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How much for a lifetime? Pricing annuities under heterogeneity and risk

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How much for a lifetime? Pricing annuities under heterogeneity and risk

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Abstract

This paper studies how life insurance companies price annuity products in the Chilean pension market. Using detailed administrative data that contains all formal offers made to retirees for various annuity contracts, I examine whether insurers adjust prices based on observable individual characteristics, such as gender, marital status, and income, and whether pricing patterns are consistent with adverse selection or prudent risk management. In particular, I assess whether back-loaded annuities systematically exhibit different money's worth ratios (MWRs). Additionally, I examine whether pricing reflects cohort-specific mortality risk. I also investigate how insurers adjust prices in response to exogenous shifts in survival probabilities, exploiting the inclusion of diseases in Chile's AUGE health reform as a plausibly exogenous shock to cohort life expectancy. My findings contribute to a better understanding of how regulated annuity providers incorporate both individual risk factors and systemic longevity risk into pricing decisions.

Keywords: Annuity markets, Risk-based pricing, Adverse selection, Mortality heterogeneity, Retirement behavior

JEL: G14, G22, L11

1. Introduction

Pension firms set annuity prices by balancing risk factors, market structure, and regulatory constraints. In the United States, Verani & Yu (2020) report that managing interest rate risk under regulatory capital rules leads to higher markups, while Warshawsky (1988) shows that lower market yields and transaction costs elevate load factors. In the United Kingdom, Finkelstein & Poterba (1999) and Cannon & Tonks (2010) describe how voluntary markets suffer from adverse selection and yield higher markups, contrasting with findings by Poterba (2005) that compulsory annuitization can lower selection costs.

European analysis (Nirmalendran et al., 2012) demonstrates that higher solvency targets under frameworks maximize firm value. In Chile, Illanes & Padi (2019) illustrate that competitive, voluntary settings with supportive policies achieve low markups and greater market stability. Across studies, pricing adjustments commonly stem from measures such as money's worth ratios, simulations, and contingent-claim models to account for interest rates, mortality uncertainty, asset returns, and regulatory influences.

Given the richness of the Chilean annuity market—characterized by its competitive structure, centralized quote system (SCOMP), and availability of detailed offer-level data—this study aims to understand how pension insurance companies determine annuity prices in practice. In particular, it examines whether insurers systematically tailor their offers in response to observable characteristics of retirees, product choices, and contextual risk factors. The analysis examines whether prices vary according to gender or marital status, and whether income levels influence the annuity terms retirees receive. It also investigates potential evidence of adverse selection in the pricing of back-loaded annuity products, which defer higher payouts to later stages of retirement. Furthermore, the study examines whether firms differentiate their pricing strategies across retirement cohorts—for example, between individuals retiring at earlier versus later ages. Ultimately, it examines how insurers respond to policy changes or macro-level events that may impact longevity expectations, survival probabilities, market returns, or retiree preferences.

Each of these questions is motivated by existing theoretical and empirical literature, but the Chilean setting allows for a highly granular empirical evaluation of these mechanisms. The remainder of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on annuities, focusing on how insurers incorporate retiree characteristics and risk into pricing. Section 3 provides an overview of the Chilean annuity market, describing its institutional design, the functioning of the centralized quote system (SCOMP), and the structure of the dataset, while also presenting descriptive statistics and detailing the range of annuity products available. Section 4 introduces the methodology for computing the Money's Worth Ratio (MWR), which serves as the main metric to evaluate the generosity of offers. Building on this, Section 5 examines whether insurers adjust prices based on gender, marital status and income. Section 6 explores the presence of adverse selection, particularly in the pricing of back-loaded products, while Section 7 evaluates how insurers respond to external shocks that may affect survival probabilities and longevity expectations. Section 8 examines firms' responsiveness to retiree preferences and market conditions. Finally, Section 9 concludes with a discussion of the main findings and their implications for annuity pricing.

2. Pricing in Annuity Markets: Theory and Empirical Evidence

Pricing in annuity markets reflects underlying differences in life expectancy across demographic and behavioral groups. A growing body of evidence shows that mortality rates vary systematically with observable characteristics such as gender, marital status, occupation, religion, ethnicity, retirement age, obesity, and health-related behaviors. These mortality gradients imply that different groups face different expected durations of annuity payments, creating incentives for insurers to adjust prices accordingly.

For instance, regarding age, there is substantial evidence showing that mortality increases with age (Horiuchi & Wilmoth, 1998; Brown, 1997). There is also literature indicating that this pattern differs across groups. The evidence suggests that gender gaps in mortality are smaller at younger ages but widen significantly in older age groups (Trovato & Lalu, 1998). Additionally, there is evidence of differences in mortality by socioeconomic status across age groups. Specifically, Williams & Collins (1996) found that mortality differences between socioeconomic groups are larger during middle age but tend to decrease among older individuals. In sum, while mortality generally increases with age, the rate and shape of this increase vary significantly across different population groups.

In addition, several studies have documented significant gender differences in mortality, consistently finding that women tend to have higher life expectancy than men (Trovato & Lalu, 1998; Vallin, 1995; Deaton & Paxson, 1999; Lantz et al., 1998; Hurd et al., 1999). However, the underlying causes of this gap have been widely debated. Vallin (1995) argues that part of the difference may be attributed to the distinct social roles traditionally held by men and women. Moreover, other authors have found that gender-based mortality differences interact with additional factors such as income and education (Deaton & Paxson, 1999; Lantz et al., 1998; Hurd et al., 1999). Some results suggest that income has a positive effect on mortality for young men, whereas the effect is negative for young women. Behavioral differences have also been proposed as a key explanation. For instance, women are generally higher consumers of health services and may have benefited earlier from medical advances compared to men (Vallin, 1995).

Additionally, different authors have found significant differences in mortality based on marital status. Specifically, married individuals tend to exhibit lower mortality rates than those who are not married (Rogers, 1995; Hurd et al., 2001; Brown & Di Meo, 1995). As in the previously mentioned cases, some studies have shown that this pattern varies across different groups. In particular, there is evidence that men benefit more from marriage than women (Kallan, 1997; Rogers, 1995). Rogers (1995) suggests that women may experience greater psychological constraints within marriage, which could mitigate its protective effect. Additionally, other findings indicate that the relationship between marriage and mortality also varies by age (Kallan, 1997). Specifically, Kallan (1997) found that the association between being married and lower mortality is strongest among younger individuals.

Furthermore, there is evidence that individuals with higher levels of obesity tend to have lower life expectancy. For example, studies have found that obesity is associated with significantly higher risks of cardiovascular and all-cause mortality (Allison et al., 1999; Wei et al., 1999). Also, regarding other health-related behaviors such as smoking, there is evidence that it has a significant positive impact on mortality (Kennedy et al., 1996).

In response to these mortality differentials, insurers often engage in risk-based pricing based on observable characteristics such as gender, marital status, and retirement age. Since firms do not have access to other relevant factors, like alcohol consumption, health behaviors, or family medical history, they rely on the limited information available. As a result, they tend to offer lower annuity payouts to individuals expected to live longer, thereby reducing the present value of future liabilities (Mitchell et al., 1999; Fong, 2015). For instance, Mitchell et al. (1999) used data for annuities in the United States in 1985, 1990, and 1995, and found that because women have a higher life expectancy than men, they received on average 10 percent less of the value of the MWR (controlling by age and income). In addition, they also found that a couple that buys a joint and survivor annuity received on average 18 percent less than a single man (controlling by age). Fong (2015) analyzed the same market but between 2011 and 2014. Fong (2015) examines different MWRs for different groups of people, for example, comparing the MWR of a woman of 65 years old for different combinations of education and marital status. The results of the paper show that, among individuals of the same age, men received a payout of 10.898 dollars annually, while women received 9.492 dollars annually for the same quantity of money invested. This represents a difference of approximately 12.9% in favor of men.

