# The Effect of Annuities on Longevity

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**Abstract**

We study the effect of annuities on longevity, using payout data on roughly 600,000 Chilean retirees between 2004 and 2022. To address selection effects, we rely on the fact that annuity sales vary with recent stock market returns. We find that the decision to annuitize—instrumented by the recent stock market returns—has a positive and economically meaningful effect on longevity. When we investigate the mechanisms behind this evidence, we document that our results are robust to controlling for post-retirement income levels and volatility. Annuitants report fewer disability symptoms than nonannuitants several years after retirement. Our findings suggest that annuities have the potential to provide incentives to live longer and healthier lives.

**Keywords**: annuities; retirement; longevity; post-retirement health.

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# 1 Introduction

Retirees are increasingly unlikely to receive lifetime income through an annuity and directly bear the longevity risk—or the risk of outliving their retirement wealth. Many countries have reduced the generosity of annuitized public pensions and nudge citizens to rely more on private retirement plans that do not directly provide longevity insurance.[1] Similarly, employers have moved away from offering defined benefit (DB) retirement plans towards defined contribution (DC) plans. Retirees from DB plans typically receive an annuity, while DC plans rarely provide the option to annuitize retirement savings.[2] Retirees from DC plans can directly purchase annuities from insurance companies. Nonetheless, these sales have historically been limited, a fact known as the "annuity puzzle" since the work of Modigliani (1986). These trends raise the question of whether reducing access to annuitized income affects retirees' health and longevity.

Previous studies have documented how annuitants live longer than nonannuitants. For example, in the US and UK, survival probabilities for a 65-year-old male annuitant are roughly 20 percent higher than for a typical 65-year-old male (Murthi, Orszag, and Orszag, 1999; Finkelstein and Poterba, 2002; Brown, Mitchell, and Poterba, 2002).[3] This evidence is generally interpreted through the lenses of adverse selection models, consistent with individuals having private information about their longevity and choosing to annuitize accordingly. Using data from the UK annuity markets, Finkelstein and Poterba (2004)

[1]This trend reverses the postwar increase in mandatory annuity programs such as Social Security. Philipson and Becker (1998) highlight how introducing such programs could lead to a rapid rise in life expectancy at older ages.

[2]For example, in the US, only one DC plan in six offers an in-plan annuitization option (LIMRA, 2023).

[3]For example, Finkelstein and Poterba (2002) consider the probability of surviving from age 65 to age 82. For the average 65-year-old man, this probability is 41%. For the average 65-year-old male compulsory annuitant this probability is 48% or 17% higher, and for the average 65-year-old voluntary annuitant, this probability is 56% or 37% higher.

document that annuitants who live longer are more likely to select annuities with back-loaded payments. Similarly, individuals who live less select annuities with guaranteed payments in case of an early departure.

This paper complements existing annuity studies by investigating whether annuities directly affect longevity. Annuities can extend life through several non-mutually exclusive channels. Lifetime income can reduce the likelihood of running out of money and facing financial hardship, mimicking the positive effect of personal bankruptcy protection on longevity (Dobbie and Song, 2015). Analogously, annuities provide a stable stream of income that can reduce the negative impact on health and longevity of income volatility (Sullivan and von Wachter, 2009a) and stock market fluctuations (Engelberg and Parsons, 2016). Finally, annuities can provide economic incentives to invest in health and increase longevity (Philipson and Becker, 1998). This last explanation would be consistent with annuities generating non-negligible moral hazard effects.

Using administrative payout data on roughly 600,000 Chilean retirees between 2004 and 2022, we document that choosing an annuity over phased withdrawals (PW) increases longevity. To address selection effects, we rely on an instrumental variable approach that exploits the fact already established in the literature[4] that annuity demand is counter-cyclical to recent stock market returns. In our preferred specification, a 2SLS with retirement year fixed effects, we document that annuities increase longevity by 3.61% to 6.53% at the ten-year horizon. In other words, a non-negligible fraction of the longevity difference between annuitants and the general population could be due to the effects of the annuity treatment.

[4]Previous research has shown how take-up of annuities in retirement plans and annuity sales from insurance companies are lower following strong recent stock market returns (Chalmers and Reuter 2012, Previtero 2014). In particular, Previtero 2014 documents how this evidence is consistent mainly with households having extrapolative beliefs about future market returns and being more willing to settle for fixed-income products (i.e., annuities) after a poor run in the market and less so after good returns.

To further investigate our main results, we conduct several empirical analyses to assess the relevance of our instrument, test for potential violations of the exclusion restriction, and explore the mechanisms behind the annuity treatment.

Our empirical setting is Chile's defined-contribution (DC) pension system, which in 1980 replaced a government-run pay-as-you-go scheme with privately managed DC accounts. At retirement, households choose between an inflation-indexed life annuity and phased (programmed) withdrawals whose payments vary with investment returns and remaining life expectancy (the longer someone lives, the smaller the payments). Around two-thirds of Chilean retirees choose an annuity, making Chile a distinctive laboratory for studying annuitization choices.

Following the annuity literature (Chalmers and Reuter 2012, Previtero 2014), we chose the recent return on the Chilean stock market as an instrument for annuity demand. In practice, we use the returns on the most common pension fund held by Chilean households in the last six (or twelve) months before retirement. We first document a strong, significant negative correlation between the pension fund returns and annuitization ($-0.55$) in the raw data. In our first stage regression, we find that a one-standard-deviation shock to returns reduces the likelihood of taking annuities by 2.7%. Given that we include retirement year fixed effects, our specification exploits the within-year variations in exposure to recent stock market 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 indicate a weak-instrument problem.

In the second stage, we regress longevity on the instrumented annuity decision. At the five-year horizon, we find that the 2SLS coefficient on annuities is $-2.52\%$, which implies that taking annuities increases longevity. This effect is comparable with other findings in

the literature. For example, Dobbie and Song (2015) document 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 stock market returns affect longevity only through the annuitization decision, not directly or through other omitted variables. One concern is that the stock market returns can correlate with the business cycle, and that the economic conditions around retirement can directly impact mortality. Coile, Levine, and McKnight (2014) show that employees approaching retirement during a recession suffer long-lasting negative consequences because of higher unemployment and worse health-care access. We document that annuitization is higher following poor stock market 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 stock market returns.

To investigate further potential violations of the exclusion restriction, we run a placebo test using stock market returns *immediately after* the retirement date (i.e., the six months following retirement). Given that the stock returns follow the annuitization decision, a correlation between these returns and longevity might signal problems related to omitted variables. In these tests, 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.

In terms of mechanisms, we first examine whether annuities prevent retirees from facing financial hardship and running out of money towards the end of their lives when, for example, medical costs are higher. Retirees choosing phased withdrawals typically receive

declining payments over time, the longer they live. Conversely, annuitants receive increasing life-contingent payments due to inflation adjustments. Moreover, phased withdrawals adjust to reflect stock returns. Therefore, retirees with phased withdrawals face higher income volatility. This higher uncertainty can be a source of stress and consequently mortality (see Sullivan and von Wachter 2009a, and Engelberg and Parsons 2016). We control for post-retirement income levels and volatility in our regressions to address these two channels. We find that the impact of annuities on longevity is quantitatively similar in these specifications. These results suggest that the effect of annuities on longevity is not simply about higher disposable income in the later years or more stable income.

Last, we test for the possibility that annuities provide incentives to live longer (Philipson and Becker, 1998). By providing life-contingent payments, annuities introduce a classical moral-hazard problem, whereby the insured face stronger incentives to do more of what they are insured against, in this case, living. Annuitants can extend their longevity by adopting a healthier lifestyle or investing more resources to improve their health.

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 in the waves between 2002 and 2020. Retirees who receive significant[5] income from annuities are more likely to exercise, less likely to smoke, and have a lower weight. Moreover, they self-report higher life satisfaction, better health status, fewer depression and disability symptoms, and higher annual health-related expenses.

To examine this evidence further and to address the obvious selection effects in the HRS, we analyze data from CASEN, a survey that the Chilean Ministry of Development runs every two years. This survey collects detailed disability information about the difficulty with day-to-day activities such as eating, getting dressed, or communicating. This

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

data helps to advance our analyses in two different ways. First, this survey data are different from the administrative data used in our main analyses on longevity. Therefore, they can serve as an out-of-sample test of our previous evidence. Second, in CASEN, we do not observe the actual retirement date for each individual. Therefore, as an instrument, we use the stock returns before a pseudo-retirement date based on the standard retirement age, consisting of the 60th birthday for women and the 65th birthday for men. Even when the retirement date is measured with noise, 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. Overall, this evidence is consistent with annuities improving the health and well-being of retirees and, consequently, reducing mortality.

