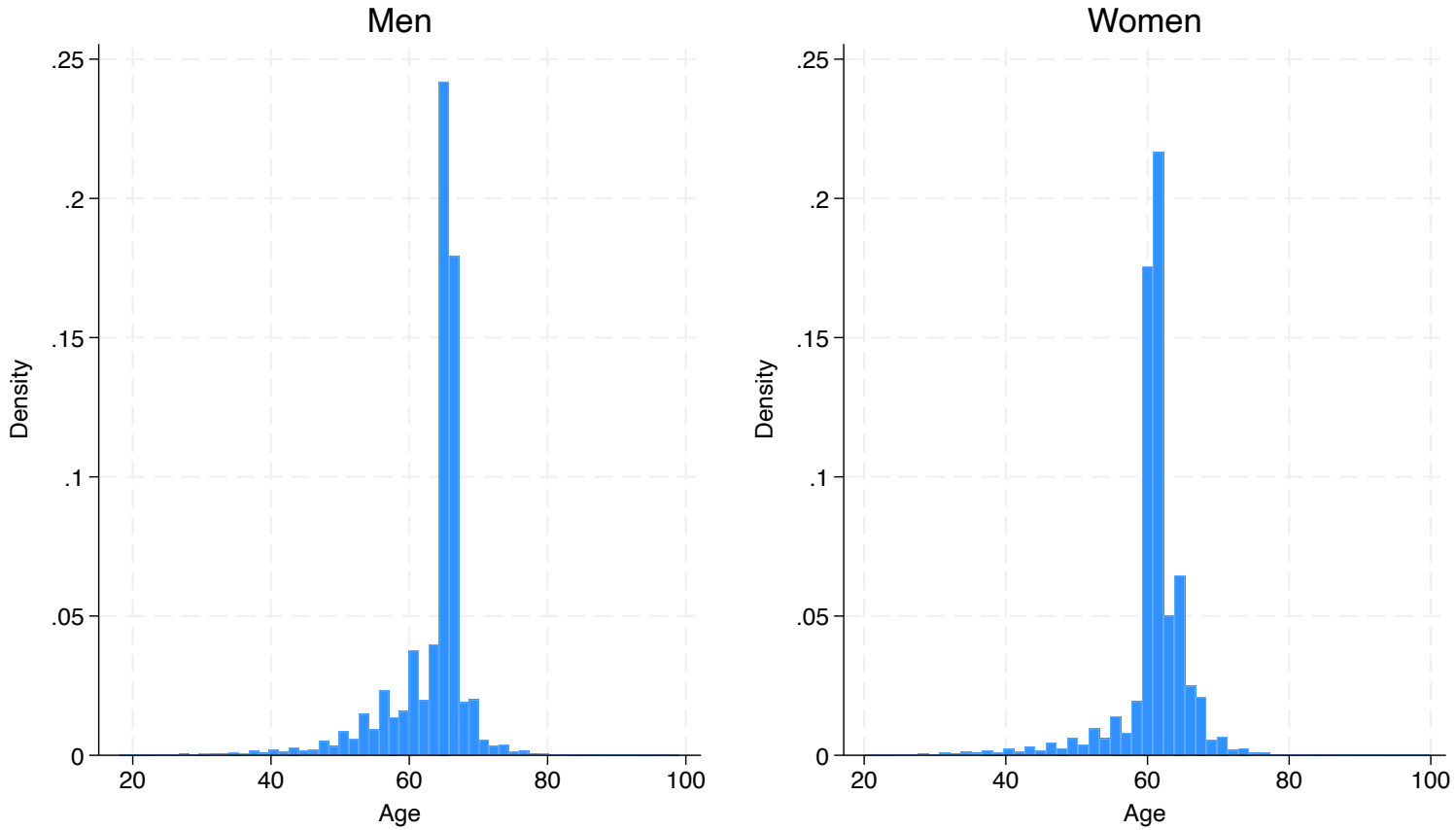
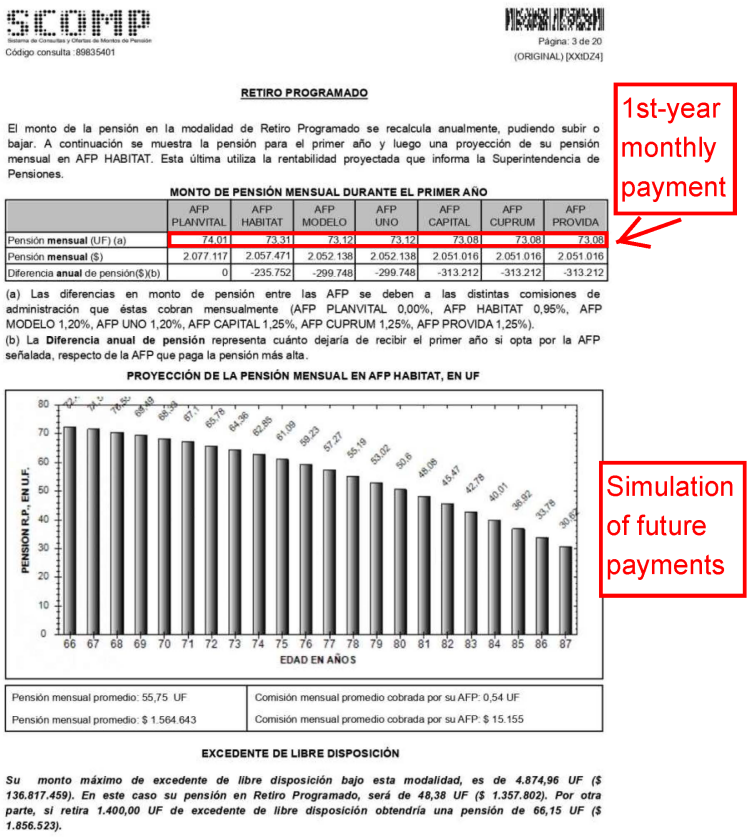
Figure 1: Retirement Age in the Chilean Pension System



Notes: This figure shows the distribution of retirement ages for men (left panel) and women (right panel) in the Chilean pension system. Data are obtained from the SCOMP exchange. More details are reported in Table 1.

Figure 2: Offers of Phased Withdrawal from SCOMP



SCOMP
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Código consulta :89835401

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RETIRO PROGRAMADO

El monto de la pensión en la modalidad de Retiro Programado se recalcula anualmente, pudiendo subir o bajar. A continuación se muestra la pensión para el primer año y luego una proyección de su pensión mensual en AFP HABITAT. Esta última utiliza la rentabilidad proyectada que informa la Superintendencia de Pensiones.

MONTO DE PENSIÓN MENSUAL DURANTE EL PRIMER AÑO

	AFP PLANVITAL	AFP HABITAT	AFP MODELO	AFP UNO	AFP CAPITAL	AFP CUPRUM	AFP PROVIDA
Pensión **mensual** (UF) (a)	74,01	73,31	73,12	73,12	73,08	73,08	73,08
Pensión **mensual** ($)	2.077.117	2.057.471	2.052.138	2.052.138	2.051.016	2.051.016	2.051.016
Diferencia **anual** de pensión($)(b)	0	-235.752	-299.748	-299.748	-313.212	-313.212	-313.212

(a) Las diferencias en monto de pensión entre las AFP se deben a las distintas comisiones de administración que éstas cobran mensualmente (AFP PLANVITAL 0,00%, AFP HABITAT 0,95%, AFP MODELO 1,20%, AFP UNO 1,20%, AFP CAPITAL 1,25%, AFP CUPRUM 1,25%, AFP PROVIDA 1,25%).
(b) La **Diferencia anual de pensión** representa cuánto dejaría de recibir el primer año si opta por la AFP señalada, respecto de la AFP que paga la pensión más alta.