While insurers often adjust prices based on observable characteristics that correlate with mortality, such as age, gender, or marital status, individuals also hold private information about their own mortality risk, and this information is not accessible to firms. For example, personal health conditions, family medical history, or lifestyle choices may be known only to the individual. As a result, people with longer expected life spans are more likely to purchase annuities or choose contracts with higher long-term value. This phenomenon is known as *adverse selection*, and it plays a central role in shaping both the structure of annuity markets and the design of products offered by insurers.

For that, insurers use product design to price differentiate and screen risk types in the presence of asymmetric information. Offering front-loaded versus back-loaded annuities allows for self-selection: individuals who expect to live longer may choose contracts with larger payments in later life, while less healthy individuals may prefer immediate higher payments (Finkelstein & Poterba, 2002).

However, recent work suggests that the observed pricing patterns may also arise from cohort mortality risk faced by insurers, especially for products with long-dated liabilities like back-loaded annuities (Cannon & Tonks, 2016). Because these products concentrate payments further into the future, they are more exposed to uncertainty about future mortality improvements and thus require greater reserves.

In sum, while actuarial principles are key to annuity pricing, insurers make decisions in a more complex setting. They must deal with asymmetric information, regulations, uncertainty about how long people will live, and market competition. As a result, prices are not based only on expected mortality, but also reflect how firms manage risk and design products to appeal to different types of customers. These factors are essential to understand how pricing works in annuity markets.

3. The Chilean Annuity Market

The theoretical and empirical literature highlights how annuity pricing reflects both actuarial fundamentals and strategic firm behavior. However, in many countries, data limitations and institutional constraints make it difficult to observe how insurers set prices in practice. In this context, the Chilean pension system offers a particularly valuable setting for studying firm-level pricing behavior. Chile combines a mandatory defined-contribution system with a centralized annuity quote platform that records all formal offers made by insurers to each retiree. This setup provides detailed, individual-level data on the timing, structure, and terms of each annuity offer, allowing researchers to observe how firms adjust prices based on retiree characteristics, regulatory constraints, and competitive dynamics.

Pension Fund Administrators (*Administradoras de Fondos de Pensiones*, i.e. AFPs) are private institutions responsible for managing workers' retirement savings. During their working life, individuals contribute to these funds, which are invested in diversified portfolios. Upon retirement, they must choose between two main modalities: programmed withdrawal (PW) and life annuity, each with different implications for risk-sharing, inheritance, and payout structure.

Since 2004, retirees can access the SCOMP system (*Sistema de Consultas y Ofertas de Montos de Pensión*), a centralized platform designed to increase transparency in the annuitization process. SCOMP collects and distributes formal pension offers issued by insurance companies and AFPs, allowing retirees to compare multiple options. This system not only improves consumer decision-making, but also generates an invaluable dataset for analyzing how firms compete and differentiate their offers across individuals.

Programmed withdrawal pensions are recalculated annually and are offered solely by the AFP with which the retiree is affiliated. In contrast, life annuities are sold in a competitive market by licensed insurance companies. These products are denominated in *Unidades de Fomento* (UF), an inflation-indexed currency, and offer fixed monthly payments for life. By choosing an annuity, the retiree transfers longevity and interest rate risk to the insurer.

A key point is that, annuity products in Chile are not uniform. Retirees can choose from several variants, including immediate annuities, deferred annuities, and hybrid products such as immediate annuities with programmed withdrawal. Each product entails different risk profiles and payout timing, allowing for self-selection based on expectations, preferences, and individual circumstances. Furthermore, annuitants can include guaranteed payment periods, which transfer remaining payments to beneficiaries if death occurs within a specified time.

Chile's legal framework also allows for early retirement, contingent on the projected pension reaching a threshold tied to the *Pensión Máxima con Aporte Solidario* (PMAS). This introduces additional heterogeneity in the timing of retirement and the nature of the annuity offers individuals receive.

Taken together, these features make the Chilean market an ideal environment to investigate the core question of this study: how do insurance companies set annuity prices, and what individual characteristics or regulatory constraints influence those pricing strategies? The availability of detailed quote-level data enables an empirical exploration of price differentiation, risk adjustment, and selection behavior in a real-world setting.

4. MWR calculations and data description

In this paper, one of the most important steps is the calculation of the MWR. To do that, I use official mortality tables published by the Chilean *Superintendencia de Pensiones* and the *Comisión para el Mercado Financiero*. Unlike previous studies that rely on a single mortality table, this analysis employs a dynamic approach by matching individuals to different mortality tables depending on their retirement cohort. Specifically, the following tables are applied: the RV-2004 tables for individuals who retired between 2004 and June 2010, the RV-2009 tables for those who retired between July 2010 and June 2016, and the RV-2014 tables for those retiring from July 2016 onward. For example, a retiree who began receiving pension payments in 2020 is assigned the RV-2014 table. These tables provide age and sex-specific mortality probabilities, along with official improvement factors that allow for the construction of cohort-specific survival paths.

The MWR is calculated as the ratio between the expected present discounted value (EPDV) of annuity payments and the premium transferred to the insurance company. The EPDV includes the stream of monthly pension payments indexed in *Unidades de Fomento* (UF) and the funeral allowance (*cuota mortuoria*) paid upon death. All future payments are discounted using the average implicit interest rates published monthly by the *Superintendencia de Valores y Seguros* (SVS), based on actual annuity sales and weighted by premium size, ensuring that the discount factor reflects prevailing market conditions.

The methodology accounts for different annuity product structures. For immediate annuities without a guaranteed period, the present value is computed using the survival probabilities conditional on the retiree's characteristics, and payments are weighted accordingly. In the case of immediate annuities with a guaranteed period, all payments within the guaranteed phase are included in full (i.e., with weight one), regardless of the retiree's survival status, while payments beyond the guaranteed period are weighted by the individual's survival probabilities. This reflects the contractual feature that ensures payments during the guaranteed phase are made even if the retiree dies.

For deferred annuities, which begin after a deferral period (e.g., 1, 2, or 3 years after retirement), the EPDV calculation excludes any pension income during the deferral phase. The present value is calculated only for the annuity stream that starts after the deferral ends, again weighted by the probability of surviving to that point. In these cases, the survival probability from the retirement date to the beginning of the payment stream is also incorporated, ensuring that only retirees who are expected to survive to the deferral threshold are included in the valuation of future payments.

This comprehensive approach to EPDV calculation, which adjusts for survival probabilities, guarantee provisions, and deferral structures, allows for more accurate estimation of annuity generosity across heterogeneous products and cohorts. As a result, the MWRs reported in this study reflect realistic conditions faced by retirees and allow for meaningful comparison across firms and annuity designs.

Regarding the data description, I use individual-level data on annuity and programmed withdrawal offers in Chile between May 2007 and October 2023. The dataset includes a total of 450,231 individuals who accepted an offer, either an annuity or a programmed withdrawal.

The proportion of individuals choosing annuities has varied over time. Figure 1 shows the evolution of the percentage of individuals who selected an annuity (immediate or deferred) between May 2007 and October 2023. Notably, around the beginning of 2020, this percentage experienced a decline, followed by an increase approximately one year later.

Figure 2 displays the number of individuals who accepted immediate annuities, deferred annuities, and programmed withdrawals. In addition to the overall decline observed in Figure 1, Figure 2 shows that there was a significant drop in the number of deferred annuities in 2020.