Our study contributes to several streams of literature. First, our findings are related to the literature on the effects of economic conditions on longevity. There are several studies relating recessions and economic crises to mortality (see Ruhm 2016, Coile, Levine, and McKnight 2014, and Finkelstein, Notowidigdo, Schilbach, and Zhang 2024, among others). For example, Sullivan and von Wachter (2009b) find evidence that displaced workers experience higher mortality rates in the short and long term (from one year to twenty years after displacement). Looking at more financial decisions, Dobbie and Song (2015) document that bankruptcy protection reduces mortality. Similarly, Engelberg and Parsons (2016) document that aggregate stock market downturns can negatively affect investor health on the same day. We contribute to this literature by showing that the payout choice at retirement and, more specifically, annuities can have long-term effects on retiree health and longevity. Our findings have implications for the design of payout options in employer-sponsored and private retirement saving plans.

Second, several studies have investigated adverse selection in annuity markets. For

example, Finkelstein and Poterba (2004) document that individuals choose backloaded annuities when living longer. This evidence would suggest that individuals have private information about their longevity. Recent studies on subjective beliefs about life expectancy and mortality question this assumption. Using data from ELSA, O'Dea and Sturrock (2023) document that individuals underestimate their longevity and exhibit survival pessimism. Similarly, Heimer, Myrseth, and Schoenle (2019) find that individuals underestimate their life expectancy well in their 60s. How can retirees systematically underestimate their life expectancy yet be able to make annuity decisions based on their realized mortality? Our evidence that the annuity treatment can also drive–above and beyond the documented adverse selection effects—differences in longevity between annuitants and nonannuitants can help reconcile this contradictory evidence in the literature.

Lastly, many researchers have presented several rational reasons to explain the annuity puzzle, from bequest motives to precautionary savings, from adverse selection and fees to hedging within the family (for a review, see Brown (2007)). Furthermore, researchers have proposed behavioral reasons such as framing, trend-chasing, present-biased preferences, and regret aversion (for a review, see Benartzi, Previtero, and Thaler (2011)). In this paper, we contribute to these studies by documenting the effects of annuities on health and longevity. If annuities positively affect longevity, they are a better deal than previously estimated, making the annuity puzzle even more stark. These findings also have implications for the pricing of annuities in private insurance markets.

# 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 have to 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 correspond to approximately USD 175 billion, or close to 65% of Chilean GDP. Fund C, which started in 1980 instead of 2002, is the largest, with USD 65 billion in assets under management. At the system level, close to 42% of the assets under management 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 65 for men and 60 for women. Most people retire at the legal age or shortly thereafter as seen in Figure 1. We call old-age retirees those men and women who retire after 65 and 60, 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 UF 12 (around USD 1,050).[6] 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.[7]

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 on to the insurance company. The annuity payments can start immediately or in a future date (e.g., three years after retirement). In the case of the deferred annuity, the retiree

[6]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.). The Chilean peso is still the only legal tender. For our calculations, we use a conversion rate of 1 UF = 37,015 Chilean pesos, and then adjust for purchasing power using 1 USD = 426 Chilean pesos (from the OECD). For comparison purposes, consider that the legal minimum wage in Chile increased from UF 6.56 in 2002 to UF 11.39 in 2022.

[7]We exclude from the analysis survivorship pensions that are allocated to the spouse or dependents of a deceased 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 receiving 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 fund 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 a main concern. At the same time, 24% (19%) of those under PW (annuities) cite higher pensions in the beginning as their 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.[8]

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

## 2.3 The SCOMP Exchange

Since 2004, the choice of pension type has been implemented through an exchange called SCOMP (Sistema de Consultas y Ofertas de Montos de Pensión). The purpose of this exchange was 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 UF 3 (about USD 250). For those above UF 3 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. Close to two thirds of retirees choose annuities. The average value of the annuity bought at retirement or the initial balance under PW is UF 2,600 or around USD 225,000. The monthly payment in the first year is on average UF 16.3. The mean (median) ratio of this initial payment to the

individual's last income before retirement is 93% (59%), which suggests a relatively high replacement rate in this sample. There are more men (66%) than women (34%) in our sample, as the SCOMP database is biased toward higher incomes. Individuals retire on average at 63, after saving for more than 26 years. The deceased represent 10% 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 of 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 $\beta$ 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 about 10% 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. Another possibility would be a cross-sectional specification for which we compute 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 $\beta$, which captures the impact of retiring with an annuity (instead of PW) on the future likelihood of death. The magnitude of $\beta$ 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 retiree with PW who died in year 9. The annuitant lives for 2 more years out of 10, or 20% more, hence $\beta = -20\%$.

The vector $X_{i,t}$ includes continuous variables measured at retirement for each individual: accumulated savings, last monthly income before retirement, and years with contributions to the 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. 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 (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 that a man born in 1950, and a different fixed effect that a woman born in 1950 but who retired in 2011. Birth-year effects control for cohort differences 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 $\beta$ is unlikely to capture the 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, $\beta$ 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 $\beta$ would be biased upwards. For example, Puri and Robinson (2007) show that extreme optimists have self-control problems, for example, 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.

## 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 is exogenous to all market forces, only that the instrument is uncorrelated with these other mechanisms that potentially impact mortality.

We propose to use as instrument the returns faced by individuals in the 6 months leading up to 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 5 funds available. It was the only fund available in the first two decades of the system. As a moderate fund (close to a portfolio of 40% equity and 60% fixed income), fund C is a good summary of the returns faced by investors across multiple asset classes.

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. In Figure 3 shows that there is a similar relationship among Chilean retirees. There is significant time-series variation in the aggregate annuitization rate and the returns of fund C. The annuity take-up steadily increased from a low point of 51% in early 2007 to a peak of 86% in January 2009 during the Great Recession. Then, it fell 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. Under extrapolation, there is no obvious relationship between past returns and mortality (more on this when we discuss the exclusion restriction).

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 $\lambda$ 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 $\beta$ 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 (UF 2,627) than those who retire after low returns (UF 2,574), 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.

## 3.4 Exclusion Restriction

The exclusion restriction implies that the instrument has an effect on future mortality only through the choice of annuities or PW. One immediate concern is that 6-month returns

can be related 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 because of higher unemployment and worse health-care access. This is separate from the *contemporaneous* association between recessions and mortality (Ruhm, 2016).

The observations with extremely low returns (below $-10\%$) that we see in Figure 3 correspond to the Great Recession, which as documented by Finkelstein, Notowidigdo, Schilbach, and Zhang (2024) had a negative impact on long-term mortality in the U.S. Three things are important to notice for our purposes. 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, more than a traditional recession. Second, annuitization peaked at the time, so, if anything, the alleged nexus between recessions and long-run-mortality works *against* a positive association between returns and mortality like we find. This reduced-form relationship between returns and mortality is already apparent in Table 2 when comparing the fraction of deaths in high- and low-return samples. Third, our setup (regressions 2 and 3) includes retirement-year fixed effects precisely to control for such long-run effects of business cycles on mortality.

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 an impact on the already fixed pension choice. Any remaining influence on returns on future mortality would be an indication of omitted variables. If we find no relationship between these other 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. To argue that there is a violation of the exclusion restriction, it is not enough to show that there is a relationship between a behavioral trait and annuitization on average, e.g., "strong" people –with better mental or physical health– prefer annuities. It has to be 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 can simply be a signal of the underlying health of the return-induced annuitants. 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.

Similarly, risk preferences are not enough to violate the exclusion restriction. Maybe risk-averse individuals prefer annuities and at the same time live longer since they avoid reckless activities. After poor returns, risk-averse retirees may even increase their annuity take-up. However, it is not obvious that those risk-averse retirees should take PW after good returns.

The flexibility that individuals have about their retirement age (see Figure 1), whether to retire earlier or later than the legal age, can 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. 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 reality of such a selection story is not 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 lower mortality over the next five years. An annuitant gains 0.71% of the life years available at her disposal over a 5-year horizon. This corresponds to close to a 13-day gain ($0.71\% \times 5 \times 365 \approx 13$).

The positive reduced-form coefficient 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 loss of approximately 1.2 days over the 5-year horizon (column 2), and 3 days over the 10-year horizon (column 6). The effects are small, but strongly significant. The reduced-form regression is inconsistent with a pure 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 partialling out a substantial fraction of the variation 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.[9]

The second-stage coefficient shows a strongly negative effect of annuities on mortality. Mortality is reduced by 2.52% at the 5-year horizon (column 4), and 3.61% at the 10-year horizon (column 8). The effects are not statistically different from each other. In day terms, an annuitant would gain 46 days of life at the 5-year horizon, and 132 days at the 10-year horizon.

