Adverse selection in annuity markets

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June 15, 2015

Retirement income around the world is increasingly dependent on private savings, creating an expanding demand for lifetime annuities. However, and with a few exceptions, annuity markets around the world have not developed as well as other insurance products. One explanation is that adverse selection could limit the scope for development of this product in voluntary markets; standardized contracts would attract individuals with exceptional longevity prospects, therefore reducing the annuity amount offered to the average participant. The Chilean case is particularly interesting in this sense, as the entire pension system relies on individual savings through compulsory individual retirement accounts. Upon retirement, workers with sufficient funds in their accounts must choose between two main pension options: programmed withdrawals or life annuities. Using a large administrative dataset on Chilean retirees, we study whether annuitants live longer than workers who chose a programmed withdrawal schedule. Unlike previous studies for Chile, we estimate survival models as a function of pension choice, providing direct evidence of adverse selection in the annuity market. Interestingly, we find that after the introduction of the SCOMP (i.e., for retirees after 2004), the adverse selection effect is larger and is present both for men and women retiring at normal age. Women (men) who choose an annuity live on average five (two and a half) years longer than those choosing the phased withdrawal option. To control for potential unobserved characteristics that could be related to the choice of pension product, we use interest rate data at the time of retirement as an instrumental variable, within the framework of a parametric duration model. In this case, the marginal effect of annuitization is no longer significant, suggesting that there is no causal effect of annuities on longevity.

**JEL codes:** G14, G22, G23, J32, J64.

**Keywords:** Adverse selection, annuities, duration model, instrumental variables, Chilean pension system.

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1. INTRODUCTION

The Chilean Pension Fund System was deeply reformed in 1980, transforming a classical pay-as-you-go system into one of the first individual capitalization systems. The key elements of the system—beyond the individual capitalization accounts—are that funds are privately managed by pension fund administrator (PFA hereafter), workers can freely choose their PFA,\(^2\) dependent workers must contribute every month 10% of their taxable income, and the role of the Government is limited to regulation and supervision, and to ensure some minimum benefits for those who did not accumulate enough funds during their working life and are entitled to retire.

Workers must also choose their pension modality. In a nutshell, workers who retire with enough funds to enjoy a pension above a certain threshold must choose between two main options: a programmed withdrawal schedule and a life annuity (we discuss this choice in greater detail in the next section). Workers with low balance can only access the programmed withdrawal option.

From a theoretical perspective, when individuals must decide their pension product (or pension modality) they may consider their life expectancy. E.g., someone who expects to live longer than the average may wisely choose a life annuity. Similarly, more risk averse individuals may prefer life annuities as they provide insurance against extreme longevity and shocks to the financial markets. At the same time, this type of individuals tends to have less risky habits and live longer, therefore reinforcing the preference for annuities. As a result, those who choose life annuity are, on the margin, more likely to live longer than those on programmed withdrawals schedules. As some of these individual characteristics (like risk aversion, behavioral habits and genetic factors affecting longevity) are known by retirees but usually unobserved by insurance companies offering annuities, this type of market may suffer from an adverse selection problem.

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\(^2\) Since 2002 workers also choose how to allocate their funds among five different funds that PFAs hold that vary on their riskiness and expected return.
From an empirical perspective, the analysis of adverse selection in annuity markets is simpler than in other insurance markets for two reasons. First, as noted by Finkelstein and McGarry (2006), unlike other insurance markets there should be no advantageous selection in annuity markets.\(^3\) Second, moral hazard should play no role (or a minimal one) in annuity markets as it is unlikely that insurees, after purchasing an annuity, will change their behavior in a way that would increase their life expectancy (Cutler, Finkelstein, and McGarry, 2008; Finkelstein and Poterba, 2006).

Finkelstein and Poterba (2006) study the issue of adverse selection on annuity markets in the UK. They analyze adverse selection in three different dimensions: the annuity premium paid up front, whether the stream of income is constant or increasing, and whether it has or not a guaranteed period. With a semi-parametric proportional hazard model, they find evidence of adverse selection in the two last dimensions: annuitants who self-select to increasing annuities and annuities with no guaranteed period have larger probability of surviving each period. They also show that the ‘money’s worth’ value\(^4\) of those annuity contracts chosen by longer-lived individuals is lower than for contracts preferred by shorter-lived annuitants.

Finkelstein and Poterba (2002) also find evidence consistent with adverse selection by comparing specific mortality tables for annuitants in the voluntary market, in the compulsory market, and for the general population. They show that adverse selection explains around 90% of the difference between the actual amount paid and what would be a ‘fair’ payment to a random person of the population.

The Chilean market for annuities is interesting, as a large fraction of workers must, at the moment of retirement, opt for an annuity or a programmed withdrawal (PW) scheme and to do that they must go thru an administrative process in which they receive several offers from insurance companies. Several authors have tackles the issue

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3 Advantageous selection is the opposite of adverse selection. In a health insurance market, for example, poorer risks will tend to buy more comprehensive insurance policies –because of a standard adverse selection argument–, but more risk averse people will also tend to buy more comprehensive insurance policies, and they may also have better life habits that reduce the number of expected claims.

4 The money’s worth is defined as the ratio between expected present value of the stream of payments to the annuity premium (Mitchell et al., 1999).
of adverse selection in the Chilean annuity market and the evidence found is mixed. We review these few papers in Section 2 after describing the Chilean pension-choice system.