PROYECCIÓN DE LA PENSIÓN MENSUAL EN AFP HABITAT, EN UF

Pensión mensual promedio: 55,75 UF	Comisión mensual promedio cobrada por su AFP: 0,54 UF
Pensión mensual promedio: $ 1.564.643	Comisión mensual promedio cobrada por su AFP: $ 15.155

EXCEDENTE DE LIBRE DISPOSICIÓN

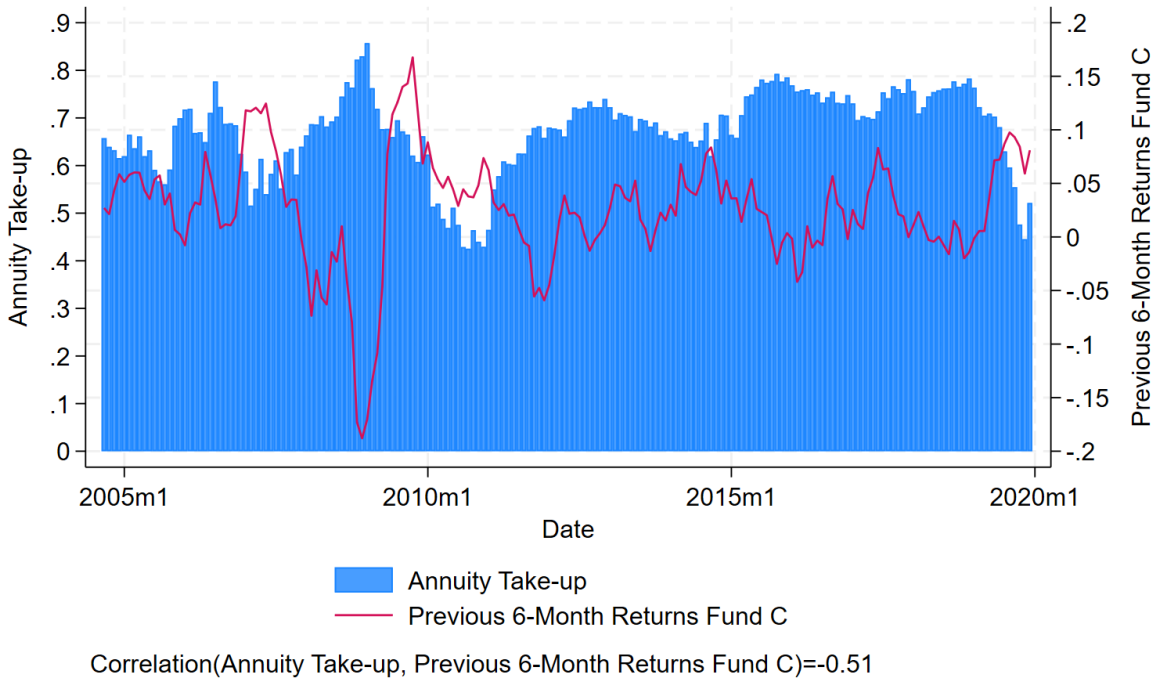
Su monto máximo de excedente de libre disposición bajo esta modalidad, es de 4.874,96 UF ($ 136.817.459). En este caso su pensión en Retiro Programado, será de 48,38 UF ($ 1.357.802). Por otra parte, si retira 1.400,00 UF de excedente de libre disposición obtendría una pensión de 66,15 UF ($ 1.856.523).

1st-year monthly payment

Simulation of future payments

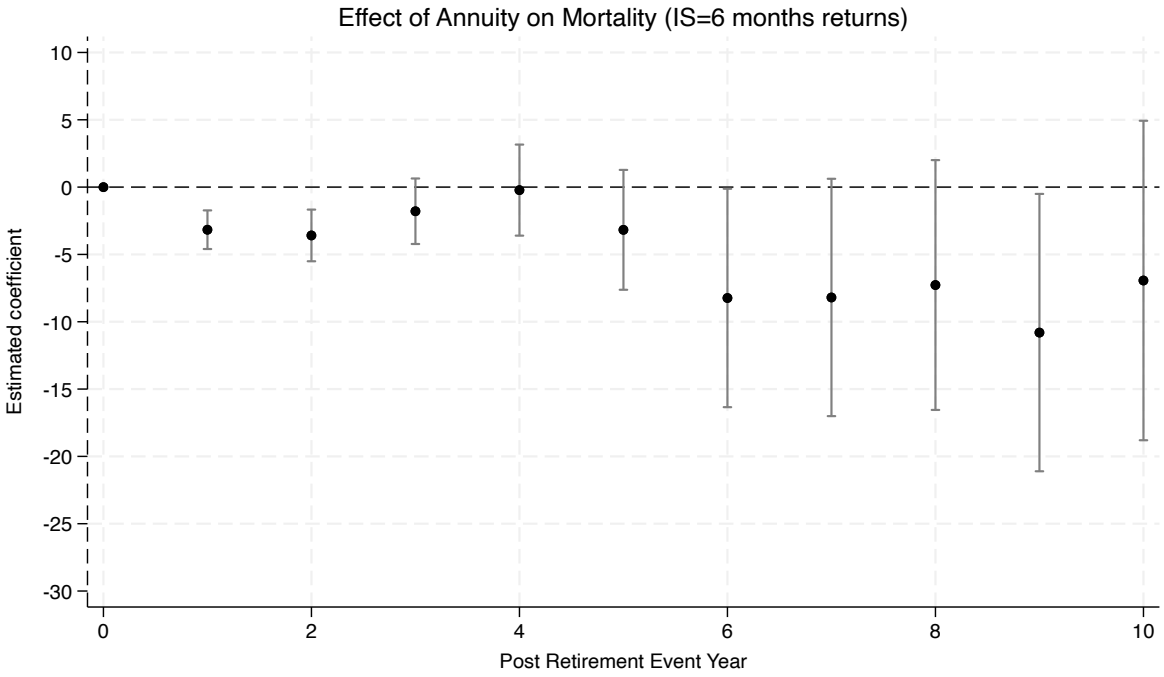
Notes: The figure shows an example of the summary of phased withdrawal (*Retiro Programado*) offers that an individual receives from the SCOMP exchange. The 1st-year monthly payment is expressed in UFs (*Pension mensual (UF) (a)*) and pesos (*Pension mensual ($)*). Several pension fund administrators (*AFP*) make bids, and the table orders them from the least to the most expensive one in terms of fees for the individual. The difference between offers (*Diferencia anual de pension ($)(b)*) is the annual fee charged by each pension fund administrator compared to the least expensive one. The graph below the table shows a simulation of future monthly payments at different ages (*edad en años*) of the individual, and under one particular pension fund administrator. This example is taken from https://www.scomp.cl/scompsa/certificado-de-ofertas-pension-vejez-CO.html.