Figure 1:Monthly Evolution of the Percentage of Annuities in Chile

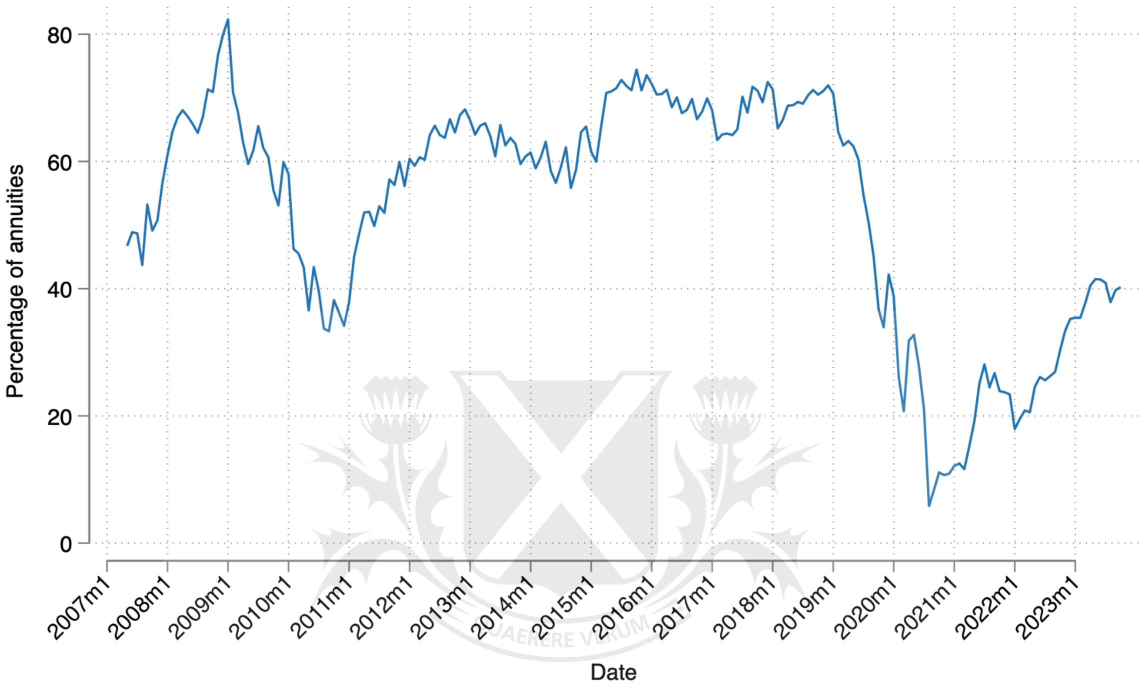
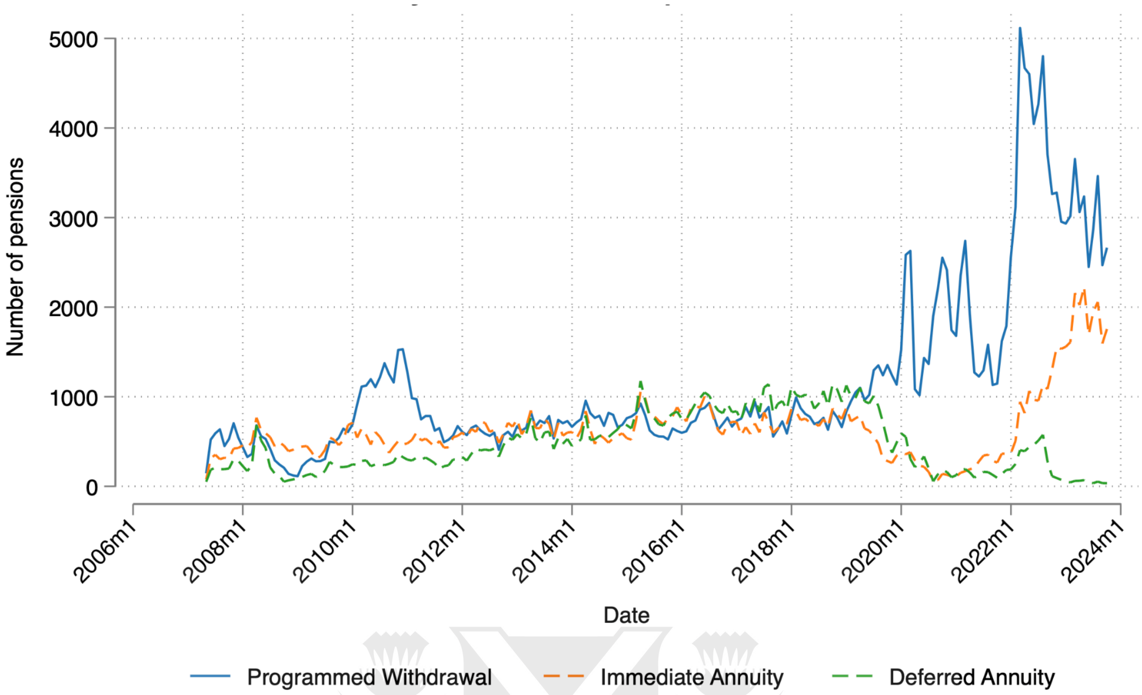


Figure 2: Monthly Evolution of the Total Pension Amount in Chile, by Type of Pension



An additional feature that makes the Chilean data particularly valuable is that it includes all the annuity offers each individual receives. On average, each person receives around 100 annuity offers, and each firm makes, on average, 11 offers per person. Furthermore, the average number of active firms per year is approximately 12.

In addition, with respect to the annuity products available for selection, there are 16 main combinations of deferred years and guaranteed periods (Table 1).

Table 1: Types of Pension Products in the Chilean System

Product	Deferred years	Guaranteed months
1	0	0
2	0	120
3	0	180
4	0	240
5	1	0
6	1	120

7	1	180
8	1	240
9	2	0
10	2	120
11	2	180
12	2	240
13	3	0
14	3	120
15	3	180
16	3	240

Over time, the most frequently chosen annuity products have changed. Table 2 presents the most selected products for each year. Although there are some year-to-year variations, annuities with 120 guaranteed months and 0 deferred years, as well as those with 180 guaranteed months and 0 deferred years, have consistently been the most popular options throughout the period.

Table 2: Most Selected Pension Product by Year

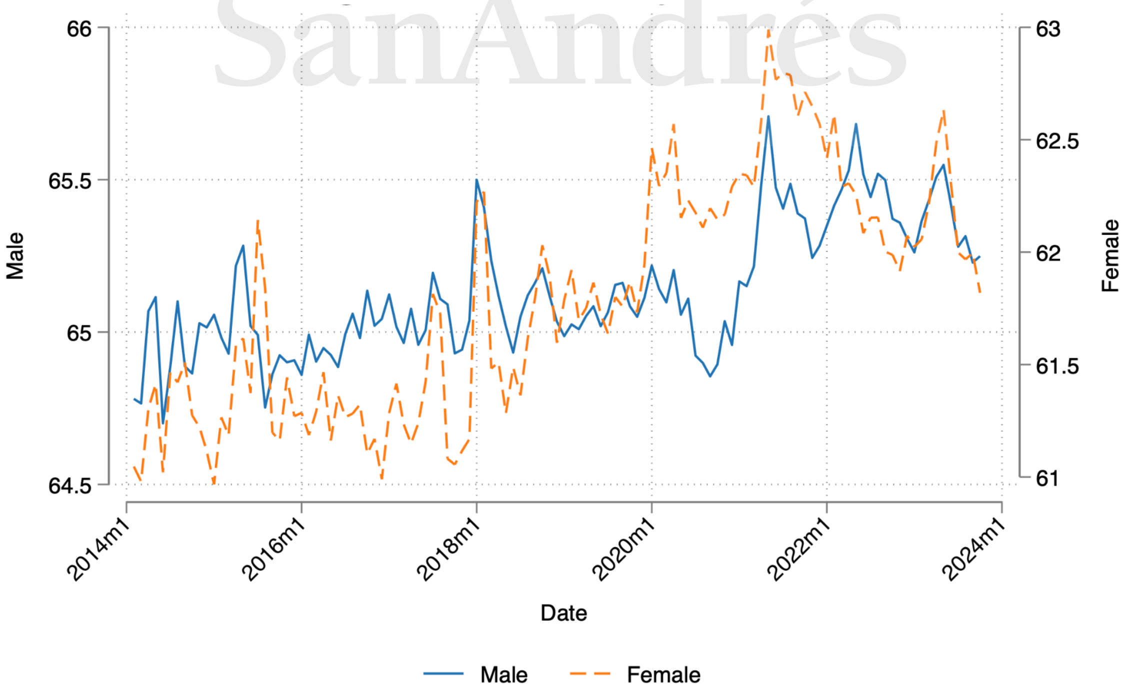
Year	Pension Product
2007	120 guaranteed months, 0 deferred years
2008	180 guaranteed months, 0 deferred years
2009	180 guaranteed months, 0 deferred years
2010	180 guaranteed months, 0 deferred years
2011	0 guaranteed months, 0 deferred years
2012	180 guaranteed months, 0 deferred years
2013	180 guaranteed months, 0 deferred years
2014	120 guaranteed months, 0 deferred years
2015	120 guaranteed months, 0 deferred years
2016	120 guaranteed months, 0 deferred years