In this article, we use administrative data on a large sample of Chilean retirees to evaluate the presence of adverse selection effects in the annuity market. We focus on the Chilean market, as it provides an extremely clean environment where all participants (with some minimal attachment to the formal labor market) are required to choose between and insurance product (an annuity) and a self-insurance option (a programmed withdrawal).

The dataset provides detailed information on birth, retirement and mortality dates, providing the perfect opportunity to look at difference in the mortality processes as a function of the type of product that was chosen. We present results from a series of parametric models, showing the degree of correlation between the type of product and the mortality hazard function. We also present results that make use of a novel instrumental variable approach that allows us to abstract from unobserved confounding factors.

Our results confirm the adverse selection hypothesis, showing that individuals who chose to annuitize tend to live longer than those who opted for a PW schedule. This is particularly visible among women, individuals who retired after the introduction of SCOMP (an electronic system to receive bids for pension products) and workers who retire on or after the normal retirement age. These effects are no longer significant when following the instrumental variable approach, suggesting that the choice to annuitize does not have a causal effect on longevity but rather reflects the adverse selection problem that has been found in the literature.

The rest of the paper is organized as follows. In the next section we describe the pension choice faced by Chilean retirees and the literature that has looked at adverse selection issues in that market. In section 3 we present the different data sets used and the corresponding methodological strategies. In section 4 we present the results and in section 5, we conclude.
2. BACKGROUND

Reformed in 1980, the Chilean pension system is based on compulsory savings in individual accounts managed by private fund managers (known as AFPs, for its Spanish acronym). The system provides benefits for old age, invalidity and survivorship.

Upon retirement, workers must choose between two main alternative pension products: transfer their savings to a life insurance company in exchange for a life annuity or keep their balance with an AFP and start withdrawing their funds, following a regulated payment schedule (this option is called a programmed withdrawal schedule, PW).\(^5\) In this section, we provide more detail on the different factors that could affect the choice between the two main options and about the empirical evidence of adverse selection in this market.

2.1. Pension products under the Chilean pension system

In both cases, the pension level is a function of a number of factors: the balance in the account, the age and sex of the retiree and their potential beneficiaries, the expectations of interest rates and the applicable mortality table.\(^7\) In essence, pensions are calculated as the stream of benefits (for the retirees and potentially for the surviving beneficiaries) whose net present expected value is equal to the balance of the individual.\(^8\)

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5 To purchase an annuity, workers must have a minimum balance in their account. Otherwise, they are restricted to a programmed withdrawal schedule.
6 There are two additional alternatives, which are combinations of the two main ones: a retiree can split their balance in two parts, buy an annuity with one part and receive a programmed withdrawal schedule from the rest; the worker can use part of its balance to buy a deferred annuity (which starts paying at some point in the future) and use the remaining balance to finance a stream of payments from the AFP from retirement until the deferred annuity starts paying.
7 There are 6 different official mortality tables, applicable to the calculation of programmed withdrawal schedules: separate tables for men and women, depending on the type of pension under calculation (old age, invalidity or survivorship)
8 Potential beneficiaries of survivorship pensions are the spouse of the retiree, the children of the retiree (if they are under age 18, under age 24 and studying or at any age if they are disabled), the mother or father of children in common born out of wedlock (if they depend financially of the retiree) and, in absence of other beneficiaries, the parents of the retiree (if they are considered family charge of the retiree).
In the case of a worker of gender $g$ who retires at age $a_0$, without potential beneficiaries, a general formula for the initial pension, $P_0$, would be the following:

$$P_0 = \frac{B}{UNC(pt, a_0, g, r)}$$

where $B$ represents the balance of the worker at retirement, $r$ represents a vector of interest rates for the years following retirement, $pt$ represents the type of pension under calculation (old age, invalidity or survivorship) and $UNC$ stands for “Unitary Necessary Capital”, the stock of resources necessary to finance a pension of one monetary unit until death.

Applying a calculation of net present expected value to the previous benefit yields the following formula for the $UNC$:

$$UNC(pt, a_0, g, r) = \sum_{a=a_0}^{MaxAge} q_{a_0,a}^{pt,g} \left( \prod_{t=0}^{a-a_0} (1 + r_t) \right)$$

where $q_{a_0,a}^{pt,g}$ is the probability (for a person of gender $g$ and pension type $pt$, i.e. old-age, disabled or beneficiary of a survivorship pension) of being alive at age $a$, conditional on being alive at age $a_0$, $MaxAge$ is the maximum age used for calculations (110 in the Chilean case) and $r_t$ is the annual real interest rate for year $t$ (starting with year 0, the moment of calculation).

In the presence of potential beneficiaries, the previous pension formula would include in the denominator the sum of the UNCs of the person under calculation and of each potential beneficiary.$^9$

The main differences between the two main types of pension products (annuity or PW) are the following:

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$^9$ In the case of beneficiaries, the probabilities used in the calculation of the UNC correspond to the probabilities of outliving the retiree. Also, the amount of the pension is, in general, a fixed percentage of the pension of the retiree. The percentage depends on the type of beneficiary: spouse, children, etc.
Timing of calculation: In the case of an annuity, the calculation is performed once (upon retirement) and the pension is fixed in real terms from that moment until death. Programmed withdrawals benefits are recalculated every year (if the person is still alive) with the more current parameters (new balance, new ages of all relevant individuals, the mortality applicable in that year, the more recent expectation of interest rates). As a result, PW benefits tend to diminish in real terms as the individual ages, eventually being exhausted if the individual lives long enough. This can be seen in the next figure, which presents the pension schedule for an annuity and PW.¹⁰

Who makes the calculation: In the case of PW, all formulae and parameters are set by the regulation, including official mortality tables and interest rates. In the case of annuities, insurance firms participating in the market are free to use their own mortality tables and their own expectations of future interest rates.