Figure 3: Annuity Take-up



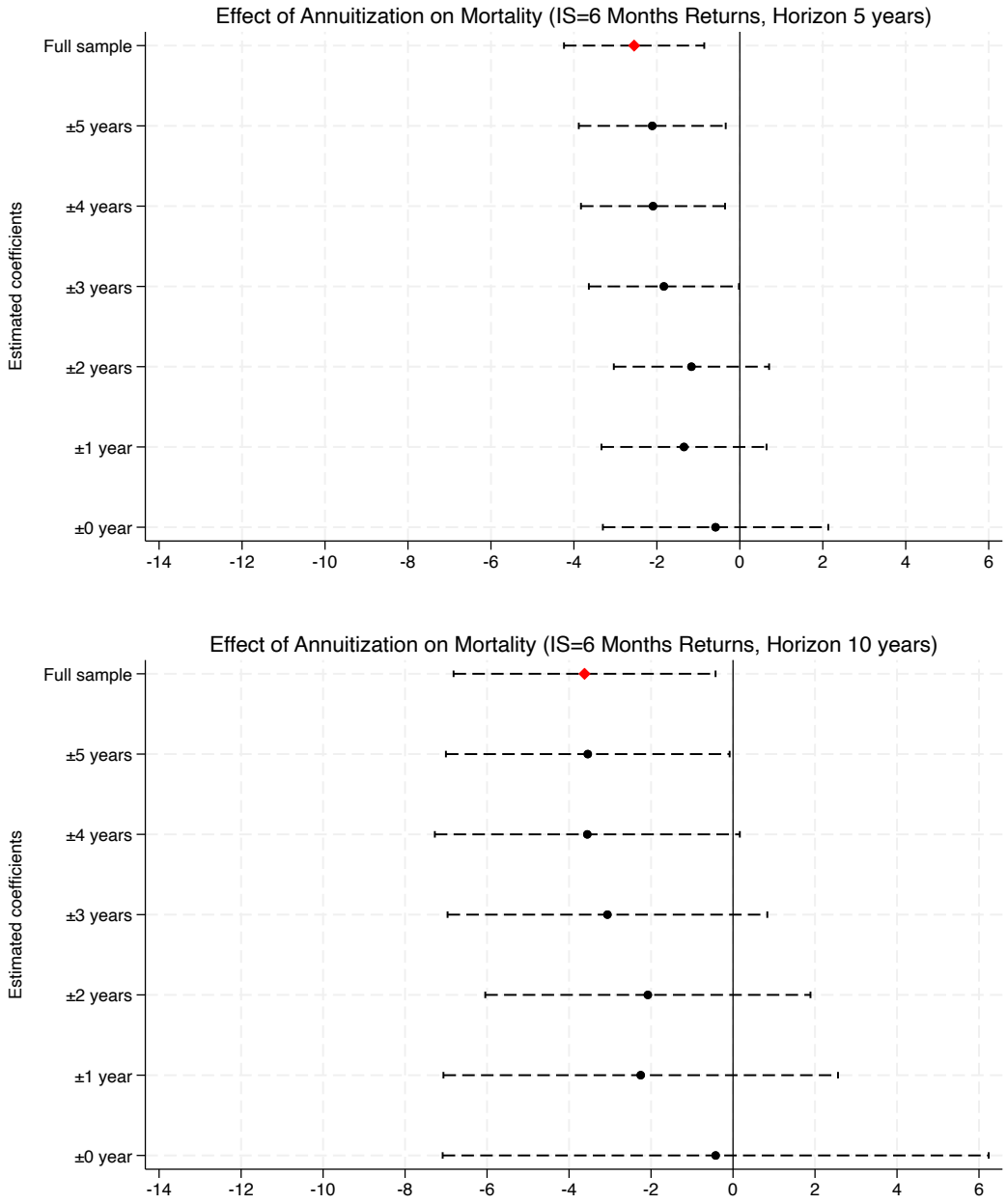
Notes: The bars represent the fraction of investors retiring each month that take annuities, and the line shows the previous 6-month cumulative returns for Fund C. Data on retirees comes from the SCOMP database.

Figure 4: Effect of Annuities on Mortality by Post-Retirement Year



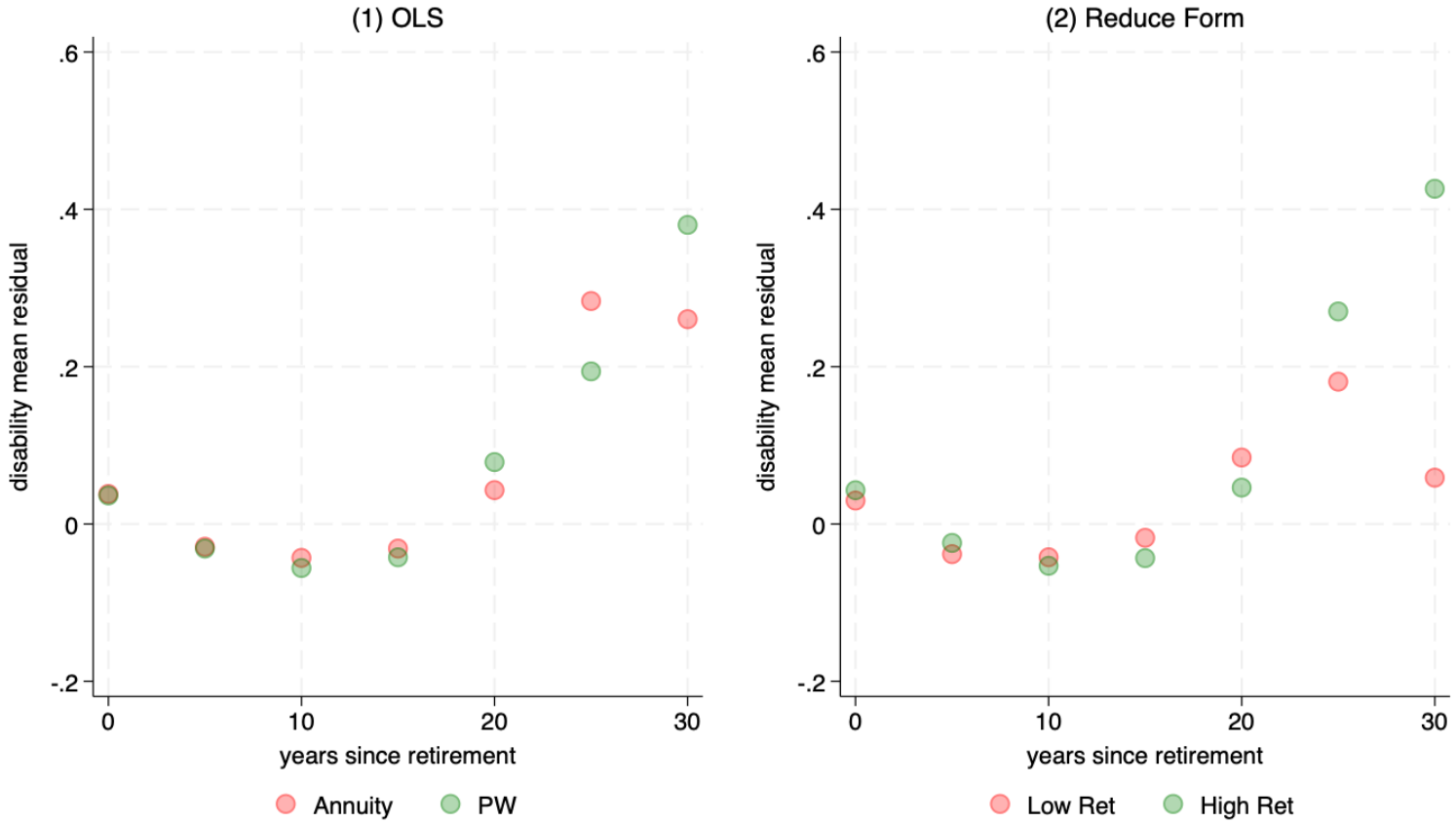
Notes: These plots estimate the dynamic effect by year post-retirement of the estimated coefficient of annuities on mortality, followed by the specification in equation 3.