The magnitude of the effects is plausible in comparison to other determinants of mortality. For example, the effects are smaller than those of quitting smoking. Taylor, Hasselblad, Henley, Thun, and Sloan (2002) find that by quitting smoking at age 65 a man gains between 1.4 and 2.0 years of life, and a woman gains between 2.7 and 3.7 years. Among economic shocks, Sullivan and von Wachter (2009b) show that job displacement reduces life expectancy between 1.3 and 1.4 years for a worker aged 55. There is not much evidence for comparison in terms of the mortality impact of other financial decisions or products. Among the few estimates is the study of bankruptcy protection in the U.S. by Dobbie and Song (2015). They find that bankruptcy protection among individuals 60 and older reduces 5-year mortality by 10.9%, or close to three times the impact of annuities in our sample.

The difference between the OLS and IV coefficients for $Annuity_{i,t}$ implies that selection effects towards annuities increase mortality. Or conversely, selection effects towards PW increase longevity. One possibility is that survival optimism, which increases the demand

[9]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)

for annuities, can be correlated with reckless behavior and lower demand for medical care. Standard adverse selection arguments, which would make the OLS coefficient larger in magnitude than the IV coefficient, are less likely to apply given the institutional design of the annuities market in Chile (see Boehm 2024, and Illanes and Padi 2025).

## 4.2 Robustness

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 ($-6.53$ vs. $-3.61$ using 6-month returns), and it is strongly significant. Over a 10-year horizon, individuals would add close to 238 days to their lives by taking annuities. 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.

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 these 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 4 here

Strategic retirement timing induced by returns poses a potential challenge to the exclusion restriction. If that 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 take annuities after poor recent returns, and "weak" people (those who know that will live shorter lives) rush to take PW after good returns. The argument is symmetric for delayed retirement, which is also a possibility as seen in Figure 1. Strong people should delay their annuity take-up after good returns, and weak people should delay taking 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 4, we cannot reject that the different estimates of the effect of annuities are the same as in the full sample. In other words, strategic retirement does not appear to affect our results. In the sample with individuals that retire exactly at the legal age (i.e., $\pm$ 0 years), the variation left 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 retire early in the year and others late in the year, but we can expect noisy estimates.

Insert Figure 5 here

In Figure 5 we show the coefficients we get on a year-by-year estimation for 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 to a certain point in time that we mentioned in section 3. We find that the point estimates for the effect of annuities on mortality grow in time. In particular, after year $t = 5$ the effect roughly doubles in magnitude. 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.

# 5 How do annuities reduce mortality?

## 5.1 Is the annuity effect an income effect?

Annuities provide a constant income stream (in purchasing power terms, since payments are adjusted for inflation). PW, on the other hand, is computed assuming payments that decline with age (Figure 2). PW is recalculated every year, so falling income is not necessarily true if there are positive return shocks after retirement. If there are negative return shocks, then income can fall more strongly than initially projected.

Living expenses, such as food, utility bills, or rent, can decrease with age as children leave the home. However, medical expenses typically increase with age. For example, using data from the U.S. Health and Retirement Study, Fahle, McGarry, and Skinner (2016) show that out-of-pocket medical spending rises sharply at older ages and near the end of life. Therefore, one potential explanation for the mortality of individuals under PW is that they simply run out of money when faced with high medical costs at the end of their lives.[10]

To study this possibility we include among the set of explanatory variables in equation 1 a proxy for the income realization of each retiree. If the effect of annuities is an income effect, then the coefficient for $Annuity_{i,t}$ should fall in magnitude and perhaps turn insignificant once we control for future pension income. We do not have data on future

[10]Expected health costs can be a determinant of the demand for annuities and portfolio choice more generally speaking. See De Nardi, French, and Jones (2010), Peijnenburg, Nijman, and Werker (2017), and Yogo (2016).

income, but we can approximate it. This is easy for annuitants, since we know the first payment and all future payments are constant (in inflation-adjusted terms). For those under PW we can estimate future payments using the realized returns of the pension funds and the assumptions defined by the pension regulator. These assumptions include mortality tables and expected returns going forward.[11]

Insert Table 5 here

In Table 5 we show the results where we control for post-retirement income. Future income enters the regression with the expected negative sign, i.e., higher income reduces mortality. However, the annuity effect is similar in magnitude to our baseline results and is also strongly significant. Our interpretation is that an annuity is not simply an indicator of higher future income. There is something else that explains the powerful effect of annuities on mortality.

## 5.2 Do annuities reduce financial anxiety?

A related hypothesis is that those with PW are exposed to higher income or wealth volatility, and therefore with anxiety about their financial future. The constant stream of income provided by annuities can reduce the negative impact on health and longevity of income volatility (Sullivan and von Wachter, 2009a). High income volatility can be a source of stress and consequently mortality. For instance, Engelberg and Parsons (2016) show that poor stock market returns increase anxiety and hospital admissions. In Table 5 we also control for the standard deviation of post-retirement income. We find a negative instead of positive effect of volatility on mortality, but the effect is ultimately weak. For

[11] We do not know the exact fund that PW-retirees choose, so we assume they take fund C. We compute the NUC (defined in section 2.2) using the Stata module `cnu` provided by the pension regulator.

instance, the effect of volatility is not statistically significant once we control for post-retirement income. Taken together, the results in Table 5 suggest that the positive impact of annuities on longevity is not simply about higher disposable income in the late years or about the volatility of such income.

## 5.3 Annuities and life style

If the annuity effect is unrelated to income levels or financial anxiety, we are left with the (perhaps unconventional) idea that annuities modify the life style of annuitants. Philipson and Becker (1998) argue that annuities provide incentives to live longer. By setting up life-contingent payments, annuities introduce a classical moral-hazard problem, whereby those insured simply do more of what they are insured against, in this case living.

Annuitants can live longer by investing in a healthier life style. We do not have a way of testing this hypothesis with Chilean data at this point. As suggestive evidence for this channel, we collect data on the life styles of fully retired individuals in the 2002-2020 U.S. Health and Retirement Study (HRS). In the appendix we provide more details on the data and the exact questions that we look at. 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 6 we show that non-annuitants are less likely to exercise, are more likely to smoke, and have higher weight. Annuitants have higher health expenses, which can be related to the income channel as well. The differences are stronger when we focus on annuitants that receive at least USD 18,000 annually (1,500 monthly).

Insert Table 6 here

We cannot claim this as definitive evidence of the incentive effects of 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 retirement well-being

In this final section we explore well-being and health in retirees as another indication of the effect 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 6 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 treatment 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. 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).

Insert Table 7 here

Table 7 reports summary statistics for the CASEN sample: 49% of retirees chose an annuity, their average age is 71.5, and 57 % of them are men. Mean disability is the average over the ten disability questions and has an overall average of 1.18. Max disability is the highest number across the ten responses for an individual and has an average of 1.39. Annuitants suffer from less 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 ahead of this pseudo-retirement date.

Insert Table 8 here

In column 1 of Table 8 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 weak-instrument problem.

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 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%). These estimates are consistent with annuities improving well-being and health during retirement years.

Insert Figure 6 here

To further alleviate concerns about selection into treatment, we document the differences in these disability measures by annuitants and non-annuitants, 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 faced high and low returns before retirement are similar for the first 20 years after retirement. Differences arise beyond 20 years: low-return individuals, associated with higher annuity take-up, have a lower disability in the last few years of their lives.

# 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. Moreover, annuities provide an additional economic incentive to improve health and longevity (a case of moral hazard).

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 someone happens to turn 65 (or 60 for women) should be exogenous and unrelated to mortality rates 10 or 15 years later. Our instrumental variable approach documents that annuities have a positive and 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. Our findings are also important for insurance companies' correct pricing of annuities. Insurance companies rely on annuitants' mortality projections to price their annuities. Understanding the annuity selection and treatment effects can help improve this pricing process ((Koijen and Yogo, 2023)).