Property of outstanding funds: When buying an annuity, workers transfer their funds to the insurance company in exchange for the lifetime annuity (for the person and his beneficiaries). The firm’s obligation expires with the death of the worker and his beneficiaries. In contrast, when choosing a PW schedule, the worker maintains the property of his funds so when he dies, if the outstanding funds exceed the amount required to finance the survivorship benefits (which could happen in the event of an early death or in the absence of legal beneficiaries), the remaining funds become part of his inheritance.

Reversibility: After choosing a PW schedule, a worker can switch at a later period to an annuity (as long as he complies with the minimum balance requirement), whereas the decision to buy an annuity is irreversible (the person cannot switch to another pension product or another provider).

¹⁰ When the formula implies a benefit below a certain threshold, the “base pension”, the person can adjust the benefit to this amount (as shown in the following figure). This implies a more rapid decumulation of funds.
In summary, a PW schedule has the advantage of keeping the property of the funds, which implies the possibility of greater inheritance in the event of an early death but with the disadvantage of decreasing benefits and potentially depleted funds if the person lives long enough. An annuity implies forgoing the property of the funds in exchange for insurance against higher-than-normal longevity and against financial shocks affecting the interest rate of retirement funds.

As mortality tables (both official and those used by insurance providers) are representative of average beneficiaries, a PW schedule should be more attractive to individuals with low longevity prospects (because of illness or the presence of risk factors in the family). Also, individuals with family members who are not eligible for survivorship benefits (like children over age 24) and have a high preference for bequests would marginally prefer a PW over an annuity. On the other side, individuals with higher risk aversion would tend to favor annuities, which protect them against high longevity and negative financial shocks.
The main source of information asymmetry is the fact that the individuals may know more than the insurance companies about their own longevity prospects; individuals coming from families with high longevity may be particularly attracted to the annuity option, therefore raising the average longevity of actual participants and increasing the average cost of providing such a product.

In the next section, we provide a brief overview of the literature that has looked at the empirical evidence on the presence of such adverse selection effects.

2.2.- Adverse selection in the Chilean annuity market – empirical evidence

The few papers that have analyzed whether there is adverse selection between annuitants and non-annuitants tackle the question by estimating a discrete choice probability model. This is done working with one of two data sets or both paired (we describe them below in Section 3). One data set consists of all retirees’ administrative records from the supervising authorities, and the second one is a panel survey started in 2002 that collected historical labor information that also has some information on health status, family composition, financial literacy and other information that can be relevant for the pension choice (Encuesta de Protección Social, EPS).

Edwards and James (2006) work with the first wave of the panel. They study directly the pension modality choice focusing on two main issues: the degree of substitution between a publicly financed minimum pension and an annuity, and the role of several variables such as risk aversion, degree of knowledge about the system, time preferences and health status on the pension choice. This latter variable captures potential adverse selection, as it is expected that healthier individuals would be more prone to annuitize their savings.

The data available to the authors has several shortcomings that the authors recognize. First, it does not allow them to separate those who can choose to annuitize from those that cannot do it among the normal age retirement group and those that are eligible for the minimum pension guaranteed. Second, there is a mismatch between the moment at
which the explanatory variables are collected (2002, the year of the survey) and the moment at which the pension decision was made.

For the early retirement group, which is the one that unequivocally can choose to annuitize and it is weakly protected by the minimum pension guaranteed, they find that the health status and life expectancy at the moment of the survey are irrelevant for the decision to annuitize. However, they do find for those who declared that bad health was a reason for early retirement the probability of annuitizing is reduced by 18 percentage points. This is consistent with adverse selection, but the market for annuities is still large enough for this group (around 80% choose this modality).

Ruiz (2014) combines the information of the EPS with the administrative data and addresses two questions. Similarly to Edwards and James, he tackles the issue on the determinants of the pension modality choice. Following Brown (2001) and Mitchell et al (1999), he also calculates the “Annuity Equivalent Wealth”, which represents the utility gain of being able to access an actuarially fair annuity. This variable is included as an explanatory one for the pension choice.

Consistent with Edwards and James (2006), Ruiz (2014) finds evidence of health status having a positive impact on the probability of annuitization for early retirement, but none for normal age. Somewhat surprisingly, he finds that having the right to the minimum pension guarantee has a positive effect on the probability of choosing an annuity, which contradicts the hypothesis of Edwards and James (2006) that this benefit could be a substitute for an annuity.