Figure 5: Effect of Annuities by Sub-Samples Around Legal Retirement Age



Notes: This figure shows the coefficient for annuities from equation 3 estimated in different sample. The full sample estimate corresponds to the results in Table 3, +/- 5 years defines the sample with men that retire between ages of 60 and 70 and women that retire between ages 55 and 65, so on and so forth.

Figure 6: Disability Mean Index and Time Since Retirement



Notes: Data from these figures use the CASEN survey sample. The y-axis uses the disability mean index residual, obtained by regression of the disability mean index for each individual in a set of controls that includes age, gender, income, and survey year. The left panel plots the average of mean disability residuals by annuity or phased withdrawal grouping observations by year-since-retirement bins of size five years. The right panel follows the same structure but dividing the residual into low and high pseudo pre-retirement returns, thus mimicking a reduced-form estimation, where low previous returns are associated with higher annuity take-up.

Table 1: Summary Statistics for Retirees

The table reports summary statistics of various variables for the entire sample of retirees (All), as well as the sub-samples of retirees with Phased Withdrawal (PW) and Annuities (AN). The data consists of all retirees between 2004-2022 in the SCOMP system. Annuity is an indicator variable for retirees that choose annuities (1=AN, 0=PW). Annuity value or initial balance refers to the total pension savings at the start of retirement denominated in UF (inflation-adjusted unit of account). Initial monthly payment is the amount received each month during the first year of retirement. Last monthly income corresponds to income measured just before retirement. Years of contributions to pension funds correspond to the number of years during which the individual saved for retirement. Retirement age and age of death are measured in years. Returns pre-retirement correspond to the returns on Fund C (moderate fund) in the 6 months before the retirement decision (PW or AN). Early retirement is an indicator variable for individuals who retire earlier than the legal age. Dead is an indicator variable for individuals who died in our sample. Guaranteed annuity is an indicator variable for annuities with any guaranteed period of payment. The last column reports the difference in means between columns AN and PW. The level of statistical significance is estimated by partialling out retirement-year fixed effects, and clustering standard errors at the birth-year level. Significant at: *10%, **5% and ***1%.

	All			PW			Annuity (AN)			
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean AN - Mean PW
Annuity (1=AN, 0=PW)	0.66	1.00	0.47							
Annuity value or initial balance (UF)	2,600	1,794	2,910	2,510	1,380	3,983	2,646	1,932	2,167	135.918
Initial monthly payment (UF)	16.3	11.5	16.0	15.5	8.4	20.1	16.7	12.5	13.4	1.189***
Last monthly income (UF)	27.2	19.6	22.2	27.0	17.6	23.3	27.3	20.6	21.7	0.301***
Initial payment over last income	0.93	0.59	0.83	0.89	0.53	0.83	0.96	0.62	0.83	0.069***
Years of contributions to pension funds	26.2	27.4	8.5	26.6	28.3	9.3	26.0	27.2	8.0	-0.575**
Retirement age	63.2	65.0	4.1	64.0	65.0	3.8	62.8	64.0	4.2	-1.163**
Returns pre-retirement (months t-6 to t-1)	0.018	0.020	0.049	0.013	0.015	0.053	0.021	0.021	0.0	0.008**
Early retirement	0.15	0.00	0.35	0.11	0.00	0.31	0.17	0.00	0.37	0.064**
Gender (1=Male, 0=Female)	0.66	1.00	0.47	0.70	1.00	0.46	0.65	1.00	0.48	-0.051**
Year of birth	1952	1952	5.4	1953	1954	5	1951	1951	5	-1.746**
Dead	0.08	0.00	0.27	0.07	0.00	0.25	0.09	0.00	0.29	0.023**
Age of death	68.6	69.0	6.5	68.8	69.0	6.4	68.5	69.0	6.6	-0.329**
Guaranteed annuity							0.81	1.00	0.39	
Observations	591,909			199,704			392,205			

Table 2: Balance Test

The table reports the averages of different variables for sub-samples based on the returns for fund C in the 6 months before retirement. High (Low) Returns refers to individuals for whom returns are higher (lower) than the sample median. The data consists of all retirees between 2004-2022 in the SCOMP system. Annuity value or initial balance refers to the total pension savings at the start of retirement, denominated in UF (inflation-adjusted unit of account). Initial monthly payment is the amount received each month during the first year of retirement. Last monthly income corresponds to income measured just before retirement. Years of contributions to pension funds correspond to the number of years during which the individual saved for retirement. Retirement age and age of death are measured in years. Early retirement is an indicator variable for individuals who retire earlier than the legal age. Dead is an indicator variable for individuals who died in our sample. The last column reports the difference in means between columns with high and low returns. The level of statistical significance is estimated by partialling out retirement-year fixed effects, and clustering standard errors at the birth-year level. Significant at: *10%, **5% and ***1%.

	High Returns			Low Returns			
	Mean	Median	SD	Mean	Median	SD	Mean Low - Mean High
Annuity value or initial balance (UF)	2,627	1,818	3,106	2,574	1,770	2,696	-52.955
Initial monthly payment (UF)	16.16	11.34	15.80	16.50	11.56	16.12	0.334
Last monthly income (UF)	26.10	18.55	21.74	28.27	20.72	22.69	2.172
Initial payment over last income	0.93	0.60	0.82	0.93	0.58	0.84	-0.003
Years of contributions to pension funds	25.45	26.67	8.36	26.96	28.25	8.53	1.510
Retirement age	62.84	64.00	4.24	63.54	65.00	3.89	0.701
Returns pre-retirement (months t-6 to t-1)	0.06	0.05	0.03	-0.02	-0.01	0.03	-0.074**
Early retirement	0.18	0.00	0.39	0.11	0.00	0.32	-0.07
Gender (1=Male, 0=Female)	0.66	1.00	0.47	0.66	1.00	0.47	0.002
Year of birth	1951	1951.0	5	1953	1953.0	5	1.909
Dead	0.09	0.00	0.29	0.07	0.00	0.25	-0.02
Age of death	68.79	69.00	6.55	68.26	68.00	6.48	-0.521
Observations	297,595			294,314			