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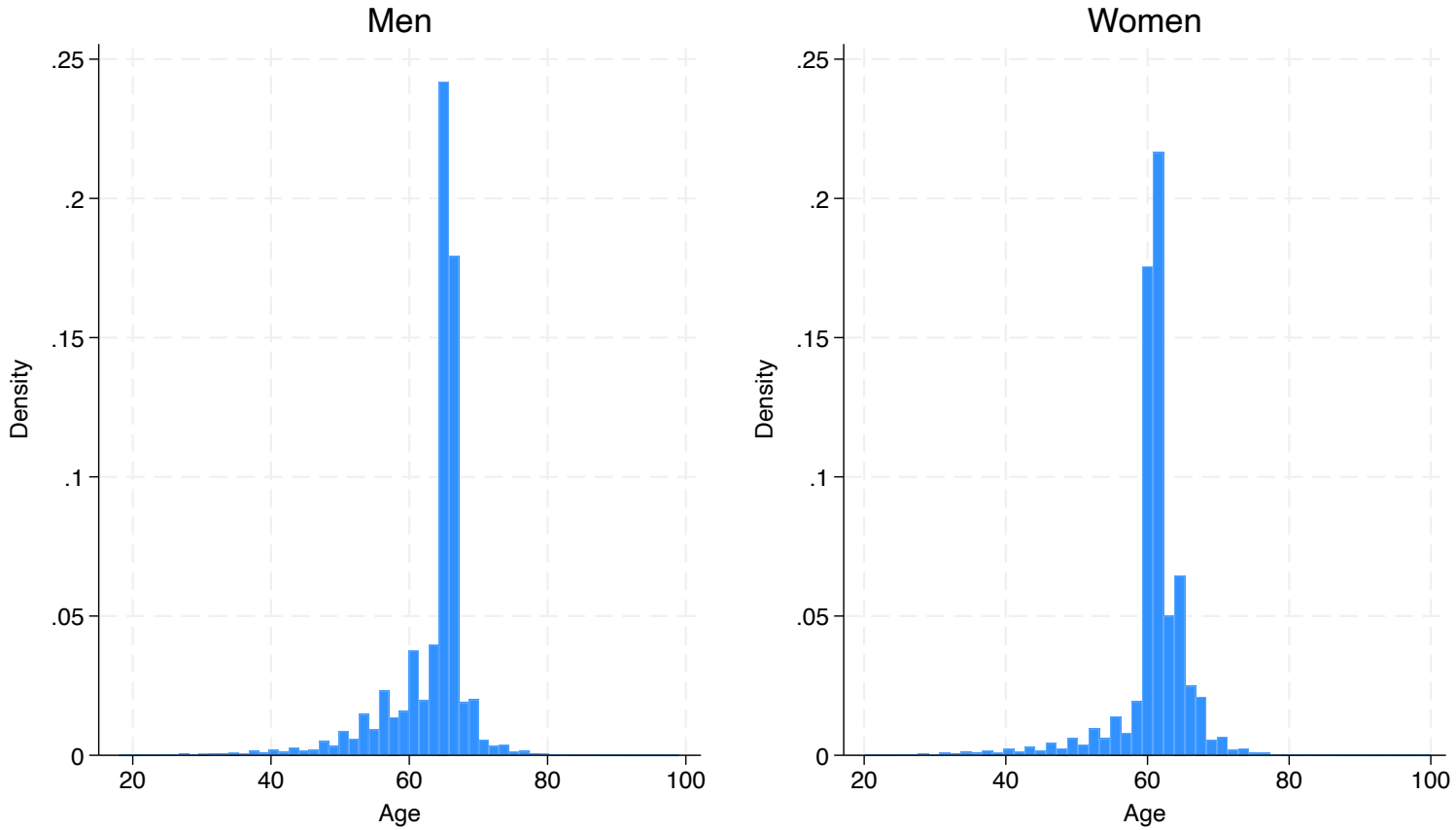
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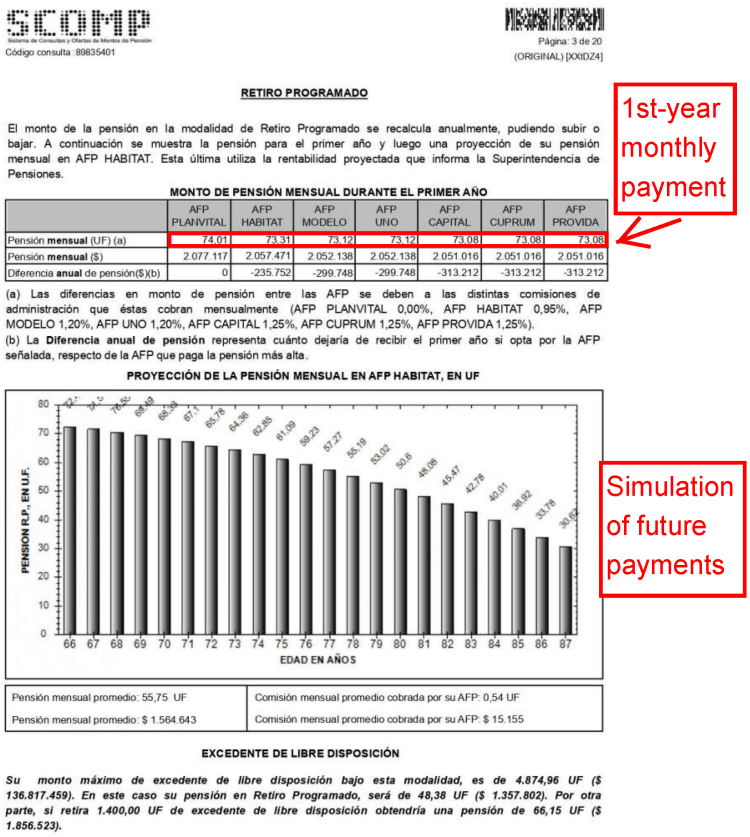
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**Figure 1:** Retirement Age in the Chilean Pension System




**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



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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**

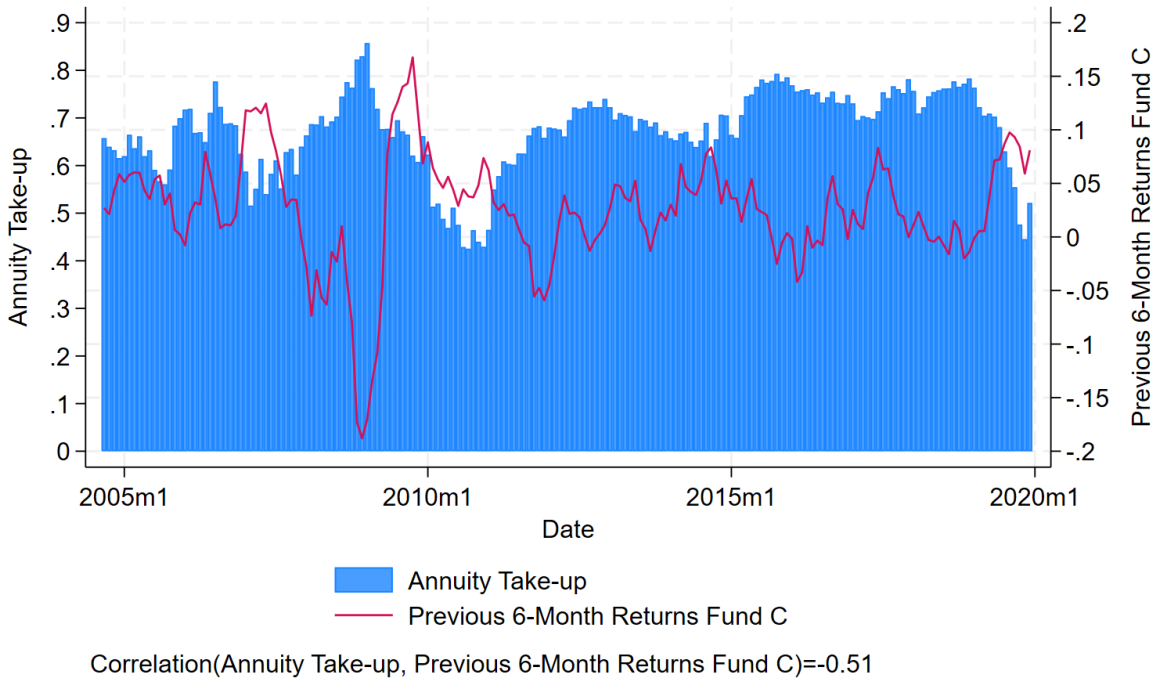
***Su monto máximo de excedente de libre disposición bajo esta modalidad, es de 4.874,96 UF ($ 136.817.459). En este caso su pensión en Retiro Programado, será de 48,38 UF ($ 1.357.802). Por otra parte, si retira 1.400,00 UF de excedente de libre disposición obtendría una pensión de 66,15 UF ($ 1.856.523).***