All the studies presented above (except for James et al, 2006) find some weak or indirect support to the existence of adverse selection in the Chilean annuity market. They all model and/or estimate the pension choice decision and rely mainly on the self-reported health status that is reported at the time of the survey, which in general does not coincide with the moment of retirement. In the next sections, we present a novel approach. We work with the universe of retirees in Chile that can choose between annuity and phased withdrawal and look directly at mortality rates. Like Finkelstein
and Poterba (2006) for the UK annuity market, we estimate a duration model for the Chilean data.\textsuperscript{11}

### 3. DATA AND METHODOLOGY

Our main source of information for the empirical analysis of adverse selection comes from a dataset that was built by the supervising agencies (pensions and insurance and securities) to update the official mortality tables. The dataset includes the birth, retirement and death (if applicable) dates for every retiree and beneficiary of the current pension system as well as some beneficiaries from the previous Pay-As-You-Go scheme. It also includes the gender, type of pension (old age, invalidity or survivorship) and the type of pension product (annuity or PW) implicit in the origin of the data (the AFPs or the insurance companies). The original data set was restricted to individuals who were eligible to choose between an annuity and a PW schedule.

The main advantage of this dataset is that it provides us with a large sample of individuals, which allows us to look at the mortality process as a function of the type pension product they chose. The large sample size further allows us to control for differences in cohort and age of retirement with few parametric assumptions. The main disadvantage is the few number of covariates that can be controlled for in the estimation. This implies a difficulty in distinguishing between adverse selection and unobserved heterogeneity effects (like socioeconomic status, which also tends to be correlated with socioeconomic status or risk aversion).

In order to deal with this problem, we also explore an instrumental variable approach in which we make use of the financial circumstances at the time of retirement (particularly the interest rates affecting the choice between PW and annuities) as an instrument for the choice of pension product. Results coming from this type of approach

\textsuperscript{11} We are not aware of any works for the Chilean case that use a duration model except for Pizarro (2012) where we worked a cloglog model with the data of the pairing of the EPS and administrative records that we report in Section 3.2.
can be interpreted as the causal effect of the pension product on longevity (for instance as a result of moral hazard).

In what follows we provide some descriptive statistics on the dataset used and the methodological approach that was followed.

3.1.- Descriptive statistics

The original dataset contains information on 2,064,105 retirees, coming both from the AFP system and the previous PAYG scheme. As mentioned early, this data set does not include individuals whose only pension option is to follow a PW schedule.\(^{12}\)

We restrict our analysis to old age retirees under the new scheme, who retired after 1991, between the ages of 40 and 70, leaving us with 533,755 individuals.\(^{13}\) For this people, we know the gender, the type of pension product and the dates of birth, retirement and death (or the last day of exposure, June 1\(^{st}\) 2014, if they were still alive). By the age at retirement, we can determine if they had an early retirement or retired at (or after) the normal retirement age (60 years for women, 65 for men).

The following table presents some descriptive statistics on the individuals in the data set. As legal retirement age in Chile is different for men and women, we present all statistics and results separate for both genders. The more striking fact is that most individuals in the sample are men (72.6%). This reflects in part the high difference between Chilean men and women in terms of lifetime attachment to the labor market. It also reflects the fact that many women retire with the required balance to opt for an annuity and therefore were excluded from the original dataset. Most individuals in this dataset (74.5%) chose to annuitize, without great differences between men and women. Women in the sample were born, on average, slightly later than men, making

\(^{12}\) The reason for this exclusion from this original data set is that this was put together to construct mortality tables for retirees from the pension system. Besides affecting the calculation of PW schedules, these tables are used to calculate the required capital to be held by insurance companies offering annuities. As this type of individuals tend to live longer, the decision was made to concentrate on potential annuity recipients, therefore excluding low balance individuals.

\(^{13}\) We excluded retirees before 1991, as we detected a group of individuals with death occurring simultaneously (or even before) retirement.
them younger by the end of the exposition period and much more likely to be alive by 2014; 14.9% of the individuals had died by the end of the exposure period (18.2% men and 6.4% women). Even if the average age at retirement is similar for men and women (around 59.4 years), 66.6% of men retired before the legal retirement age (LRA) whereas only 26.7% of women were in that situation. This is partly explained by the earlier LRA for women (60 instead of 65) but also by the fact that eligibility for early retirement is more easily complied by men, who tend to have higher savings on lower life expectancy.\footnote{To be eligible for early retirement, a worker must comply two main requirements: that the resulting pension is above a minimum threshold (approximately US$ 355 under current rules) and that the replacement rate (pension divided by average income over last 10 years) must be at least 70%. Women's lower attachment to the formal labor market (mostly due to child caring arrangements) tend to reduce their eligibility for early retirement. In addition, as pensions are actuarially calculated with separate mortality tables for men and women, women's pension at early ages are smaller than those of men (for any given balance), further reducing the likelihood of complying with the early retirement requirements.} Finally, men in the data are slightly older at the end of the retirement window, which reflects the small difference in the year of birth.