Table 3: The Effect of Annuities on Mortality

The table reports regression results for samples with horizons of 5 and 10 years. Each panel contains the OLS regression (equation 1), the reduced-form (RF) regression, the first stage (equation 2), and the second stage (equation 3) of the IV setup. $Dead_{i,t+j}$ is multiplied by 100, so the coefficients can be interpreted as percentage points. The instrument is the pre-retirement return of fund C between months $t-6$ and $t-1$. All regressions include as controls: total pension savings, last monthly income before retirement, years of contributions to pension funds, dummies for retirement type (early, disability, old-age), retirement month dummies, and birth-year and retirement-year fixed effects interacted with gender dummies. The Kleibergen-Paap robust F-statistic is reported for the first stage regression. Standard errors clustered at the birth-year level are reported in parentheses, and p-values are reported below standard errors. Significant at: *10%, **5% and ***1%.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	5-Year Horizon				10-Year Horizon			
	OLS	RF	1st Stage	2nd Stage	OLS	RF	1st Stage	2nd Stage
VARIABLES	Dead	Dead	Annuity	Dead	Dead	Dead	Annuity	Dead
Annuity	-0.69***			-2.55***	-0.87***			-3.62**
	(0.081)			(0.862)	(0.085)			(1.630)
	0.000			0.004	0.000			0.029
Returns (t-6 - t-1)		1.41***	-0.55***			1.67**	-0.46***	
		(0.498)	(0.066)			(0.738)	(0.055)	
		0.006	0.000			0.027	0.000	
Observations	2,746,058	2,746,058	2,746,058	2,746,058	4,460,606	4,460,606	4,460,606	4,460,606
R-squared	0.050	0.049	0.175		0.068	0.067	0.142	
Kleibergen-Paap F-stat			69.88				69.89	

Table 4: The Effect of Returns of Different Horizons on Mortality

Panel A reports the reduced-form regression for the effect of different returns before and after retirement on mortality at the 10-year horizon. Panel B reports the second stage coefficient on annuitization using the returns in Panel A as instruments. The regression specification is the same as in Table 3. Standard errors clustered at the birth-year level are reported in parentheses, and p-values are reported below standard errors. Significant at: *10%, **5% and ***1%.

	10-Year Horizon									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
Panel A: Reduced Form										
Returns (t-36 through t-1)	0.28									
	(0.581)									
	0.636									
Returns (t-24 through t-1)		0.45								
		(0.598)								
		0.455								
Returns (t-12 through t-1)			2.02***							
			(0.617)							
			0.002							
Returns (t-6 through t-1)				1.67**						
				(0.738)						
				0.027						
Returns (t-3 through t-1)					1.10					
					(1.054)					
					0.298					
Returns (t+1 through t+3)						1.67				
						(1.192)				
						0.165				
Returns (t+1 through t+6)							1.32			
							(1.027)			
							0.201			
Returns (t+1 through t+12)								0.61		
								(0.655)		
								0.353		
Returns (t+1 through t+24)									-0.21	
									(0.561)	
									0.704	
Returns (t+1 through t+36)										0.22
										(0.949)
										0.817
Panel B: Second Stage										
Annuity [Ret. (t-36 through t-1)]	-1.53									
	(3.094)									
	0.622									
Annuity [Ret. (t-24 through t-1)]		-1.21								
		(1.580)								
		0.446								
Annuity [Ret. (t-12 through t-1)]			-7.22***							
			(2.157)							
			0.001							
Annuity [Ret. (t-6 through t-1)]				-3.62**						
				(1.630)						
				0.029						
Annuity [Ret. (t-3 through t-1)]					-1.82					
					(1.732)					
					0.297					
Annuity [Ret. (t+1 through t+3)]						22.61				
						(22.578)				
						0.320				
Annuity [Ret. (t+1 through t+6)]							3.95			
							(3.203)			
							0.221			
Annuity [Ret. (t+1 through t+12)]								2.07		
								(2.240)		
								0.358		
Annuity [Ret. (t+1 through t+24)]									-0.48	
									(1.285)	
									0.709	
Annuity [Ret. (t+1 through t+36)]										0.81
										(3.552)
										0.819
Observations	4,460,606	4,460,606	4,460,606	4,460,606	4,460,606	4,460,606	4,460,606	4,460,606	4,338,585	4,214,570

Table 5: Characterization of Compliers

This table shows the ratio of the first-stage coefficient in a subsample divided by the full-sample first-stage coefficient. Subsamples are defined using a categorical variable (e.g., men) or observations above the median of a continuous characteristic (e.g., balance). If the ratio of first-stage coefficients is above (below) 1, then the compliers are more (less) likely to have that characteristic than the full sample. The 95% confidence intervals for the ratio are computed through the delta method. The complier population is significantly different from the full sample (in terms of a given characteristic) if the confidence interval excludes the 1.

Sub-sample	Ratio of 1st Stage Coeffs.	95% C.I.
Men	0.959	(0.807 - 1.111)
Large Balance	0.530	(0.210 - 0.849)
More years of contributions	0.678	(0.440 - 0.916)
High replacement rate	0.540	(0.201 - 0.878)
Early retirement	0.561	(0.309 - 0.812)
At legal age	1.221	(0.719 - 1.723)
Late retirement	1.243	(1.010 - 1.477)
$50 \leq$Age<60	0.490	(0.203 - 0.777)
$60 \leq$Age<70	1.084	(0.985 - 1.182)
$70 \leq$Age	1.559	(0.921 - 2.197)
With advisor	1.074	(1.008 - 1.139)

Table 6: The Effect of Annuity on Mortality: Heterogeneity by Income Levels

The table reports second-stage regressions of the effect of annuity on 10-year mortality. The annuity decision is instrumented using the previous 6-month returns on Fund C. Sample splits are based on the sample median of the following continuous variables: post-retirement income, pension balance at retirement, and replacement rate. The post-retirement income for annuitants is constant and equal to the first payment. For retirees with PW, post-retirement income is computed with the Stata module `cnu` provided by the pension regulator, and assuming the retiree selects fund C after retirement. The regression specification is the same as in Table 3. Standard errors clustered at the birth-year level are reported in parentheses, and p-values are reported below standard errors. The p-value for the difference in the annuity coefficient across subsamples is also reported. Significant at: *10%, **5% and ***1%.

Sample split by:	Post-Retirement Income		Pension Balance		Replacement Rate	
	Dead	Dead	Dead	Dead	Dead	Dead
Annuity	-7.36*	-1.41	-4.66**	-3.74	-5.39**	-2.20
	(3.975)	(1.774)	(2.205)	(4.225)	(2.565)	(2.386)
	0.069	0.429	0.037	0.378	0.039	0.360
p-value of difference in coeff.		0.172		0.847		0.363
Sample	High	Low	High	Low	High	Low
Observations	1,470,041	2,883,018	2,292,160	2,168,446	2,510,666	1,949,940

Table 7: The Effect of Annuity on Mortality: Heterogeneity by Ex-post Return Differentials

The table reports second-stage regressions of annuity on 10-year mortality. The annuity decision is instrumented by the previous 6-month returns on Fund C. Sample splits are based on the difference in returns between the chosen and the alternative payout option. For an annuitant, we compute the difference between the annuity yield and the return on the most popular pension fund, Fund C. Conversely, for a non-annuitant, we compute the differential between the returns of Fund C and the annuity yield. In Column 1, we pool annuitants and PW-retirees with negative return differentials, using the sample median as the cutoff. In Column 2, we examine retirees with positive or above-median return differentials. In Columns 3 and 4, we use the top and bottom quartiles of the return differentials as cutoffs. The same procedure is applied for columns 5-8 using the return differential computed over two years. The regression specification is the same as in Table 3. Standard errors clustered at the birth-year level are reported in parentheses, and p-values are reported below standard errors. The p-value for the difference in the annuity coefficient across subsamples is also reported. Significant at: *10%, **5% and ***1%.