1st-year monthly payment

Simulation of future payments

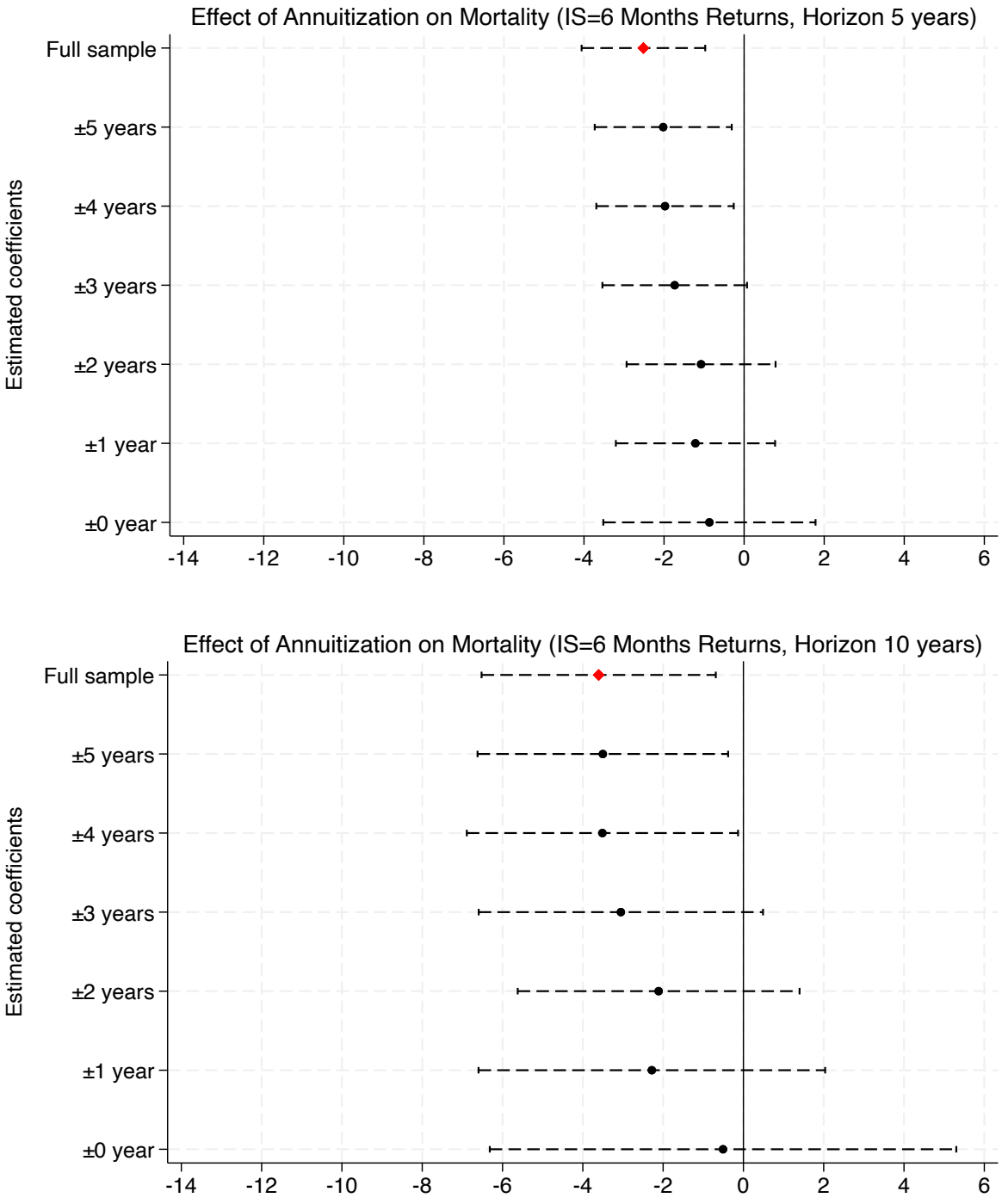
**Notes**: The figure shows an example of the summary of phased withdrawal (*Retiro Programado*) offers that an individual receives from the SCOMP exchange. The 1st-year monthly payment is expressed in UFs (*Pension mensual (UF) (a)*) and pesos (*Pension mensual ($)*). Several pension fund administrators (*AFP*) make bids, and the table orders them from the least to the most expensive one in terms of fees for the individual. The difference between offers (*Diferencia anual de pension ($)(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



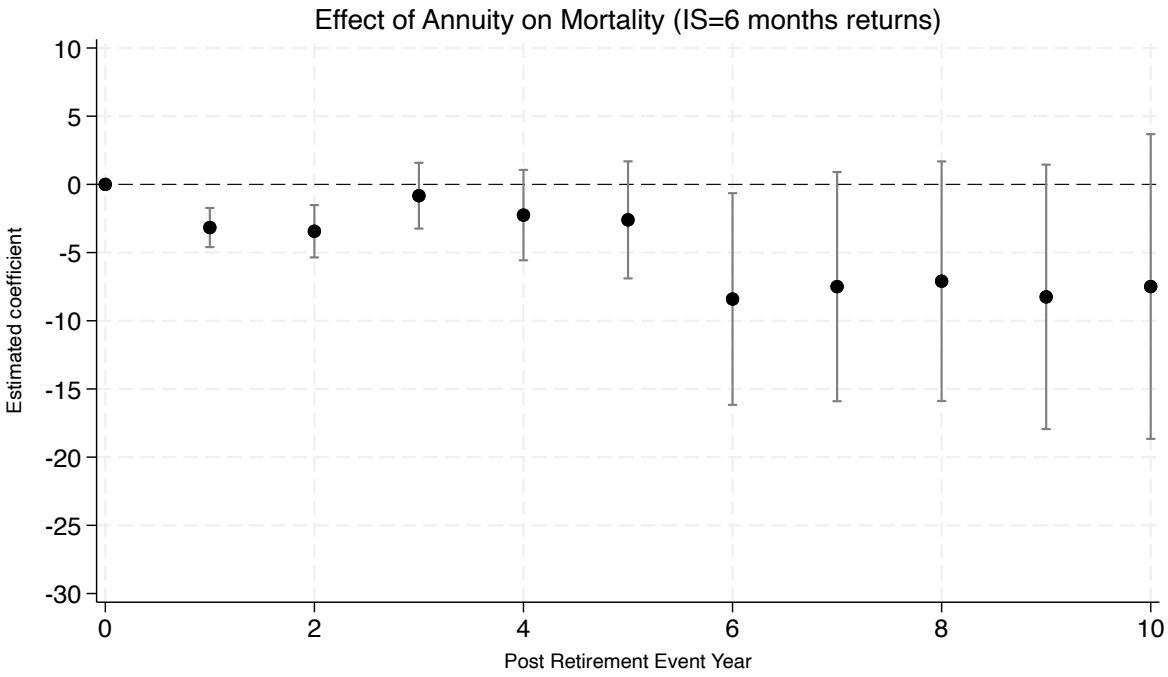

**Notes**: Data for this figure comes from the SCOMP database and includes both currently alive and deceased retirees. The blue bars represent the fractions of retirees that take the annuity in a particular month, and the red line shows the previous 12-month cumulative returns for Fund C