### Table 1 – Descriptive statistics by gender

<table>
<thead>
<tr>
<th></th>
<th>Men (N=387,395)</th>
<th></th>
<th>Women (N=146,360)</th>
<th></th>
<th>All (N=533,755)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>Mean</td>
<td>St. Dev.</td>
<td>Mean</td>
<td>St. Dev.</td>
</tr>
<tr>
<td>Annuitized (dummy)</td>
<td>75.1%</td>
<td>43.2%</td>
<td>72.7%</td>
<td>44.5%</td>
<td>74.5%</td>
<td>43.6%</td>
</tr>
<tr>
<td>Year of birth</td>
<td>1942.6</td>
<td>7.0</td>
<td>1945.1</td>
<td>6.1</td>
<td>1943.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Deceased by end of exposure period (dummy)</td>
<td>18.2%</td>
<td>38.5%</td>
<td>6.4%</td>
<td>24.4%</td>
<td>14.9%</td>
<td>35.6%</td>
</tr>
<tr>
<td>Age at retirement</td>
<td>59.3</td>
<td>5.9</td>
<td>59.5</td>
<td>4.4</td>
<td>59.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Early retirement (dummy)</td>
<td>66.6%</td>
<td>47.2%</td>
<td>26.7%</td>
<td>44.2%</td>
<td>55.6%</td>
<td>49.7%</td>
</tr>
<tr>
<td>Age of death (or at the end of exposure window)</td>
<td>70.0</td>
<td>6.6</td>
<td>68.4</td>
<td>5.9</td>
<td>69.6</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Source: own calculations.

To reflect more clearly the importance of early or normal retirement, the following figure shows the distribution of the age at retirement by gender. The figure shows significant modes at normal retirement ages (65 and 60), but more pronounced for women, who are less likely to retire early.
The basic thesis behind the idea of adverse selection in the provision of annuities is that individuals who choose the insurance product do so because they expect to live longer than the average. If that is the case, the hazard function (the probability of dying at a particular age, conditional on having reached that age) should be different depending on the choice of product. In particular, annuitants should present a hazard function with lower values (higher life expectancy).

The following figures present the non-parametric Nelson-Aalen cumulative hazard function for annuitants and individuals who opted for the PW schedule. The first figure is for women who retired at age 60 and the second corresponds to men who retired at age 65. It is important to notice that, at this point, we are not controlling for potential cohort or time-of-retirement effects; the goal is to present the raw data before any formal statistical model is applied. The curve corresponding to women presents a clear
and significant difference backing the thesis of adverse selection, while that of men does not show such clear pattern.\footnote{A number of tests of equality of the survivor functions of women were rejected at 95\% confidence: the log-rank test, the Cox test, the Wilcoxon-Breslow-Gehan test, the Tarone-Ware test and the Peto-Peto-Prentice test. On the other side, none of these tests were rejected in the case of men retiring at age 65.}

**Figure 2 – Cumulative hazard functions by pension modality**

a) Women who retire at age 60

b) Men who retire at age 65

Source: own calculations.
3.2.- Methodological approach

The previous non-parametric figures do not control for potential confounders, either of the observed type (such as cohort effects or time of retirement) or non-observed ones (such as income or education). In this section we propose some parametric approaches for controlling for these additional variables and, under certain assumptions, combine the data for individuals with different retirement ages.

The first modeling decision concerning parametric models of the survivor probability is whether to treat durations as resulting from a continuous or discrete time process. In our case, all dates are measured precisely (day, month and year) so the minimum interval corresponds to days, which is a small interval relative to average durations (in the order of years). For that reason, it is reasonable to treat this problem as a continuous time one.

Given the problem under analysis (mortality data) and the shape of hazard function in the previous figure, we chose a duration model with a Gompertz distribution. In this case, it is assumed that the hazard function follows the following model:

\[ h(t, X_i) = \lambda_i \cdot \exp(\gamma \cdot t) \]

where \( \gamma \) is a shape coefficient\(^{16} \) \( \lambda_i \) is given by

\[ \lambda_i = \exp(X_i'\beta) \]

The data set corresponds to individuals who retired under an old age pension after age 40 and before age 70. This is a case of delayed entry or left truncated spell data, in the sense that survival observations are conditional on having reached the age at which they retired; individuals were exposed since birth but entered the sample upon retirement after age 40. The corresponding estimation method must take into account this selection process. At the same time, not all spells were observed until completion (the death of the individual) but until the end of the observation period (approximately,

\(^{16} \) A positive value for \( \gamma \) implies a hazard function that monotonically increases with age.
June 1\textsuperscript{st} 2014). Some of the spells are therefore right censored. The parameters of the model were then estimated by maximizing the following likelihood:

\[
logL = \sum_{i=1}^{N} \left\{ d_i \cdot \log[h(t_i, X_i)] + \log \left[ \frac{S(t_i)}{S(r_i)} \right] \right\}
\]

where \( d_i \) is a dummy equal to 1 if the person died during the observation window (between retirement and June 1\textsuperscript{st} 2014) and 0 otherwise, \( t_i \) is the time elapsed (in days) between retirement and death (or between retirement and June 1\textsuperscript{st} 2014 if \( d_i = 0 \)) and \( r_i \) is retirement age (in days). \( S(t) \) represents the survival function associated with the chosen distribution function (Gompertz).

3.3.- Estimation based on instrumental variables

In the previous model, we expect the independent variable of interest (the annuitization dummy) to capture the potential adverse selection problem (related to the unobserved longevity prospects) but it could also capture some unobserved income effect (associated with higher income workers being more likely to choose an annuity and at the same time presenting higher longevity due to better access to medical treatment).

To abstract from the effects of these confounders, we also present results using an instrumental variable approach. The instrument is based on the differences in the interest rates used in the calculation of both types of products. As described earlier, insurance companies are responsible for making their own estimations of the structure of interest rates that are relevant during the duration of the annuity. In contrast, PW schedules are calculated using a particular interest rate.\textsuperscript{17} This creates a significant difference in the relative attractiveness of the two products.