2017	120 guaranteed months, 0 deferred years
2018	0 guaranteed months, 0 deferred years
2019	180 guaranteed months, 2 deferred years
2020	0 guaranteed months, 0 deferred years
2021	240 guaranteed months, 0 deferred years
2022	0 guaranteed months, 0 deferred years
2023	120 guaranteed months, 0 deferred years

Another interesting aspect of the retirement data is the timing of individuals' retirement decisions and the differences between men and women. On average, retirees choose to retire at around 63 years of age, although this varies across years. For instance, until the onset of the COVID-19 pandemic, the average retirement age was following an upward trend. However, after the pandemic began, this trend reversed, and the average retirement age started to decline.

It is also important to examine retirement age differences by gender. On average, women retire at age 62, while men retire at age 65 (Figure 3).

Figure 3: Age of Retirement by Gender



These descriptive patterns provide valuable insights into retirement behavior and product selection in the Chilean annuities market. In summary, to conduct the analysis and address the main research questions of this paper, I use a dataset that includes all annuity and programmed withdrawal offers made to individuals in Chile between May 2007 and October 2023. For some parts of the analysis, I focus exclusively on annuity offers. However, to examine the impact of COVID-19 as a shock to life expectancy, I also include information on the acceptance of programmed withdrawal offers.

5. Do Firms Adjust Prices Based on Gender, Marital Status, or Income?

Gender and marital status are among the most salient demographic factors associated with differential longevity expectations. Empirical and actuarial studies consistently show that, on average, women live longer than men, and married people live more than single people, which implies a longer stream of annuity payments for female retirees and for married people. Consequently, women and married people typically receive lower monthly annuity payouts for a given premium.

In the Chilean annuity market, where pricing is personalized and quote-level data are available, it becomes possible to test whether firms systematically incorporate gender into their pricing offers. Given that annuity contracts are indexed to inflation and offer lifelong income, even small differences in expected duration can have significant implications for the present value of payouts.

In this section, I explore whether annuity providers in Chile adjust pricing offers on the basis of gender and marital status. The availability of detailed, individual-level data from the SCOMP system allows us to compare the MWR of nearly identical products across individuals who are observationally similar in key dimensions, such as sex, age, marital status, cohort, and the total amount of funds available for retirement.

This level of granularity enables us to isolate pricing differentials that are not explained by observable characteristics. To formally examine these questions, the main model used is:

$$MWR_{icpf} = \beta_1 Female_i + \beta_2 Married_i + \beta_3 Age_i + \sum_{q=1}^{5} \lambda_q BalanceQuintile_i + \zeta_c + \gamma_p + \delta_f + \varepsilon_{ipf} \quad (1)$$

where $Female_i$ is a dummy variable that takes value 1 if the retiree is a woman and 0 otherwise; $Married_i$ is a dummy variable that takes value 1 if the retiree is married and 0 otherwise; Age_i is age in years; $BalanceQuintile_i$ is a set of dummies that reflects the quintile of the savings balance before retirement; ζ_c are fixed effects at the cohort-level (month - year); γ_p are fixed effects at the product level; δ_f are firm fixed-effects.

Table 3

	(1)	(2)	(3)	(4)
	MWR			
Female	-0.000544	-0.00530***	-0.00326***	-0.00422**
	(0.000898)	(0.00158)	(0.000682)	(0.00154)
Married	-0.00245***	-0.00372***	0.00276***	-0.00500**
	(0.000797)	(0.000950)	(0.000660)	(0.00174)
Age	0.000900***	0.000185**	-0.000412***	0.000614***
	(0.000188)	(6.81e-05)	(7.13e-05)	(0.000196)
Quintile 2	0.00559***	-0.00277***	0.00966***	0.00962***
	(0.00162)	(0.000675)	(0.000528)	(0.000875)
Quintile 3	0.00839***	-0.00104	0.0125***	0.0150***
	(0.00224)	(0.000833)	(0.001000)	(0.00175)
Quintile 4	0.00845***	-0.00223	0.0115***	0.0117***
	(0.00243)	(0.00138)	(0.00168)	(0.00303)
Quintiel 5	0.00808**	-0.00839**	0.00186	0.0158***
	(0.00283)	(0.00337)	(0.00333)	(0.00441)
FE Cohort	Yes	Yes	Yes	Yes
FE Product	Yes	Yes	Yes	Yes
FE Firm	Yes	No	No	No
Firm	All	Firm 1	Firm 2	Firm 6
Observations	43,910,920	2,478,025	3,921,206	4,105,705
R-squared	0.381	0.539	0.454	0.451

Note: clustered standard errors at the firm level in parenthesis for column (1), and at the product level for columns (2), (3), and (4). *** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the results. There is no evidence to suggest that firms adjust for differences in survival expectancy based on gender. The MWR between identical products (same number of guaranteed years and deferred years), offered to individuals of the same age, cohort, marital status, savings quantile, and from the same firm, does not exhibit significant differences by sex.

It is important to note that, in this case, the expected result was a difference in MWR by sex, given the existing evidence that women live longer than men. Moreover, it is crucial to emphasize that the results found in this regression are valid only under the assumption that the only way MWR could differ by sex (after controlling for product and individual characteristics) is if firms intentionally adjust pricing to account for women's higher life expectancy.

Now, regarding the differences by marital status, the results are as expected. The regression shows that firms offer more generous annuity terms to single individuals. This finding is consistent with the assumption that the only channel through which such a difference could arise, after controlling for product and individual characteristics, is that married individuals tend to live longer than those who are single.

I also estimated three additional specifications focusing on the three firms with the highest volume of annuity contracts granted between 2007 and 2023 (Table 3). This allows for an examination of whether firms differ in how they adjust for sex and marital status. The results show that all three firms account for both sex and marital status in their pricing, suggesting a consistent pattern of adjustment across the main players in the market.

While gender and age are explicit inputs in the actuarial pricing of annuities, income is not directly observable by insurers in most markets. However, firms may use proxies, such as the size of the pension fund, the type of annuity chosen, or patterns of early versus late retirement, to infer income levels and adjust offers accordingly.

In the Chilean context, retirees' account balances vary significantly, and since annuity offers are individualized and formally recorded in the SCOMP system, it is possible to empirically test whether firms offer different terms to retirees with larger funds, holding constant other characteristics such as age, gender, and product type. If firms do adjust prices based on inferred income levels, this could suggest price discrimination or strategic segmentation, which may have implications for both efficiency and equity in retirement outcomes.

Moreover, differences in pricing by income proxies could reflect broader concerns about access to high-quality financial products, especially if individuals with smaller pension balances systematically receive worse terms. Identifying such patterns is crucial for understanding whether competitive dynamics in the Chilean annuity market reinforce or mitigate existing income inequalities at retirement. To formally examine these questions, the main model used is (1).