**Figure 4:** Effect of Annuities by Sub-Samples Around Legal Retirement Age



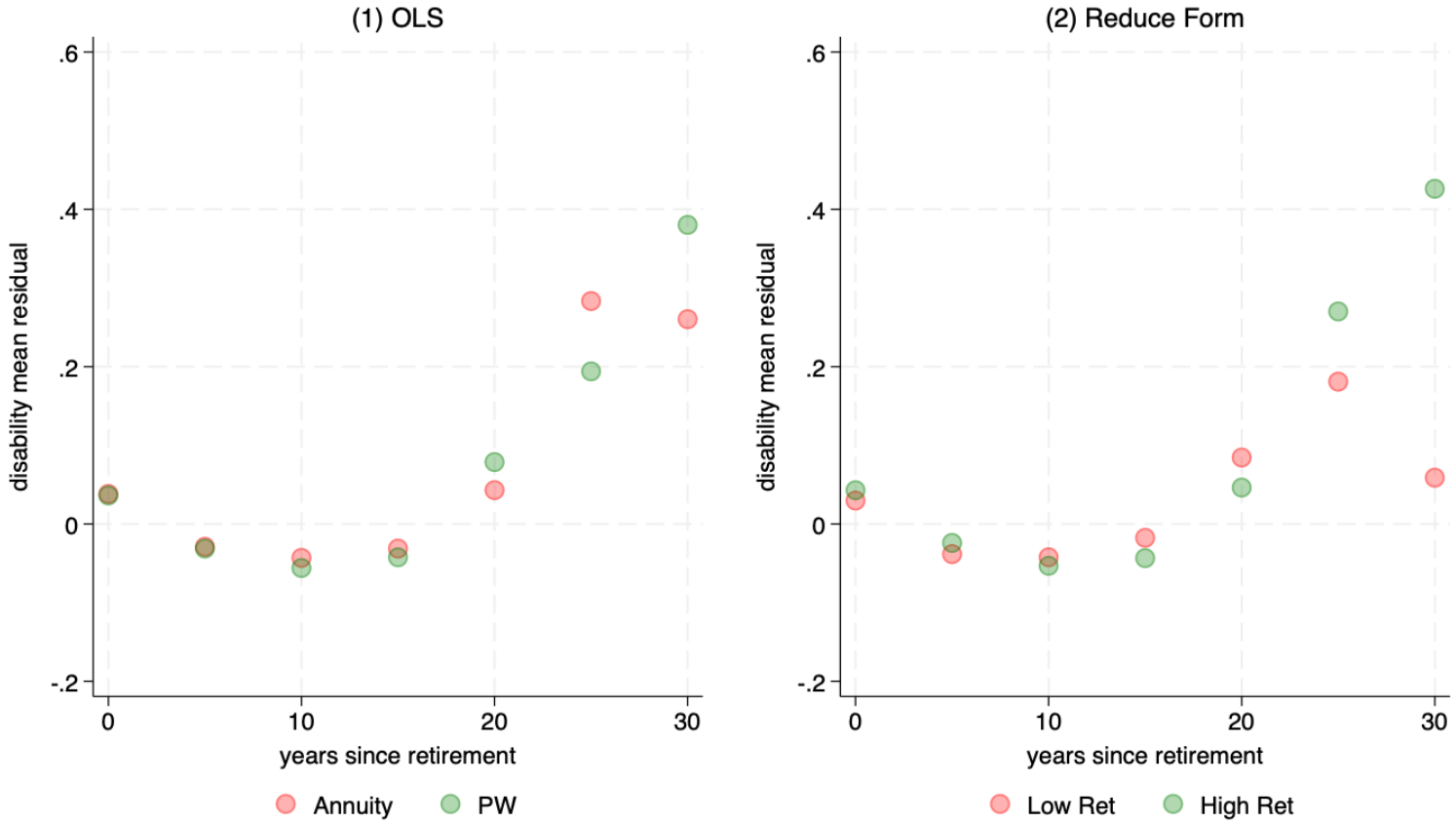

**Notes**: These figures estimate equation 3 using different sample specifications, full sample replicates the results in table 3, +/- 5 years defines the sample as men retirees between age of 60 and 70, and women retirees between age 55 and 65, etc.

**Figure 5:** 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 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 disability mean 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 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 12 months before the retirement decision (PW or AN). Fraction of deaths shows the share of deceased retirees as of 2022 within each sample. 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*** |
| 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** |
| 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** |
| Year of birth | 1952 | 1952 | 5.4 | 1953 | 1954 | 5 | 1951 | 1951 | 5 | -1.746** |
| 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** |
| Age of death (longevity) | 68.6 | 69.0 | 6.5 | 68.8 | 69.0 | 6.4 | 68.5 | 69.0 | 6.6 | -0.329** |
| Fraction of deaths | 0.10 | | | 0.08 | | | 0.11 | | | |
| No. 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 12 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. Fraction of deaths shows the share of deceased retirees as of 2022 within each 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 |
| Gender(1=Male, 0=Female) | 0.66 | 1.00 | 0.47 | 0.66 | 1.00 | 0.47 | 0.002 |
| 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 |
| Year of birth | 1951 | 1951.0 | 5 | 1953 | 1953.0 | 5 | 1.909 |
| Returns pre-retirement (months t-6 to t-1) | 0.06 | 0.05 | 0.03 | -0.02 | -0.01 | 0.03 | -0.074** |
| Age of death (longevity) | 68.79 | 69.00 | 6.55 | 68.26 | 68.00 | 6.48 | -0.521 |
| Fraction of deaths | 0.12 | | | 0.08 | | | |
| No. observations | 297,595 | | | 294,314 | | | |

## **Table 3:** The Effect of Annuities on Mortality

The table reports regression results for samples with horizons of 5, 10, and 15 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 $t-12$ and $t-1$. All regressions include as controls: accumulated 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 | -0.71*** | | | -2.52*** | -0.84*** | | | -3.61** |
| | (0.082) | | | (0.788) | (0.080) | | | (1.488) |
| | 0.000 | | | 0.002 | 0.000 | | | 0.018 |
| Returns (t-6 - t-1) | | 1.39*** | -0.55*** | | | 1.66** | -0.46*** | |
| | | (0.453) | (0.066) | | | (0.656) | (0.055) | |
| | | 0.003 | 0.000 | | | 0.013 | 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 | 0.224 | 0.224 | 0.175 | | 0.178 | 0.178 | 0.142 | |
| Kleibergen-Paap F-stat | | | 69.88 | | | | 69.89 | |

# **Table 4:** The Effect of Returns on Longevity and Annuities

The table in Panel A reports the regression results for the effect of returns on longevity. for a horizon of up to 15 years after retirement, exploring the effect for different return windows backward and forward looking. Panel B reports the 2SLS effect of annuities on death using different return windows to instrument the annuity decision. All regressions include as controls: last salary, accumulated balance, years contributed, dummies for retirement type (early, disability, standard), acceptance month dummies, and gender dummies interacted with birth-year and acceptance year fixed effects. 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 | | | | | |
|---|---|---|---|---|---|---|
| VARIABLES | (1) Dead | (2) Dead | (3) Dead | (4) Dead | (5) Dead | (6) Dead |
| *Panel A: Reduced Form* | | | | | | |
| Returns (t-12 through t-1) | 1.83*** | | | | | |
| | (0.585) | | | | | |
| | 0.002 | | | | | |
| Returns (t-6 through t-1) | | 1.66** | | | | |
| | | (0.656) | | | | |
| | | 0.013 | | | | |
| Returns (t-3 through t-1) | | | 1.25 | | | |
| | | | (0.972) | | | |
| | | | 0.203 | | | |
| Returns (t+1 through t+3) | | | | 1.44 | | |
| | | | | (1.110) | | |
| | | | | 0.199 | | |
| Returns (t+1 through t+6) | | | | | 1.10 | |
| | | | | | (0.974) | |
| | | | | | 0.264 | |
| Returns (t+1 through t+12) | | | | | | 0.52 |
| | | | | | | (0.621) |
| | | | | | | 0.403 |
| *Panel B: Second Stage* | | | | | | |
| Annuity [Ret. (t-12 through t-1)] | -6.53*** | | | | | |
| | (-2.096) | | | | | |
| | 0.002 | | | | | |
| Annuity [Ret. (t-6 through t-1)] | | -3.61** | | | | |
| | | (-1.488) | | | | |
| | | 0.018 | | | | |
| Annuity [Ret. (t-3 through t-1)] | | | -2.05 | | | |
| | | | (-1.595) | | | |
| | | | 0.201 | | | |
| Annuity [Ret. (t+1 through t+3)] | | | | 19.45 | | |
| | | | | (20.486) | | |
| | | | | 0.345 | | |
| Annuity [Ret. (t+1 through t+6)] | | | | | 3.28 | |
| | | | | | (3.007) | |
| | | | | | 0.279 | |
| Annuity [Ret. (t+1 through t+12)] | | | | | | 1.77 |
| | | | | | | (2.115) |
| | | | | | | 0.405 |
| Observations | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 |

## **Table 5:** The Effect of Annuity on Mortality: Post Retirement Income Controls

The table reports regression results for the effect of annuity on longevity for the 2SLS, where the annuity decision is instrumented with the previous 12 months' returns on Fund C. Columns 1-4 report results for a horizon of up to 15 years after retirement. Column 1 reports the main results, while Column 2 reports the effect of controlling for post-retirement income, which is a constant value for annuities and an estimated income stream for PW. Column 3 reports the effect, controlling for the standard deviation of the post-retirement income over the time horizon after retirement. Column 4 controls for both the post-retirement income path and standard deviation. Columns 5-8 (9-12)report the same coefficients for a 10 (5) year horizon. All regressions include as controls: last salary, accumulated balance, years contributed, dummies for retirement type (early, disability, standard), acceptance month dummies, and gender dummies interacted with birth-year and acceptance year fixed effects. 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%.

| | 5-Year Horizon | | | | 10-Year Horizon | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) Dead | (2) Dead | (3) Dead | (4) Dead | (5) Dead | (6) Dead | (7) Dead | (8) Dead |
| Annuity | -1.96** | -2.38*** | -2.11** | -2.35*** | -2.82* | -3.37** | -3.06* | -3.38** |
| | (0.764) | (0.791) | (0.810) | (0.820) | (1.469) | (1.526) | (1.579) | (1.562) |
| | 0.013 | 0.004 | 0.012 | 0.006 | 0.060 | 0.031 | 0.057 | 0.035 |
| Retirement Income | | -0.03*** | | -0.03*** | | -0.03*** | | -0.03*** |
| | | (0.007) | | (0.007) | | (0.008) | | (0.008) |
| | | 0.000 | | 0.000 | | 0.000 | | 0.000 |
| S.D. Retirement Income | | | -0.03** | 0.02 | | | -0.06* | 0.00 |
| | | | (0.013) | (0.019) | | | (0.032) | (0.044) |
| | | | 0.042 | 0.298 | | | 0.082 | 0.969 |
| Observations | 2,667,508 | 2,667,508 | 2,665,814 | 2,665,814 | 4,353,059 | 4,353,059 | 4,351,927 | 4,351,927 |
| Kleibergen-Paap F-stat | 67.17 | 62.36 | 58.94 | 60.88 | 67.09 | 62.20 | 57.45 | 62.21 |