\textsuperscript{17} Until 2008, the interest used in PW calculations was set once a year (in January) as a 20%-80% combination of the realized return of the pension funds (past returns) and the average implicit interest rates of the annuities sold during the previous year. In some of the years, the realized return was the particular fund (of the particular PFA) in which the worker held his savings. Later on, a common rate per fund was used for all workers, independently of the PFA. To maintain an exogenous source of variation, we assumed in all cases the average return of the intermediate fund (Fund C) throughout the calculations.
The following figure presents the evolution over time of the log difference between the annuity rate (measured monthly as the average implicit interest rate of annuities sold on the market) and the PW rate (extracted from the annual official published rates). The log difference is presented separately for early retirement and normal retirement. The graph also includes the monthly fraction of individuals in our data who chose an annuity. The first message is that the two rates present some significant (and varying) difference over time (between +20% and -40%). In addition, there is a clear correlation between this difference in interest rates (which directly translates in differences in the initial pension observed by the retiring worker) and the fraction of workers choosing annuities; when the interest rate on annuities is lower than that on PW, a smaller fraction of workers opt for the insurance option.

The conclusion of the graphical analysis is that the proposed instrument seems to have some significant predictive power on the choice of pension product.

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After 2008, the regulation was changed and an annual estimation of the structure of interest rates replaced the previous calculations (outsourced from the regulator to a financial consulting firm). The average implicit annuity interest rate is published separately for old age under early retirement and normal retirement.
Figure 3 – Log difference between interest rates of annuities and PW + fraction choosing annuity

Source: PW rates extracted from annual regulation (PW), annuity rates published from Insurance Supervisor and fraction of workers choosing annuities based on own calculation from dataset on retirees.

Note: Log difference = log(interest rate annuity) – log(interest rate PW)

As the empirical model presented here is not a linear regression, it is not possible to use the traditional two-stage-least-squares approach. The current econometric literature has yet to reach a consensus on the most appropriate way to deal with instrumental variables in the context of duration models. In this article, we present results based on Terza et al (2008) and Atiyat (2011) who suggest a method that is similar to the linear approach; we first estimate a linear first stage model for the endogenous variable as a function of the instrument and all other independent variables and extract the residual of this model. This residual is then included as an additional covariate in the parametric model described in the previous section.


20 We also estimated models in which the first stage corresponds to a probit model instead of the linear probability results presented here, with essentially the same results. Furthermore, we constructed
4. RESULTS

4.1. Parametric results

The following table presents results from the maximum likelihood estimation of the parametric model presented in section 3.1, for retirees between ages 40 and 70, and between 1991 and 2014. The reported values (with their standard errors in parenthesis below), correspond to the average marginal effect of each variable on the Median duration of an individual survival period (rescaled to represent years). Results are presented for the entire sample and separately for women and men.

The variable of interest (the annuity dummy) is positive and significant in the case of women, suggesting that annuitants have a median duration of 1.187 years longer than retirees who chose programmed withdrawals (after controlling for gender, the year of birth, and age at retirement). This is consistent with the adverse selection hypothesis; the annuity product tends to attract individuals with better longevity prospects.

The estimated effect is similar in magnitude for the entire sample (though not significant at 90% confidence). The effect for men is small and not statistically significant.

The other estimated effects are all significant and suggest that women tend to live longer than men. The same occurs with more recent cohorts and with individuals who retire at more advanced ages.

estimates (not reported here but available upon request) based on the traditional plug-in method used in two-stage-least-squares estimators; in this case the predicted probability of choosing an annuity replaces the actual pension choice in the second stage. Once again, the results were qualitatively similar to the ones reported here.
Table 2 – Average marginal effects on median duration
Retirees aged 40-70, between 1991 and 2014

<table>
<thead>
<tr>
<th>Sample</th>
<th>ALL</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annuity dummy (0 if PW)</td>
<td>0.160</td>
<td>1.187***</td>
<td>-0.0105</td>
</tr>
<tr>
<td></td>
<td>(0.0988)</td>
<td>(0.249)</td>
<td>(0.107)</td>
</tr>
<tr>
<td>Female dummy</td>
<td>8.640***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.145)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of birth</td>
<td>0.285***</td>
<td>0.234***</td>
<td>0.290***</td>
</tr>
<tr>
<td></td>
<td>(0.0112)</td>
<td>(0.0299)</td>
<td>(0.0121)</td>
</tr>
<tr>
<td>Retirement age</td>
<td>0.284***</td>
<td>0.241***</td>
<td>0.285***</td>
</tr>
<tr>
<td></td>
<td>(0.0107)</td>
<td>(0.0296)</td>
<td>(0.0116)</td>
</tr>
<tr>
<td>Gamma coefficient ((\psi))</td>
<td>0.0876</td>
<td>0.0938</td>
<td>0.0869</td>
</tr>
<tr>
<td>Number of observations</td>
<td>533,755</td>
<td>146,360</td>
<td>387,395</td>
</tr>
</tbody>
</table>

Source: own calculations.
Standard errors in parenthesis (*** p<0.01, ** p<0.05, * p<0.1)

An important institutional change that occurred in the Chilean pension system was the introduction, in 2004, of SCOMP, a new electronic system to manage annuity offers for individuals considering retirement.\(^{21}\) A worker who complies with pension eligibility requirements must choose his pension product through the electronic system: he must first choose what products he would like to receive offers (a PW schedule, an immediate annuity, or other options combining the two main alternatives). Upon receiving offers from participating insurance companies, the worker can either chose one of the alternatives or postpone his retirement.