Sample split by:	One-year return differential				Two-year return differential			
	(1) Dead	(2) Dead	(3) Dead	(4) Dead	(5) Dead	(6) Dead	(7) Dead	(8) Dead
Annuity	-2.26**	0.50	-4.01***	0.04	-1.17***	0.29	-3.29**	1.00
	(1.053)	(1.204)	(1.383)	(1.078)	(0.411)	(0.605)	(1.279)	(1.671)
	0.035	0.677	0.005	0.970	0.006	0.637	0.012	0.552
p-value of difference in coeff.		0.098		0.007		0.032		0.024
Ex-post return differentials	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive
Cut off	Median	Median	Top-Bottom Quartile	Top-Bottom Quartile	Median	Median	Top-Bottom Quartile	Top-Bottom Quartile
Observations	2,345,497	2,115,109	1,255,278	3,205,328	2,475,360	1,985,246	1,330,004	3,130,602

Table 8: HRS Evidence: Summary Stats

The table reports averages of different variables for retirees in the Health and Retirement Survey. We use fully retired respondents to the surveys in 2002-2020. We compute the average for each variable across the multiple surveys where the individual appears, so each respondent is counted only once for the averages below. Any annuity means that the respondent says "yes" to the question about receiving income from annuities. Annuity>$18,000 means that annual income from annuities is higher than $18,000 (or $1,500 monthly). The no sports dummy is 1 if the respondent does not often take part in sports or vigorous activities. The smoking dummy is 1 if the respondent smokes. The log weight is the log of body weight in lbs. The log health expenses corresponds to the log of the amount paid for various health-related expenses. The possible answers to the question about retirement satisfaction are 1 (very satisfied), 2 (moderately satisfied), or 3 (not at all satisfied). The mean number of depression symptoms is the average number of "yes" answers to 8 cognitive questions (e.g.,"much of the time during the past week, you felt depressed"). Health status is a categorical variable that goes between 1 (excellent health) to 5 (poor health). Mean Disability is the average number of "yes" answers to questions regarding problems with day-to-day activities such as eating, going to the bathroom, getting dressed, going out of the house, communicating, and others. Columns 4 and 5 report the difference between averages in the previous columns. Significant at: *10%, **5% and ***1%.

	(1) Any Annuity	(2) Annuity>$18,000	(3) No Annuity	(4) Diff. (1-3)	(5) Diff. (2-3)
No sports (1= no sports; 0= yes sports)	0.581	0.594	0.627	-0.047***	-0.034**
Smoking (1=yes, 0=no)	0.06	0.058	0.149	-0.089***	-0.091***
Log weight	5.095	5.076	5.127	-0.032***	-0.051***
Log health expenses	5.023	5.027	4.914	0.109***	0.113*
Satisfied with retirement? (1=very; 3=not at all)	1.443	1.419	1.7	-0.257***	-0.281***
Mean # of depression symptoms (1=yes, 0=no)	1.269	1.226	1.815	-0.546***	-0.589***
Health status (1=excellent; 5=poor)	2.891	2.87	3.269	-0.378***	-0.399***
Mean # of disabilities (1=yes, 0=no)	0.232	0.244	0.296	-0.064***	-0.052***
Observations	2661	869	13593	16254	14462

Table 9: CASEN Survey: Summary Stats

The table reports the means of different variables for retirees in the biennial CASEN survey (except for the Covid period). Retirees are men over 65 or women over 60 who are receiving non-disability pension income from an annuity or phased withdrawal. Surveys earlier than 2011 do not ask for the source of pension income. Annuity is a dummy equal to one for an annuity (AN) and zero for phased withdrawal (PW). Age is measured in years. Income is measured in UF. Gender is equal to 1 for men and 0 for women. Health insurance can be mandatory or non-mandatory, and in each case it can be provided by the public system or a private provider. Visits to the doctor in the last 12 months can be preventive check-ups, related to chronic diseases, and others. These check-ups can also be done in the public health system or in private providers. Mean Disability is the average of ten questions regarding problems with day-to-day activities such as eating, going to the bathroom, getting dressed, going out of the house, communicating, and others. Each response can go from 1 (no difficulty) to 5 (severe difficulty). Max Disability is the highest number across the response to the ten questions. Pseudo pre-retirement returns correspond to returns for fund C in the 6 months before the assumed retirement date for each woman (60th birthday) or man (65th birthday) according to their reported ages and when the field work for each survey was conducted. Columns 4 and 7 show the test for differences in mean across sub-samples: retirees with annuities and phased withdrawal, and retirees with high and low pseudo pre-retirement returns.

		Annuitization choice			High and Low Returns		
	All	PW	AN	AN - PW	High	Low	Low - High
Annuity (1=AN, 0=PW)	0.493	0	1	1	0.492	0.494	0.002
Age	71.507	70.93	72.101	1.170***	72.062	70.971	-1.091***
Income (UF)	9.37	8.793	9.963	1.170***	9.111	9.62	0.509**
Gender (1=Male, 0=Female)	0.569	0.543	0.596	0.053***	0.568	0.571	0.003
Private mandatory health insurance (1=yes, 0=no)	0.081	0.061	0.102	0.041***	0.079	0.083	0.005
Private supplementary health insurance (1=yes, 0=no)	0.06	0.051	0.07	0.019***	0.057	0.064	0.008**
Preventive check-up in last 12 months (1=yes, 0=no)	0.348	0.325	0.372	0.047***	0.367	0.332	-0.035***
Preventive check-up in last 12 months in private provider (1=yes, 0=no)	0.151	0.137	0.167	0.030***	0.148	0.154	0.006
Mean disability	1.178	1.185	1.171	-0.014*	1.192	1.165	-0.026***
Max disability	1.385	1.407	1.363	-0.044***	1.405	1.366	-0.039***
Pseudo pre-retirement returns	0.024	0.025	0.023	-0.002**	0.064	-0.014	-0.078***
Observations	36487	18493	17994	36487	17944	18543	36487

Table 10: Survey Evidence: The Effect of Annuities on Quality of Life during Retirement