Table 3 presents the results. On average, firms offer higher MWRs to individuals in income quintiles 2 through 5 compared to those in the lowest quintile. However, this pattern does not hold uniformly across firms. For instance, Firm 1 offers lower MWRs to individuals in higher income quintiles. This is consistent with the idea that individuals with higher incomes tend to have longer life expectancies, which may lead insurers to offer less favorable terms. In sum, the relationship between income and MWR varies across firms, indicating heterogeneous pricing strategies.

6. Adverse Selection, Back-loaded Products, and Cohort Risk

One way to detect potential adverse selection in annuity markets is to examine whether different product designs receive systematically different prices. In particular, back-loaded annuity products, such as those with long guaranteed payment periods or deferred structures, could attract individuals who expect to live longer than average, making them a likely channel through which selection operates. If insurers anticipate this, they may adjust prices accordingly, either offering lower MWRs for such products or embedding protective mechanisms into their pricing.

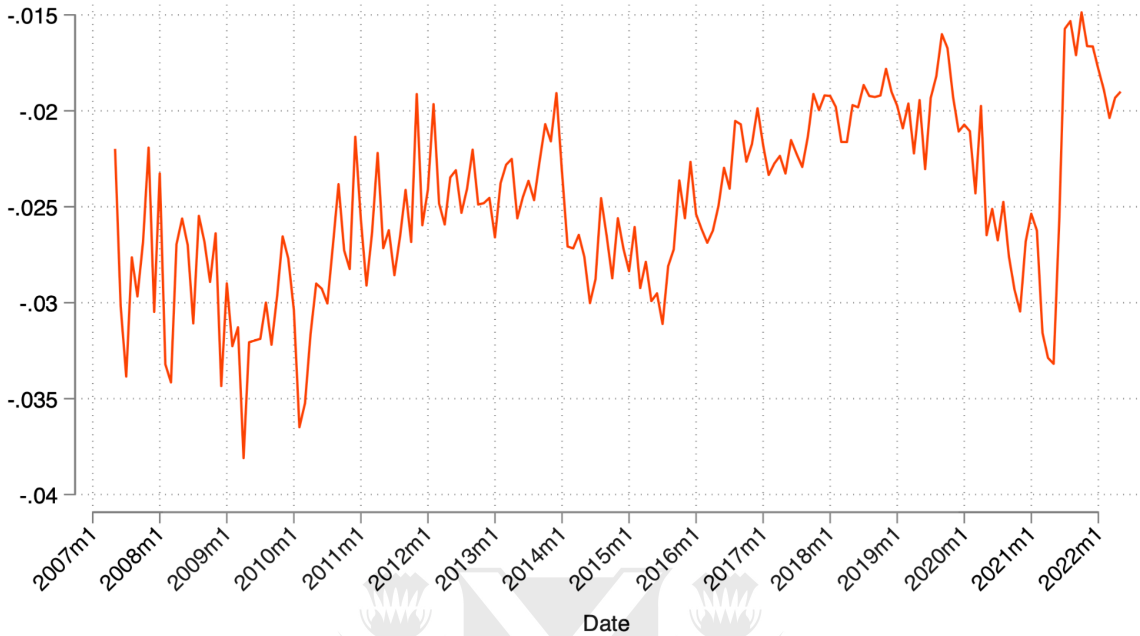
Evidence from the UK annuity market (Cannon and Tonks, 2016) shows that products with heavier back loading, where a higher share of payouts is scheduled for later in life, consistently received lower MWRs than more front-loaded alternatives. While this pattern has been interpreted as the result of an adverse selection separating equilibrium, where long-lived individuals choose back-loaded contracts (Finkelstein & Poterba, 2002), the same empirical outcome can also emerge from insurers' prudent behavior under cohort mortality risk. Back-loaded products are inherently more exposed to uncertainty in future survival trends and interest rate movements. Because insurers must reserve more capital against long-dated liabilities, these contracts are more expensive to offer, even in the absence of selection effects.

In the case of the Chilean market, Fajnzylber et al. (2023) found direct evidence of adverse selection. They used mortality data, available for a subset of the population in Chile, to train a mortality model. Using the predicted life expectancy, they then examined whether individuals with longer expected lifespans were more likely to choose annuities over programmed withdrawals. It is important to note that these products differ in structure: programmed withdrawals tend to be more front loaded, while annuities concentrate a larger share of payments in the later stages of retirement. Fajnzylber et al. (2023) effectively found that individuals with higher life expectancy tend to choose annuities rather than programmed withdrawals.

Therefore, in light of the work by Cannon and Tonks (2016), the presence of adverse selection could generate differences in the money's worth ratio (MWR) across products. However, a similar pattern of differences could also result from how insurers manage cohort mortality risk. For this reason, I seek to evaluate whether there are systematic differences in the MWR between products that are more back-loaded and those that are more front-loaded, understanding that such differences could arise from either of the two mechanisms mentioned above. To distinguish between front-loaded and back-loaded products, I use the number of guaranteed payment periods as a proxy, following the approach of Cannon and Tonks (2016).

To implement this analysis, I select all single males who retired at the age of 65 and received offers for an immediate annuity, as well as for annuities with guaranteed periods of 120, 180, and 240 months. I then calculate the MWR for each type of offer (0, 120, 180, and 240 guaranteed months). Next, I compute the difference between the MWR of each annuity with a positive guaranteed period and that of the immediate annuity (with 0 guaranteed months), focusing on single males aged 65 in the third savings quintile (Q3). Figure 4 presents the results.

Figure 4: Difference in MWR Between Annuities With and Without Guaranteed Payments - Q3



Initially, there do not appear to be significant differences indicating price adjustments due to adverse selection or cohort mortality risk (Figure 4). The observed MWR differences are very close to zero, suggesting that more front-loaded products (those with longer guaranteed periods) do not have lower MWRs than back-loaded ones. On the contrary, they tend to exhibit slightly higher MWRs. To assess whether these differences are statistically significant, I regress the MWR difference on a constant, using Newey-West robust standard errors to account for potential autocorrelation in the time series data. Table 4 shows that the estimated coefficients are negative and statistically significant at the 1% level. This result suggests that there is no evidence of price adjustments by firms in response to adverse selection or cohort mortality risk.

Table 4

	(1)	(2)	(3)	(4)	(5)
	MWR difference: guaranteed vs. no guarantee				
Constant	-0.0302***	-0.0304***	-0.0292***	-0.0223***	-0.0118***
	(0.00205)	(0.00180)	(0.00254)	(0.00229)	(0.00302)
Quintile	1	2	3	4	5
Observations	198	198	198	198	197

Note: Newey-West standard errors in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

However, unlike Cannon & Tonks (2016), I have access to more detailed data, which allows me to perform a within-individual comparison across products. This approach enables the control of all individual-specific characteristics. To formally examine this, the main model used is:

$$MWR_{if} = \alpha + \beta_1 PG120_{if} + \beta_2 PG180_{if} + \beta_3 PG240_{if} + \gamma_i + \delta_f + \varepsilon_{if}, \quad (2)$$

where $PG120$ is a dummy variable that takes value 1 if the offer have 120 month of guaranteed period; $PG180$ is a dummy variable that takes value 1 if the offer have 180 month of guaranteed period; $PG240$ is a dummy variable that takes value 1 if the offer have 240 month of guaranteed period; γ_p are fixed effects at the individual level; and δ_f are firm fixed-effects.

In this model, it is important to note that the comparison is made between products offered to the same individual by the same firm. Therefore, I am evaluating whether a given firm offers lower MWRs for products with fewer guaranteed payment periods. Additionally, I estimate four separate specifications, one for each category of deferred period length.

Table 5 reports the results of the model in equation (2). All estimated coefficients are statistically significant, indicating systematic differences in MWRs across products with and without guaranteed periods. However, these differences go in the opposite direction of what would be expected if firms were fully responding to adverse selection.