The introduction of SCOMP implied a significant improvement in the information available to workers considering retirement, about the attributes (including the competitive price) of the different alternatives; the regulated SCOMP reports include standardized information on the advantages of the two main choices (PW and annuity), a pension projection over time under a PW schedule, and the different annuity offers received from insurance companies, ordered from highest to lowest.\(^{22}\) This represents

\(^{21}\) The Spanish SCOMP stands for System of Consultations and Offers of Pension Amounts.

\(^{22}\) A table comparing annuities and PW states that attributes of an annuity are: (i) lifetime pension constant in real terms, (ii) irrevocable contract, (iii) covers investment and longevity risks and (iv) allows for special coverage conditions. The stated attributes for a pension under PW are the following: (i) the
a significant change with respect to the previous period, where each worker was responsible to get his own quotes from insurance companies and where the main source of information were insurance company salespeople, whose remuneration depended on the worker choosing some form of annuity. In other words, we would expect that in the pre-SCOMP period, with less (objective) information available, workers’ choice of pension product would be less related to the (unobserved) longevity prospects and therefore the estimated annuity effect should be smaller for this period.

The next table presents the same type of estimates as the previous summary, but restricted to individuals who retired after the introduction of SCOMP. We can see now that the positive relationship is now present in the three samples, with a higher effect among women. The other coefficients have the same signs as before and are similar in magnitude.

Table 3 – Average marginal effects on median duration
Retirees aged 40-70, between 2005 and 2014 (post SCOMP)

<table>
<thead>
<tr>
<th>Sample</th>
<th>ALL</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annuity dummy (0 if PW)</td>
<td>2.416***</td>
<td>5.152***</td>
<td>1.881***</td>
</tr>
<tr>
<td></td>
<td>(0.317)</td>
<td>(1.275)</td>
<td>(0.317)</td>
</tr>
<tr>
<td>Female dummy</td>
<td>8.566***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.677)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of birth</td>
<td>0.492***</td>
<td>1.112***</td>
<td>0.374***</td>
</tr>
<tr>
<td></td>
<td>(0.0930)</td>
<td>(0.366)</td>
<td>(0.0922)</td>
</tr>
<tr>
<td>Retirement age</td>
<td>0.345***</td>
<td>0.719***</td>
<td>0.279***</td>
</tr>
<tr>
<td></td>
<td>(0.0622)</td>
<td>(0.209)</td>
<td>(0.0652)</td>
</tr>
<tr>
<td>Gamma coefficient (( \gamma ))</td>
<td>0.0821</td>
<td>0.0632</td>
<td>0.0869</td>
</tr>
<tr>
<td>Number of observations</td>
<td>215,560</td>
<td>80,899</td>
<td>134,661</td>
</tr>
</tbody>
</table>

Source: own calculations.
Standard errors in parenthesis (** p<0.01, * p<0.1)

Another element to be considered in the analysis is whether workers are retiring before or after the normal retirement age (60 for women and 65 for men). As mentioned...
earlier, the eligibility requirements for early retirement tend to favor individuals with higher income and more stable formal labor attachment. As the available data does not have a measure of income or socioeconomic level, it is potentially important to separate between early and normal retirement.

The following table presents the same post-SCOMP results, but distinguishing between early and normal retirement. We can see that the previous effects disappear for workers under early retirement but are still positive and significant for individuals retiring on or after the legal retirement age. One interpretation of this result is that workers eligible for early retirement (usually of higher balance) are often targeted by sales representative (even in the post SCOMP period, as representatives can still receive a commission if they act as point of entry into the SCOMP), who tend to emphasize the positive attributes of annuities.2324

23 A reform passed in 2008 replaced the figure of the insurance salesperson by that of a pension advisor, which could receive a payment even if the worker chose a PW schedule. The maximum commission in this cases is still smaller than the maximum commission if the worker favors an annuity.
24 The effect of sales representative on the choice of pension product has already been documented in Ruiz (2014).
Table 4 – Average marginal effects on median duration by early or normal retirement

Retirees aged 40-70, between 2005 and 2014 (post SCOMP)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Early retirement</th>
<th>Normal retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALL</td>
<td>Women</td>
</tr>
<tr>
<td>Annuity dummy (0 if PW)</td>
<td>0.756</td>
<td>2.889</td>
</tr>
<tr>
<td></td>
<td>(0.510)</td>
<td>(3.453)</td>
</tr>
<tr>
<td>Female dummy</td>
<td>8.422***</td>
<td>(1.408)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of birth</td>
<td>0.477***</td>
<td>0.784</td>
</tr>
<tr>
<td></td>
<td>(0.161)</td>
<td>(1.057)</td>
</tr>
<tr>
<td>Retirement age</td>
<td>0.297**</td>
<td>0.295</td>
</tr>
<tr>
<td></td>
<td>(0.116)</td>
<td>(0.730)</td>
</tr>
<tr>
<td>Gamma coefficient (𝛄)</td>
<td>0.0814</td>
<td>0.0624</td>
</tr>
<tr>
<td>Number of observations</td>
<td>69,733</td>
<td>8,284</td>
</tr>
</tbody>
</table>

Source: own calculations.
Standard errors in parenthesis (** p<0.01, * p<0.1)

4.2.- Instrumental Variables results

The following table presents results from the estimation based on the instrumental variable approach, for the entire population of post SCOMP retirees and for the subsample of individuals who retired on or after the normal retirement age.\textsuperscript{25}

We can see that, even if the coefficients are all positive and of similar magnitude to the previous ones, none of the coefficients is significant at 90% confidence. This could reflect that the annuity choice has no causal effect on longevity (which, if present, could be reflect a moral hazard effect of individuals changing their lifestyle habits as a result of purchasing an insurance product).