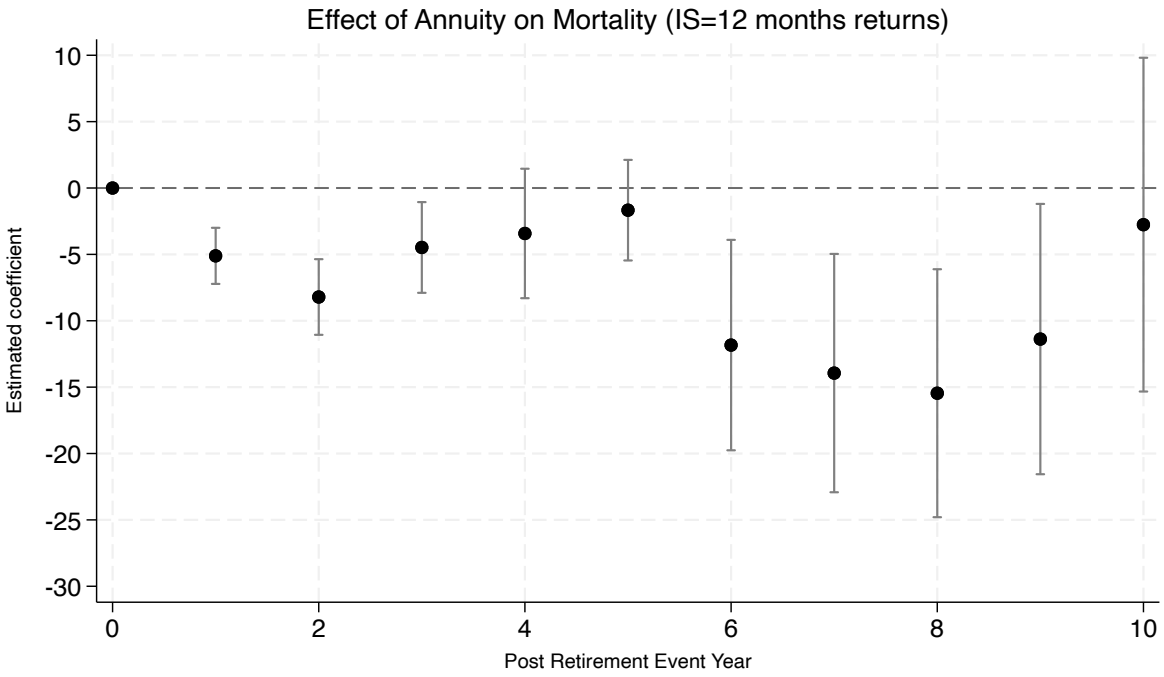
This table uses the data summarized in Table 9. Returns correspond to the returns for Fund C (the only fund available since the creation of the system in 1982) between months $t-6$ and $t-1$ from the pseudo 65(60) birthday month t for a male (female) retiree declaring to be X years old in each survey. Regression controls include age, income, and gender, plus fixed effects for each survey year. Robust standard errors are reported in parentheses. p-values are reported below. Significant at: *10%, **5% and ***1%.

VARIABLES	(1) Annuity	(2) Mean Disability	(3) Mean Disability	(4) Mean Disability	(5) Max Disabilty	(6) Max Disabilty	(7) Max Disabilty
Annuity		-0.0144***		-0.985**	-0.0213**		-1.414*
		(0.00519)		(0.491)	(0.00880)		(0.785)
		0.00546		0.0446	0.0157		0.0717
Pseudo Pre-Retirement Returns	-0.117***		0.115***			0.165**	
	(0.0418)		(0.0407)			(0.0709)	
	0.00513		0.00465			0.0196	
Regression Specification	1st Stage	OLS	Reduced Form	2nd Stage	OLS	Reduced Form	2nd Stage
Fixed effects	Survey Year	Survey Year	Survey Year	Survey Year	Survey Year	Survey Year	Survey Year
Observations	36,487	36,487	36,487	36,487	36,487	36,487	36,487
R-squared	0.063	0.091	0.091		0.120	0.120	
1st Stage F-test	7.79						