Specifically, more front-loaded products—those with longer guaranteed payment periods—exhibit lower MWRs than products with no guarantee period. Under adverse selection, one would expect the opposite: individuals with shorter life expectancy should prefer longer guarantee periods, leading firms to charge lower prices (and thus offer higher MWRs) for these products. The negative coefficients therefore imply that firms offer worse terms, not better, for products that are more attractive to high-mortality individuals.

This pattern also appears when comparing products with different deferred periods. Thus, although the Chilean annuity market displays evidence of adverse selection, the pricing patterns suggest that firms do not fully incorporate this information into their pricing strategies, and in some cases may even price in a direction inconsistent with standard adverse-selection predictions.

Table 5

	(1)	(2)	(3)	(4)
	MWR			
Guaranteed period 120	-0.00403***	-0.00447***	-0.00547***	-0.00605***
	(0.000411)	(0.000481)	(0.000534)	(0.000671)
Guaranteed period 180	-0.00873***	-0.00971***	-0.0107***	-0.0109***
	(0.000718)	(0.000775)	(0.000986)	(0.00129)
Guaranteed period 240	-0.0154***	-0.0173***	-0.0175***	-0.0222***
	(0.00107)	(0.00114)	(0.00150)	(0.00177)
FE Firm - Individual	Yes	Yes	Yes	Yes
Deferred years	0	1	2	3
Observations	15,250,785	14,030,922	9,055,839	5,565,531
R-squared	0.568	0.576	0.559	0.537

Note: clustered standard errors at the firm level in parenthesis for column (1), and at the product level for columns (2), (3), and (4). *** p<0.01, ** p<0.05, * p<0.1

In addition, I also analyze cohort risk from a different perspective. There is evidence that life expectancy increases over time, and advances in medical science suggest that it may continue to rise in the future, possibly at a faster pace. For instance, offering an annuity in 2007 likely involved less cohort risk than offering the same product in 2023. This is because, in 2007, firms had less information about future technological developments and their potential effects on longevity than they do today. For example, recent breakthroughs in cancer treatment and cardiovascular care have significantly improved survival rates among older populations. Such innovations were far less predictable in earlier years, making it more difficult for firms to accurately anticipate future improvements in mortality.

Therefore, by comparing the MWR of the same type of annuity for individuals with the same retirement age, marital status, and gender across different years, I expect to find that MWRs decrease over time. This decline could reflect the increasing role of cohort risk in annuity pricing. To formally examine these questions, the main model used is (3).

$$MWR_{icpf} = \beta Cohort_{c} + X'\phi + \gamma_{p} + \delta_{f} + \varepsilon_{ipf}, \quad (3)$$

where the variable $Cohort_{c}$ is a variable that indicates the month and year of retirement; the matrix X contains controls at the individual level, such as sex, marital status, age, and balance quintile; γ_{p} are fixed effects at the product level; δ_{f} are firm fixed-effects. The coefficient of interest is β. Standard errors are clustered at the firm level.

Table 6 presents the results of the model specified in Equation (3). The findings indicate that the MWR is lower for newer cohorts, after controlling for product type, firm, and all available individual characteristics. This suggests the presence of a pricing pattern that aligns with cohort-specific mortality risk.

Table 6

	(1) MWR
Cohort	-0.000126*** (2.38e-05)
FE Product - Firm	Yes
Observations	43,754,600
R-squared	0.242

Note: clustered standard errors at the firm level in parenthesis
*** p<0.01, ** p<0.05, * p<0.1

7. How Do Insurers Respond to Events that May Shift Future Survival Probabilities?

A fundamental challenge faced by annuity providers is the uncertainty surrounding future mortality improvements. Even when using the most up-to-date actuarial tables, insurers remain exposed to systemic longevity risk, unexpected changes in survival probabilities that affect entire cohorts. These cohort-level shifts may arise from medical innovations, public health interventions, or policy changes that improve access to healthcare. For long-term financial products such as life annuities, small changes in survival assumptions can have substantial implications for pricing, profitability, and reserve requirements.

This study exploits a unique institutional feature of the Chilean healthcare system to examine how insurers respond to cohort-level longevity shocks. In 2005, Chile implemented the *Acceso Universal con Garantías Explícitas* (AUGE) program, which established legally guaranteed access to timely diagnosis and treatment for a growing list of critical illnesses. Over time, the program incorporated more than 80 diseases, ranging from cancer and cardiovascular conditions to chronic illnesses affecting the elderly. Each condition was added at a specific date, creating a timeline of policy-induced improvements in expected survival for specific population segments.

These disease incorporations into AUGE represent plausibly exogenous shifts in cohort survival probabilities. For annuity providers, the inclusion of a disease, especially one that is highly prevalent among individuals nearing retirement, may lead to upward revisions in expected longevity for that cohort. If insurers incorporate such information into pricing, one would expect annuity offers made shortly after the inclusion of new conditions to exhibit lower MWR, particularly for products with long-dated payouts that are more sensitive to future mortality changes. To test this, I focus on three key dates of disease inclusion into AUGE: July 1, 2010; July 1, 2013; and October 1, 2019. For each of these dates, I analyze annuity offers within a three-month window before and after the policy change.

To formally examine these questions, the main model used is:

$$MWR_{icpf} = \beta Post_c + X'\phi + \gamma_p + \delta_f + \varepsilon_{ipf} \quad (4)$$

where the variable $Post_c$ is a dummy variable that takes the value 1 after each of the events (July 2010, July 2013, and October 2019) and 0 otherwise; the matrix X contains controls at the individual level, such as sex, marital status, age, and balance quintile; γ_p are fixed effects at the product level; δ_f are firm fixed-effects. The coefficient of interest is β. Standard errors are clustered at the firm level.

Table 6

	(1)	(2) MWR	(2)
Post	-0.00177	-0.00397***	0.02278***
	(0.00177)	(0.00131)	(0.0039)
Female	-0.00799***	-0.00451***	0.00529***
	(0.00168)	(0.00101)	(0.0014)
Married	-0.00236*	-0.00143*	-0.0037
	(0.00120)	(0.000741)	(0.00125)
Age	0.00136***	0.00172***	0.00222***
	(0.000263)	(0.000251)	(0.00041)
Event	July 2010	July 2013	October 2019
Observations	1,070,987	1,778,098	1,603,439
R-squared	0.528	0.463	0.2377

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: clustered standard errors at the firm level in parenthesis

Table 6 shows the results of the model specified in Equation (4). The findings are generally consistent with expectations for the July 2013 event: following the inclusion of additional diseases in the AUGE program—which represents a shock to individuals' life expectancy in Chile—the MWR decreases, as anticipated. In the case of the July 2010 inclusion, the coefficient is negative, in line with expectations, but not statistically significant. In contrast, the October 2019 inclusion yields a statistically significant coefficient, but with a positive sign, contrary to expectations. This suggests some heterogeneity in the response, possibly depending on the timing or the specific nature of the disease added.

8. Testing Firms' Responsiveness to Retiree Preferences and Market Conditions

In this section, I evaluate whether firms respond to shocks by increasing the generosity of their annuity offers. The main hypothesis is that firms may try to offer better terms —measured by a higher Money's Worth Ratio (MWR)— to attract retirees and discourage them from choosing a programmed withdrawal instead of an annuity.

However, before analyzing whether firms adjust product quality in response to policy shocks or market trends, it is essential to evaluate whether individuals actually respond to product quality when choosing between annuities and programmed withdrawals. If retirees do not react to the relative attractiveness of annuity offers, it would not make sense to assess whether firms adjust their products to influence retiree behavior. To test this, I estimate a probit model where the dependent variable is the probability of opting for a programmed withdrawal. The key explanatory variable is the difference between the first-month payment of the annuity (excluding any guaranteed period) and the first-month payment under the programmed withdrawal option. This allows me to assess whether larger differences in monthly payments are associated with changes in the probability of choosing an annuity over a programmed withdrawal.