\textsuperscript{25} The first stage results (presented in appendix) show that the instrument (the log difference in the interest rates) is a strong predictor of the probability of choosing an annuity.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Early and normal retirement</th>
<th>Normal retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALL</td>
<td>Women</td>
</tr>
<tr>
<td>Annuity dummy (0 if PW)</td>
<td>3.712</td>
<td>9.385</td>
</tr>
<tr>
<td>Female dummy</td>
<td>8.479***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.732)</td>
<td></td>
</tr>
<tr>
<td>Year of birth</td>
<td>0.502***</td>
<td>1.091***</td>
</tr>
<tr>
<td></td>
<td>(0.0994)</td>
<td>(0.364)</td>
</tr>
<tr>
<td>Retirement age</td>
<td>0.356***</td>
<td>0.668***</td>
</tr>
<tr>
<td></td>
<td>(0.0726)</td>
<td>(0.231)</td>
</tr>
<tr>
<td>First stage residual</td>
<td>-1.298</td>
<td>-4.255</td>
</tr>
<tr>
<td>Gamma coefficient ($\gamma$)</td>
<td>0.0821</td>
<td>0.0632</td>
</tr>
<tr>
<td>Number of observations</td>
<td>215,560</td>
<td>80,899</td>
</tr>
</tbody>
</table>

Source: own calculations.
Standard errors in parenthesis (*** p<0.01, ** p<0.05, * p<0.1)

5. CONCLUSIONS

The presence of asymmetric information may prevent the efficient working of some markets. Insurance markets in general have been long recognized as being affected both by ex-ante information problems –adverse selection– and ex-post information issues –moral hazard–. In the case of annuities, moral hazard is not particularly relevant as it is not expected that after choosing to sign for an annuity a person would modify her behavior and affect her expected longevity. However, adverse selection can be present as the insuree may well have better information than the insurance company about her expected longevity (e.g., about her health status or her genetics).

Adverse selection is indeed frequently mentioned as one plausible explanation for the underdevelopment of annuity markets. A few papers focused in the UK market find evidence of the presence of adverse selection, but its magnitude measured as the
efficiency loss it produces is relatively small (around 2% of the annuitized wealth). This evidence, however, is related to the choice of a particular contract within a group that chooses to voluntarily buy annuities or within a group that must annuitize part of his pension savings.

Arguably, in Chile the stakes are larger as all retirees that reach a minimum pension wealth must choose between an annuity or a programmed withdrawal scheme. Previous literature, based on a sample of around 500 retirees and studying the pension choice decision found mild evidence of adverse selection (e.g., healthier individuals are more likely to choose annuities).

We estimated a duration model with the universe of retirees eligible to choose between an annuity and a PW schedule. When working with the full sample we find evidence of adverse selection among women. Interestingly, when we restrict the analysis to retirees after the introduction of the SCOMP system, that presumably increased the degree of transparency and competition, we find consistent and significant evidence of adverse selection among men and women. In the case of normal age retirees (60 for women and 65 for men), life expectancy for annuitant women is 5.2 year longer than for non-annuitants. In the case of men, this figure is 2.5 years.

We estimated models based on a novel instrumental variable approach, which allows us to abstract from unobserved determinants of longevity that could be correlated with the annuitization choice. The results suggest that the relationship between annuities and longevity is not causal in nature (as the instrumental variables estimates are not significant) but would rather be consistent with the adverse selection explanation.
**Appendix – first stage results of instrumental variable estimator**

Dependent variable = Annuity Dummy

Retirees aged 40-70, between 2005 and 2014 (post SCOMP)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Early and normal retirement</th>
<th>Normal retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALL</td>
<td>Women</td>
</tr>
<tr>
<td>Interest rate log difference</td>
<td>-0.287*** (0.0101)</td>
<td>-0.422*** (0.0160)</td>
</tr>
<tr>
<td>Female dummy</td>
<td>0.0638*** (0.00214)</td>
<td></td>
</tr>
<tr>
<td>Year of birth</td>
<td>-0.00581*** (0.000407)</td>
<td>0.00750*** (0.000634)</td>
</tr>
<tr>
<td>Retirement age</td>
<td>-0.00745*** (0.000420)</td>
<td>0.0139*** (0.000805)</td>
</tr>
<tr>
<td>First stage residual</td>
<td>12.47*** (0.813)</td>
<td>-0.422***</td>
</tr>
<tr>
<td>Observations</td>
<td>215,560</td>
<td>80,899</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.010</td>
<td>0.011</td>
</tr>
</tbody>
</table>

Source: own calculations.

Standard errors in parenthesis (*** p<0.01, ** p<0.05, * p<0.1)
REFERENCES

Abel, Andrew B. “Capital Accumulation and Uncertain Lifetimes with Adverse Selection.”