The Effects of Annuities on Longevity

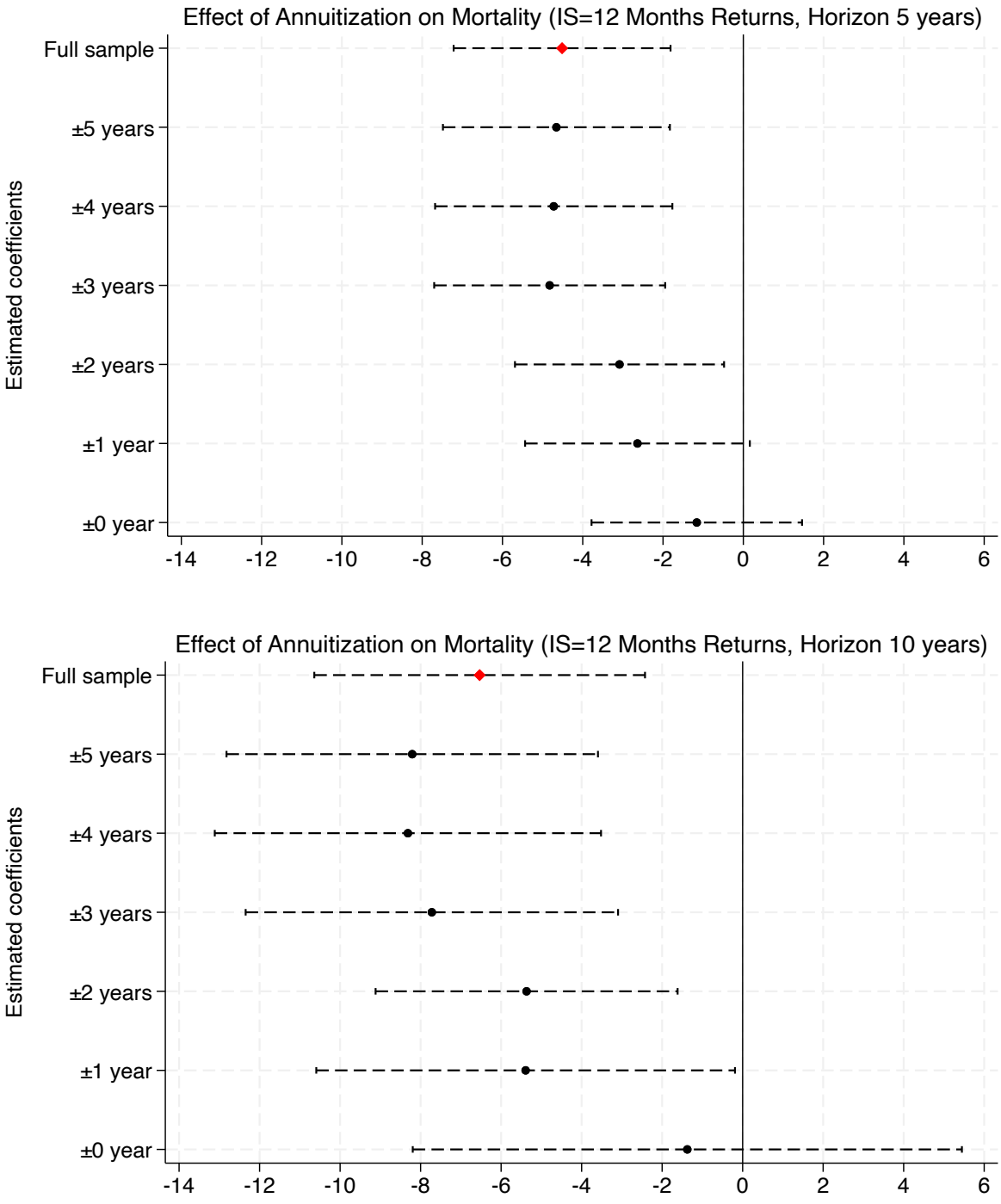
Online Appendix

Figure A1: Effect of Longevity by Year: 12 months returns



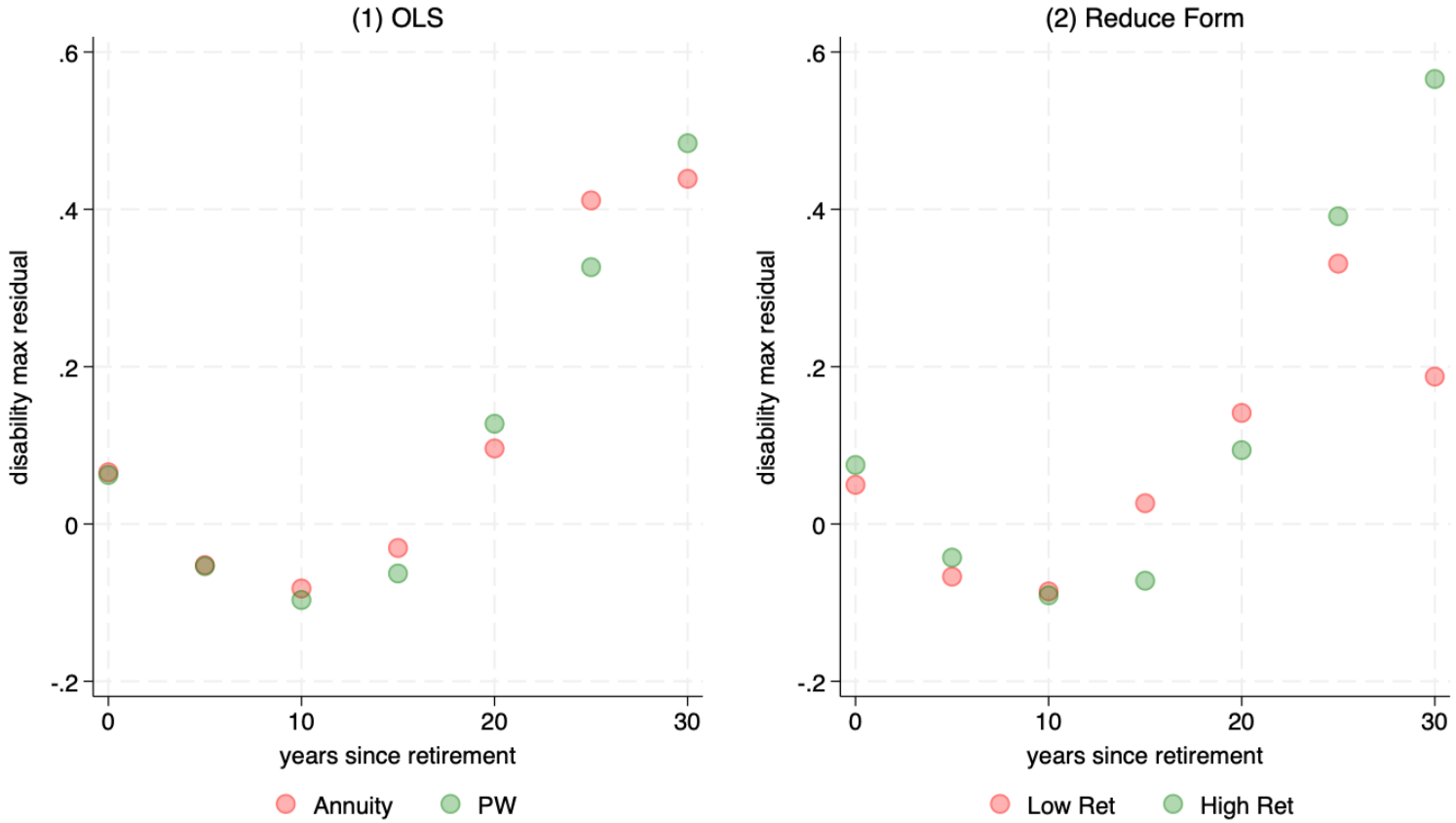
Notes: These plots estimate the dynamic effect by year post-retirement of the estimated coefficient of annuities on mortality, followed by the specification in equation 3

Figure A2: Effect of Longevity Robustness: 12 months returns



Notes: These figures estimate equation 3 using different sample specifications, full sample replicates the results in table 3, +/- 5 years defines the sample as men retirees between age of 60 and 70, and women retirees between age 55 and 65, etc.

Figure A3: Disability Max Index and Time Since Retirement



Notes: Data from these figures use the CASEN survey sample. The y-axis uses the disability max index residual, obtained by regression of the disability mean index for each individual in a set of controls that includes age, gender, income, and survey year; the left panel plots the average disability max residual by annuity or program withdrawal grouping each observation using year since retirement bins of size five years, the right panel follow the same structure but divide the residual into low and high previous returns; therefore mimicking a reduce form estimation, where low previous returns are associated with higher annuity take-ups

Table A1: CASEN Survey Evidence: Summary Stats by Year

The table reports the number of observations and averages of different variables for retirees in the biennial CASEN survey (except for the Covid period). Retirees are men over 65 or women over 60 who are receiving non-disability pension income from an annuity or programmed withdrawal. Surveys earlier than 2011 do not ask for the source of pension income. Annuity is a dummy equal to one for annuity. Age is measured in years. Income is the total income received by each person. Gender is equal to 1 for men and 0 for women. Mean Disability is the average of ten questions regarding problems with day-to-day activities such as eating, going to the bathroom, getting dressed, going out of the house, communicating, and others. Each response can go from 1 (no difficulty) to 5 (severe difficulty). Max Disability is the highest number across the response to the ten questions.

		Annuity		Age		Total Income		Gender		Mean Disability (1-5)		Max Disability (1-5)	
Survey Year	Obs.	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
2011	14,411	0.44	0.50	72.40	6.99	286,390	474,360	0.57	0.49	1.20	0.46	1.41	0.80
2013	4,411	0.62	0.48	70.52	6.35	298,237	379,713	0.6	0.49	1.19	0.58	1.23	0.70
2015	7,465	0.58	0.49	70.76	6.60	378,213	715,387	0.58	0.49	1.13	0.49	1.31	0.87
2017	6,772	0.56	0.50	71.10	6.83	424,026	775,589	0.56	0.50	1.13	0.48	1.31	0.88
2022	3,428	0.26	0.44	71.46	7.27	442,477	299,187	0.51	0.50	1.30	0.65	1.80	1.22
Total	36,487	0.49	0.50	71.51	6.87	346,818	578,729	0.57	0.50	1.18	0.50	1.39	0.88

Table A2: The Effect of Annuity on Mortality: Incentives

The table reports second-stage regressions of annuity on 10-year mortality. The annuity decision is instrumented by the previous 6-month returns on Fund C. Sample splits are based on categorical variables (guaranteed annuity and gender). The regression specification is the same as in Table 3. Standard errors clustered at the birth-year level are reported in parentheses, and p-values are reported below standard errors. The p-value for the difference in the annuity coefficient across subsamples is also reported. Significant at: *10%, **5% and ***1%.

Sample split by:	Guaranteed Annuity		Gender	
	Dead	Dead	Dead	Dead
Annuity	-4.60**	-1.11	0.57	-6.56**
	(1.811)	(1.850)	(1.362)	(2.644)
	0.013	0.551	0.675	0.015
p-value of difference in coeff.		0.177		0.0165
Sample	Yes	No	Women	Men
Observations	3,838,468	1,840,840	1,560,424	2,900,182