For this exercise, the sample is restricted to individuals who received both a programmed withdrawal offer and at least one immediate annuity offer without a guaranteed period. Due to computational limitations, the analysis is further restricted to observations up to October 2019.

I will estimate the following model:

$$Pr(AcceptedPW_i = 1) = \Phi(\beta_1 Ratio_{i,f} + \beta_2 Female_i + \beta_3 Age_i + \beta_4 Married_i + \delta_f + \varepsilon_{if}) \quad ,(5)$$

where the variable $AcceptedPW_i$ is a dummy variable that takes the value 1 if the individual i accept an programed withdraw, and zero otherwise; $Ratio_{i,f}$ is the difference between the payment for the first month of programes withdraw for the individual i and the payment of the best offer of an inmediate annuity with zero guaranteed periods that offers the firm f;

$Female_i$ is a dummy variable that takes value 1 if the retiree is a women and 0 otherwise; $Married_i$ is a dummy variable that takes value 1 if the retiree is married and 0 otherwise; Age_i is age in years; δ_f are firm fixed-effects. The coefficient of interest is β_1.

The results are presented in Table 7. They show a positive and statistically significant effect of the variable *Ratio* on the probability of choosing a programmed withdrawal. This means that when the difference between the first-month payment of a programmed withdrawal and that of the highest annuity offer with zero guaranteed periods increases, individuals are more likely to choose the programmed withdrawal option instead of an annuity. This is the expected result.

Table 7

	(1) Indicator for programmed withdrawal selection
Ratio	2.009***
	(0.0271)
Female	-0.199***
	(0.00749)
Age	-0.00151
	(0.00128)
Married	-0.192***
	(0.00648)
Observations	249,791

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Robust standard errors in parentheses

Table 8 presents the average marginal effects. In particular, the marginal effect of the *Ratio* variable is 0.693, which implies that a one-unit increase in the payment difference (as defined by the ratio) is associated with a 69.3 percentage point increase in the probability of choosing a programmed withdrawal, holding other variables constant.

Table 8

	(1) Indicator for programmed withdrawal selection
Ratio	0.693***
	(0.00910)
Female	-0.0686***
	(0.00257)
Age	-0.000522
	(0.000442)
Married	-0.0664***
	(0.00223)
Observations	249,791

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Therefore, it now makes sense to examine whether firms adjust their product offerings to attract retirees and prevent them from choosing a programmed withdrawal instead of an annuity, since I have shown that individuals do respond to differences in payments between annuities and programmed withdrawals when making their decisions.

To evaluate this, I propose two approaches. First, I exploit a policy implemented by the Chilean government during the COVID-19 pandemic, which allowed retirees to withdraw part of their savings if they had chosen a programmed withdrawal. This policy represented a shock to annuity preferences, since only those with programmed withdrawals could access these funds. Therefore, if firms aim to retain retirees by improving product quality, I expect them to offer higher MWRs after the implementation of this withdrawal policy.

Second, if firms aim to attract retirees to select annuities instead of programmed withdrawals, they may also respond to recent trends in retiree behavior. Specifically, if firms observe that, in previous months, a higher percentage of retirees chose programmed withdrawals, they may respond by offering better products (i.e., with higher MWRs) to reverse that trend and attract more annuity buyers.

For the first approach, I evaluate how firms responded in terms of MWR after the Chilean government announced that individuals would be allowed to withdraw part of their savings if they had chosen a programmed withdrawal. The government made this type of announcement three times during the COVID-19 pandemic, but I focus only on the first two, since the third also allowed withdrawals for individuals with annuities, which would compromise the identification strategy.

The key idea is that the possibility of withdrawing funds made the programmed withdrawal option more attractive. Therefore, if firms were interested in retaining potential annuitants, they would have had an incentive to offer more generous annuity products to compensate for the increased attractiveness of the alternative.

The two relevant announcements were made in July 2020 and December 2020. For each of these events, I analyze annuity offers within a three-month window before and after the policy change.

To formally examine these questions, the main model used is:

$$MWR_{icpf} = \beta Post_c + X'\phi + \gamma_p + \delta_f + \varepsilon_{ipf} \quad , (6)$$

where the variable $Post_c$ is a dummy variable that takes the value 1 after each of the events (July 2020, and December 2020) and 0 otherwise; the matrix X contains controls at the individual level, such as sex, marital status, age, and balance quintile; γ_p are fixed effects at the product level; δ_f are firm fixed-effects. The coefficient of interest is β. Standard errors are clustered at the firm level.

Table 9

	(1)	(2)
	MWR	
Post	0.00479	-0.00819**
	(0.00375)	(0.00352)
Female	0.000448	0.00511**
	(0.000873)	(0.00211)
Married	-0.00506***	-0.00268
	(0.00141)	(0.00241)
Age	0.00137***	0.000803**
	(0.000195)	(0.000314)
Event	July 2020	December 2020
Observations	1,098,332	1,041,030
R-squared	0.419	0.802

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results show that the two government announcements did not have a significant effect on the MWR offered by firms. It is important to note that the comparison is made between individuals with similar observable characteristics and among offers made by the same firm within the same cohort. This ensures that any observed differences are not driven by changes in the composition of individuals or firms over time, but rather reflect potential adjustments in the quality of offers in response to the policy changes.

For the second approach, I evaluate how firms respond to trends in retiree behavior. If firms aim to attract individuals to choose annuities instead of programmed withdrawals, they may react to recent increases in the proportion of retirees selecting programmed withdrawals.

To test this, I construct a dynamic panel dataset at the firm-by-retirement-date (month-year) level. For each firm and retirement month, I calculate the total number of individuals who received an annuity offer, as well as the number of those who ultimately chose a programmed withdrawal instead. I also compute the average Money's Worth Ratio (MWR) offered by each firm in each month, along with other firm-date-level variables: the total number of women and married individuals who received offers, the average retirement age of those receiving annuity offers from the firm, and the number of different annuity products offered by each firm in each month-year.

Annuity products are defined as either deferred or immediate annuities, with guaranteed payment periods of 0, 120, 180, or 240 months, resulting in a total of eight distinct product types.

To analyze how firms adjust the generosity of their annuity offers in response to recent retirement behavior, I estimate a dynamic panel data model using the Arellano-Bond estimator (Arellano and Bond, 1991). The specification is as follows:

$$Average\ MWR_{f,t} = \alpha_1 Average\ MWR_{f,t-1} + \alpha_2 Average\ MWR_{f,t-2} + \alpha_2 Average\ MWR_{f,t-3} +$$

$$\beta_1 percentage\ PW_{f,t} + \beta_2\ share\ PW_{f,t-1} + \beta_3\ share\ PW_{f,t-2} +$$

$$\beta_4 number\ of\ women_t + \beta_5\ number\ of\ women_{t-1} + \beta_6 number\ of\ women_{t-2} +$$

$$\beta_7 number\ of\ married\ people_t + \beta_8\ number\ of\ married\ people_{t-1} +$$

$$\beta_9 number\ of\ married\ people_{t-2} + X'\phi_{f,t} + \varepsilon_{f,t} \quad (7)$$

where the variable $Average\ MWR_{f,t}$ denotes the average MWR offered by firm *f* at time *t*; $percentage\ PW_{f,t}$ represents the share of individuals who received an offer from firm *f* at time *t* but ultimately chose a programmed withdrawal instead of an annuity. In addition, the variable $number\ of\ women_t$ refers to the number of women who received an annuity offer from firm f at time t, while $number\ of\ married\ people_t$ indicates the number of married individuals who received such an offer. Lastly, the matrix X includes product-level controls for each firm and period.