## **Table 6:** 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)<br>No Annuity | (2)<br>Any Annuity | (3)<br>Annuity>$18,000 | (4)<br>Diff. (1-2) | (5)<br>Diff. (1-3) |
|---|---|---|---|---|---|
| No sports (1= no sports; 0= yes sports) | 0.627 | 0.581 | 0.594 | 0.047*** | 0.034** |
| Smoking (1=yes, 0=no) | 0.149 | 0.06 | 0.058 | 0.089*** | 0.091*** |
| Log weight | 5.127 | 5.095 | 5.076 | 0.032*** | 0.051*** |
| Log health expenses | 4.914 | 5.023 | 5.027 | -0.109*** | -0.113* |
| Satisfied with retirement? (1=very; 3=not at all) | 1.7 | 1.443 | 1.419 | 0.257*** | 0.281*** |
| Mean # of depression symptoms (1=yes, 0=no) | 1.815 | 1.269 | 1.226 | 0.546*** | 0.589*** |
| Health status (1=excellent; 5=poor) | 3.269 | 2.891 | 2.87 | 0.378*** | 0.399*** |
| Mean # of disabilities (1=yes, 0=no) | 0.296 | 0.232 | 0.244 | 0.064*** | 0.052*** |
| Observations | 13593 | 2661 | 869 | 16254 | 14462 |

# **Table 7:** CASEN Survey: Summary Stats

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 an 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.

| | (1) All | | (2) Annuity | | (3) PW | | (4) Diff. (2-3) | (5) Low ret. | | (6) High ret. | | (7) Diff. (5-6) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mean | sd | mean | sd | mean | sd | | mean | sd | mean | sd | |
| Annuity | 0.49 | 0.50 | 1 | | 0 | | | 0.500 | 0.500 | 0.489 | 0.500 | 0.011 |
| Age | 71.5 | 6.9 | 72.1 | 6.7 | 70.9 | 7.0 | -1.2*** | 71.0 | 6.5 | 71.9 | 7.1 | -0.9*** |
| Income (Chilean Pesos) | 346,818 | 578,729 | 368,769 | 590,168 | 325,460 | 566,578 | -43,309*** | 357,658 | 612,522 | 339,694 | 555,300 | 17,964 |
| Gender (1=Male, 0=Female) | 0.57 | 0.50 | 0.60 | 0.49 | 0.54 | 0.50 | 0.06*** | 0.569 | 0.495 | 0.570 | 0.495 | 0.001 |
| Mean Disability | 1.18 | 0.51 | 1.17 | 0.51 | 1.19 | 0.51 | -0.02* | 1.17 | 0.50 | 1.19 | 0.52 | -0.02*** |
| Max Disability | 1.39 | 0.88 | 1.36 | 0.87 | 1.41 | 0.89 | -0.05*** | 1.37 | 0.87 | 1.40 | 0.89 | -0.03** |
| Pseudo-Pre-Retirement Returns | 0.024 | 0.061 | 0.023 | 0.062 | 0.025 | 0.061 | 0.002** | -0.025 | 0.057 | 0.057 | 0.039 | -0.081*** |
| Observations | 36487 | | 17994 | | 18493 | | 36487 | 14470 | | 22017 | | 36487 |

## **Table 8:** Survey Evidence: The Effect of Annuities on Quality of Life during Retirement

This table uses the data summarized in Table 7. 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. 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

## **A.1:** The Effect of Returns on Longevity and Annuities: 10 years horizon

The table in Panel A reports the regression results for the effect of returns on longevity. for a horizon of up to 10 and 5 years after retirement, exploring the effect for different return windows backward and forward looking. Panel B reports the 2SLS effect of annuities on death using different return windows to instrument the annuity decision. All regressions include as controls: last salary, accumulated balance, years contributed, dummies for retirement type (early, disability, standard), acceptance month dummies, and gender dummies interacted with birth-year and acceptance year fixed effects. 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%.

Panel A: Reduced Form

| | 10 Year Horizon | | | | | |
|---|---|---|---|---|---|---|
| VARIABLES | (1) death | (2) death | (3) death | (4) death | (5) death | (6) death |
| Returns (months t-12 through t-1) | 1.83*** | | | | | |
| | (0.585) | | | | | |
| | 0.002 | | | | | |
| Returns (months t-6 through t-1) | | 1.66** | | | | |
| | | (0.656) | | | | |
| | | 0.013 | | | | |
| Returns (months t-3 through t-1) | | | 1.25 | | | |
| | | | (0.972) | | | |
| | | | 0.203 | | | |
| Returns (months t+1 through t+3) | | | | 1.44 | | |
| | | | | (1.110) | | |
| | | | | 0.199 | | |
| Returns (months t+1 through t+6) | | | | | 1.10 | |
| | | | | | (0.974) | |
| | | | | | 0.264 | |
| Returns (months t+1 through t+12) | | | | | | 0.52 |
| | | | | | | (0.621) |
| | | | | | | 0.403 |
| Observations | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 |
| R-squared | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 |
| Birth Year | Y | Y | Y | Y | Y | Y |
| Acceptance Year | Y | Y | Y | Y | Y | Y |

Panel B: Instrumented Regression

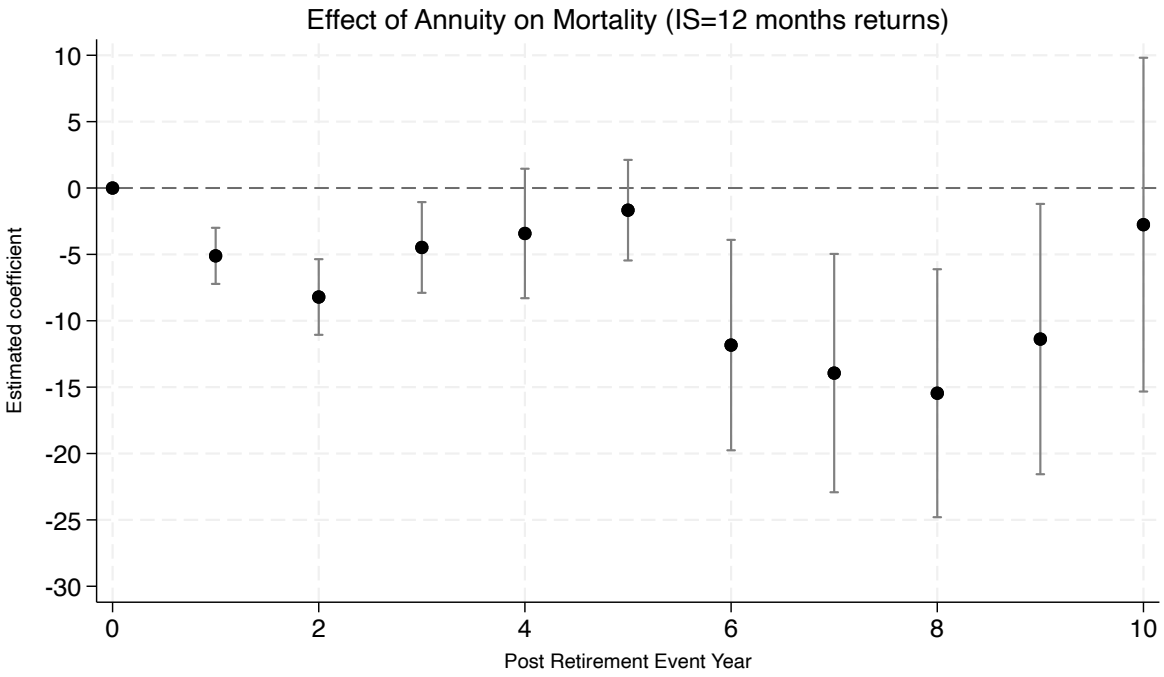
| | 10 Year Horizon | | | | | |
|---|---|---|---|---|---|---|
| VARIABLES | (1) death | (2) death | (3) death | (4) death | (5) death | (6) death |
| AN [Returns (months t-12 through t-1)] | -6.53*** | | | | | |
| | -2.096 | | | | | |
| | 0.002 | | | | | |
| AN [Returns (months t-6 through t-1)] | | -3.61** | | | | |
| | | -1.488 | | | | |
| | | 0.018 | | | | |
| AN [Returns (months t-3 through t-1)] | | | -2.05 | | | |
| | | | -1.595 | | | |
| | | | 0.201 | | | |
| AN [Returns (months t+1 through t+3)] | | | | 19.45 | | |
| | | | | -20.486 | | |
| | | | | 0.345 | | |
| AN [Returns (months t+1 through t+6)] | | | | | 3.28 | |
| | | | | | -3.007 | |
| | | | | | 0.279 | |
| AN [Returns (months t+1 through t+12)] | | | | | | 1.77 |
| | | | | | | -2.115 |
| | | | | | | 0.405 |
| Observations | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 | 4,460,606 |
| R-squared | -0.005 | 0 | 0.001 | -0.071 | -0.002 | 0 |
| Birth Year | Y | Y | Y | Y | Y | Y |
| Acceptance Year | Y | Y | Y | Y | Y | Y |

## **A.2:** 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.

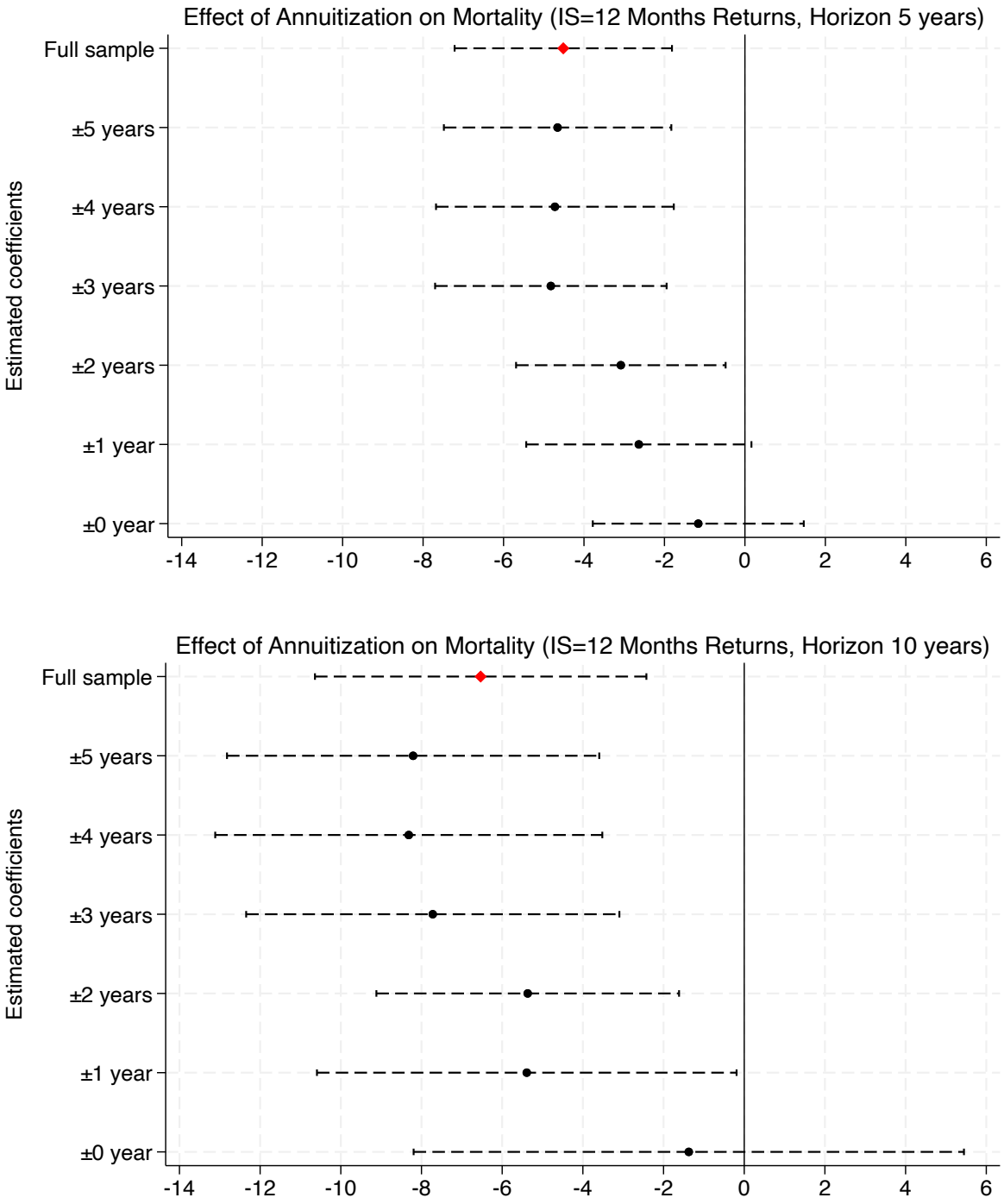
| | | Annuity | | Age | | Total Income | | Gender | | Mean Disability (1-5) | | Max Disability (1-5) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey Year | Obs. | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd |
| 2011 | 14,411 | 0.44 | 0.50 | 72.40 | 6.99 | 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 |

## **A.1:** Effect of Longevity by Year: 12 months returns



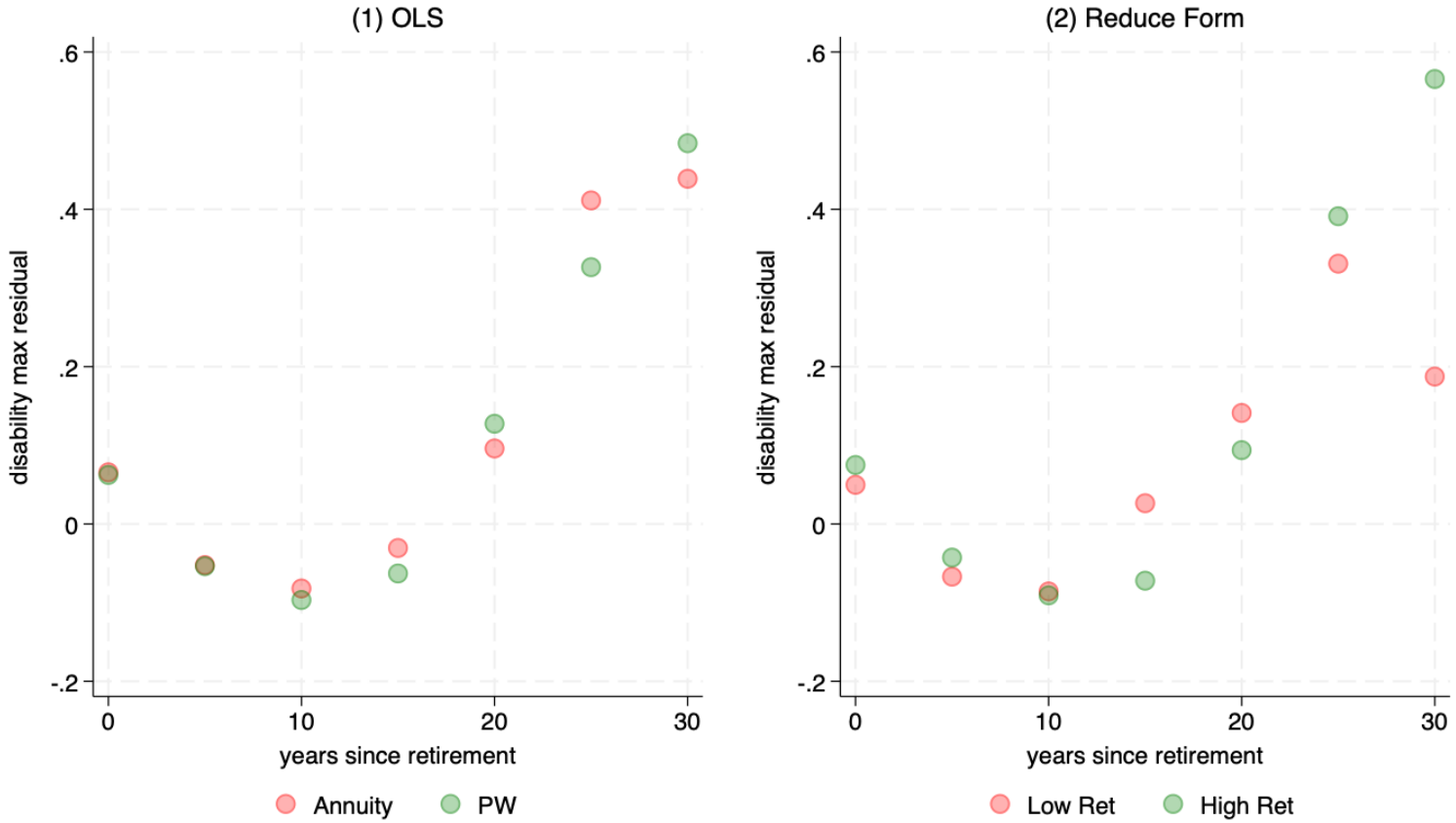

**Notes**: These plots estimate the dynamic effect by year post-retirement of the estimated coefficient of annuities on mortality, followed by the specification in equation 3

## **A.2:** 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.

## **A.3:** 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