Table 10: Dependent Variable — Average MWR

	AB (1 lag)	AB (2 lags)	AB (3 lags)
L. Average MWR	0.836***	0.820***	0.818***
	(0.0268)	(0.0605)	(0.0638)
L2. Average MWR		0.0206	-0.0529
		(0.0510)	(0.0518)
L3. Average MWR			0.0927**
			(0.0306)
Share programmed withdrawal	0.00958*	0.00958*	0.00989*
	(0.00387)	(0.00387)	(0.00387)
L. Share programmed withdrawal	-0.00163	-0.00153	-0.00144
	(0.00381)	(0.00376)	(0.00414)
L2. Share programmed withdrawal	-0.00518	-0.00527	-0.00626
	(0.00439)	(0.00437)	(0.00475)
Number of women	-0.0000356*	-0.0000359*	-0.0000370*
	(0.0000162)	(0.0000164)	(0.0000173)
L. Number of women	0.0000564*	0.0000558*	0.0000576**
	(0.0000222)	(0.0000221)	(0.0000219)
L2. Number of women	0.0000293	0.0000302	0.0000304
	(0.0000233)	(0.0000234)	(0.0000234)

Number of married people	0.0000359	0.0000359	0.0000423^{*}
	(0.0000196)	(0.0000196)	(0.0000197)
L. Number of married people	-0.0000176	-0.0000173	-0.0000199
	(0.0000142)	(0.0000144)	(0.0000145)
L2. Number of married people	0.0000139	0.0000132	0.0000148
	(0.0000154)	(0.0000159)	(0.0000155)
Product controls	Yes	Yes	Yes
Observations	2005	2005	1986
Wald_p-value	0.000	0.000	0.000

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results in the table show no evidence that firms respond by offering more attractive annuities in order to attract more individuals when the share of people choosing a programmed withdrawal was higher in the one, two, or three months prior. A Wald test was also conducted to assess the joint significance of the variables. While the results indicate that the variables are jointly significant at the 1% level across all three specifications, this does not translate into clear evidence of a behavioral response from firms.

Therefore, the question of what firms respond to remains unanswered. I now explore the possibility that firms primarily react to market trends. It is well known that annuity providers invest retirees' funds to finance future payments. Thus, it is reasonable to assume that if market expectations worsen or market conditions are unfavorable, firms may offer less attractive products, since their ability to pay annuities depends on the performance of these investments.

First, I evaluate whether the evolution of the Central Bank of Chile’s interest rates is related to the behavior of the MWR in the long run. Specifically, I test whether the two series are cointegrated, which would indicate the presence of a long-term equilibrium relationship between them. I use the Central Bank’s interest rates because they influence the returns available in the financial market, particularly on fixed-income instruments where insurance companies typically invest the premiums they receive. These rates also reflect market expectations about future economic conditions, which affect how insurers assess investment opportunities and, ultimately, how they price annuity products.

To isolate this effect, I focus exclusively on immediate annuity offers with zero guaranteed periods made to single men aged 65—the most common retirement age. This restriction allows me to examine the impact of interest rate fluctuations on a standardized annuity product offered to individuals with identical characteristics.

In this case, I aim to investigate whether there is a long-run relationship between the Central Bank of Chile's interest rate—specifically the 10-year rate—and the MWR. To do so, I employ the error correction model (ECM), which is valid only if the two series are cointegrated.

Before applying this model, it is necessary to verify whether the variables meet the conditions required for cointegration analysis. Specifically, both variables must be integrated of order one, I(1). To assess this, I apply the Augmented Dickey-Fuller (ADF) test to each series. The results indicate that the null hypothesis of a unit root cannot be rejected at the 5% significance level for either variable, suggesting that both are non-stationary in levels and therefore suitable for cointegration analysis.

Therefore, given that the variables are non-stationary and cointegrated, the long-run relationship between them can be appropriately modeled using an error correction framework. According to Engle & Granger (1987), the presence of cointegration implies the existence of a valid error correction representation that captures both short-term dynamics and long-term equilibrium. Based on this, I estimate the following error correction model:

$$\Delta\, Average\ MWR_t = \beta_0 \Delta\, interest\ rate_{t-1} + \delta Z_{t-1} + u_t\,, \quad (8)$$

where $\Delta\, Average\ MWR$ denotes the first difference of the MWR, $\beta_0 \Delta\, interest\ rate_{t-1}$ is the lagged first difference of the interest rate, and Z_{t-1} is the lagged error correction term that captures deviations from the long-run relationship. Specifically, $Z_{t-1} = Average\ MWR_{t-1} - \alpha - \beta\,.\, interest\ rate_{t-1}$, where α and β are the parameters from the cointegration equation estimated in the first stage. In that first stage, a static regression is estimated using the level of the dependent variable ($Average\ MWR$) on the level of the explanatory variable ($interest\ rate$), including a deterministic linear trend. The residuals from this regression (Z_{t-1}) represent the deviations from the long-run equilibrium and are used as the error correction term in the second stage.

In the model (8), δ represents the speed of adjustment toward the long-run equilibrium. A negative and statistically significant value of δ indicates that, when the system is out of equilibrium, the dependent variable adjusts in the next period to restore the equilibrium relationship. Meanwhile, β_0 captures the short-run impact of changes in the interest rate on the MWR.

Table 11 shows the results of the estimation of the error correction model specified in Equation (8). The estimation results are consistent with the presence of a long-run equilibrium relationship between the MWR and the interest rate. The coefficient on the error correction term is negative and statistically significant at the 1% level, indicating that deviations from the long-run equilibrium are corrected over time. Specifically, approximately 13% of the disequilibrium is eliminated in the following period, suggesting a moderate speed of adjustment.

The short-run coefficient on the lagged change in the interest rate is statistically significant at the 5% level, indicating that an increase in the interest rate is associated with a short-term increase in the MWR. One possible interpretation is that higher interest rates may reflect improved expectations regarding market returns, allowing annuity providers to offer more attractive payout conditions to retirees. In this sense, the observed positive relationship could indicate that, in periods of rising interest rates, providers anticipate better performance in the assets backing annuity contracts and are thus able to pass part of those expected gains on to future annuitants.

Table 11

	(1)
	$\Delta\ Average\ MWR$
L.Error correction term	-0.1283***
	(0.0364)
L.Interest rate	0.0034**
	(0.0016)
Constant	-0.0002
	(0.0004)
Observations	186

	(1)
R-squared	0.0789

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

9. Conclusion

This paper provides new evidence on how insurance firms set annuity prices in a context where individual heterogeneity and market risks are both salient and observable. By leveraging detailed administrative data from Chile's centralized quote system and computing individualized MWR, I analyze the extent to which pricing responds to observable retiree characteristics, product design features, and macroeconomic trends.

The results reveal that firms offer significantly better terms—higher MWRs—to married individuals, in line with their longer expected lifespans. While there are not significance differences between sex. Higher-income individuals also receive marginally more generous offers overall, but this pattern masks substantial heterogeneity in pricing strategies across firms. In fact, even Firm 1, the company that concluded the largest number of contracts between 2007 and 2023, offers less favorable terms to higher-income applicants, suggesting that market power, risk selection, and firm-specific pricing rules interact in non-uniform ways. Moreover, the analysis shows clear evidence of adverse selection in back-loaded annuity products, as individuals who choose these contracts systematically differ in observable risk.

Dynamic panel regressions suggest that firms adjust pricing in ways that depend on the evolution of market conditions over time. However, contrary to what one might expect, the estimations do not show evidence that firms offer more attractive annuity terms when a larger share of retirees recently opted for programmed withdrawals. Instead, the results point to a different pattern: firms' pricing behavior appears to be more closely tied to broader market dynamics, such as movements in long-term interest rates, than to short-run fluctuations in retirees' product choices.

Methodologically, this paper contributes to the literature by computing individualized MWRs using cohort-specific mortality tables, market-based discount rates, and product-level information on guarantee periods and deferral options. This enables a more accurate measurement of annuity generosity that reflects both demographic and institutional realities.

Taken together, the findings point to a pricing environment in which firms respond systematically to risk, preferences, and competition. These insights have implications for understanding selection in annuity markets and for designing regulatory policies that promote efficiency and fairness in retirement income provision.

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