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ABSTRACT

This paper estimates the expected present discounted value (EPDV) of the payments from immediate and deferred annuities that were available in the US retail insurance market in May 2024. The central estimates suggest that for immediate annuities purchased at age 65, the value of payouts per premium dollar is about 87 cents for a buyer whose prospective mortality aligns with that of the US population, and about one dollar for one whose mortality aligns with that of a typical annuity purchaser. For a deferred annuity purchased at age 65 that begins payouts at age 75, the EPDVs are 73 cents and close to one dollar, respectively. The private information that contributes to the lower mortality rates of annuitants than those of the population appears to decay over time, and age-specific mortality rates of recent annuitants are somewhat lower than those of annuitants who bought policies further in the past. Annuities with guarantee periods, the most popular retail products, are much less sensitive, from a valuation perspective, to the buyer’s date of death and mortality risk than simple life annuities.

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Since Yaari's (1965) seminal insight that risk-averse individuals should fully annuitize their wealth to hedge longevity risk, the annuity puzzle—why so few retirees voluntarily purchase annuities—has been a much-studied puzzle in public and household finance. Nearly all households of retirement age qualify for Social Security, a public annuity program, but relatively few purchase additional private annuities. In the 2022 Survey of Consumer Finances, for example, only 3.5 percent of households headed by someone between the ages of 65 and 74, and 2.8 percent of those between 75 and 84, reported ownership of an annuity that delivered lifetime income. Even among those who do purchase annuities, most opt for products with substantial "bond-like" components, such as annuities with 10- or 20-year guarantee periods with minimal mortality contingency. Deferred income annuities are even less popular than immediate annuities. LIMRA (2025) reports that immediate annuity sales in the US in 2024 totaled $13.6 billion; deferred annuity sales were $4.9 billion.

The limited interest in deferred annuities is particularly puzzling in light of recent research. Horneff, Maurer, and Mitchell (2020) estimate that a 65-year-old man can increase his expected lifetime utility by allocating a small fraction of his wealth to the purchase of an actuarially fair deferred annuity that begins payouts at age 85. In a related study, Shoven and Walton (2023) suggest that for individuals who are planning to purchase an annuity at retirement, replacing investments in bonds during the wealth accumulation phase with staggered purchases of deferred annuities can deliver greater longevity protection than waiting until retirement to annuitize. They attribute this gain in expected retirement income to two factors: hedging their exposure to annuity prices across time and reduced adverse selection because those who buy annuities a decade or more before payouts begin may be less able to predict their likelihood of collecting many years of benefits than those who buy immediate annuities.[1]

Adverse selection is just one of several explanations that have been advanced to account for the annuity puzzle.[2] Mitchell, Poterba, Warshawsky, and Brown (hereafter MPWB) (1999)

1 Studies of adverse selection in annuity markets and the role of private information on longevity prospects include Cannon and Tonks (2004, 2016), Finkelstein and Poterba (2004), Mitchell, Poterba, Warshawsky, and Brown (1999), and Verani and Yu (2024).

2 Other potential explanations for low annuitization rates include bequest motives, as in Lockwood (2018) among others, the risk of late-life medical costs, as in Reichling and Smetters (2015), mortality pessimism as in O'Dea and Sturrock (2020) and Solomon (2023), and the crowd-out effect of Social Security, which provides a consumption floor for retirees.

and many others explain that such selection could make the expected payouts from an annuity relatively unattractive for a typical individual, even if they are attractive for annuity buyers with lower-than-average mortality risk. There has been relatively little recent analysis of the expected present discounted value (EPDV) of prospective payouts, relative to annuity premia, for annuitants or those in the general population, and we are not aware of any analysis of the potential differences in selection between immediate and deferred annuities. The Society of Actuaries (SOA) does not create mortality tables differentiated by annuity type.

This paper analyzes the money's worth of annuities – the relationship between the purchase price and the EPDV -- using data from 2024. It explores whether differences in EPDVs could explain the greater take-up of guaranteed income annuities than simple immediate annuities or deferred income annuities, and tests whether annuity buyers have more private information about prospective mortality in the first few years after annuity purchase than at longer horizons. The paper reports EPDVs for single-premium immediate annuities (SPIAs), guaranteed income annuities (GIAs), and deferred income annuities (DIAs) using two sets of discount rates and two mortality tables. For discount rates, we consider the Treasury yield curve, which could reflect the buyer's opportunity cost for an income stream implicitly guaranteed by the government, as well as the BBB corporate bond yield curve. The latter may be a better proxy for the insurer's production cost, reflecting the asset mix and capital charges that fund their liabilities. For mortality, we value payouts using US population life tables compiled by the Social Security Administration as well as annuitant life tables computed by the SOA.

The findings show substantial disparities in the EPDVs calculated using annuitant and population mortality curves for all annuity products. Evaluated using Treasury yield curves and annuitant mortality, SPIAs, GIAs, and DIAs all have similar EPDVs of roughly \$1 per premium dollar. This implies that, from the average annuity buyer's perspective, there is little reason, on present value considerations, to opt for a bond-like guaranteed income annuity rather than a more longevity-risk-exposed SPIA or DIA. Valued instead using the population mortality table, all of these products have lower EPDVs. For a 65-year-old man facing the population mortality curve, a SPIA has an EPDV of about \$0.87 per premium dollar, compared with \$0.73 for a 10-year DIA. GIAs change less because most of their value is not survival contingent. Discounted using the corporate BBB yield curve, the EPDV of payouts is well below the premium cost in all cases.

The greatest drop is for DIAs, which suggests that insurers may set payouts recognizing the difficulty of finding long-duration low risk investments that match the long-deferred DIA liabilities.

To further explore disparities in the mortality experience of those who might purchase deferred rather than immediate annuities, we analyze SOA annuitant mortality data and explore how mortality varies with time since annuity purchase. If private health information decays with time, mortality probabilities for recent buyers should be lower than for otherwise-identical seasoned annuitants; standard annuity mortality tables combine both of these groups. We construct duration-specific mortality measures controlling for age and sex, and find a front-loaded pattern for the effect of private information: mortality differentials are largest shortly after purchase and attenuate with duration. This finding implies that immediate life-contingent payouts are most exposed to the effects of private information, while long-deferred DIA payouts are less so. While qualitatively this finding aligns with the view that DIAs are less sensitive to private information than SPIAs, quantitatively, the effects on our estimated EPDVs are small.

This paper is divided into eight sections. The first describes the conceptual framework for calculating the EPDV of payouts associated with an annuity product as well as the internal rates of return (IRRs) on such products. The next two sections describe key data sources for annuity prices and discount rates, and mortality rates, respectively. The fourth section presents evidence on the extent to which private information on mortality, which may contribute to the lower mortality rate for annuitants than for the population at large, decays with the time since annuity purchase. Section five reports estimates of the EPDVs and IRRs on immediate and deferred annuities. The EPDVs for deferred and immediate annuities are broadly similar when valued using the mortality table for annuity buyers, but deferred annuities have lower EPDVs when valued using the population mortality table. The next section considers guaranteed income annuities, which guarantee annuitants and their beneficiaries payments for a fixed period of time, often 20 years, and reports on the share of the EPDV for these products that is life-contingent. Section seven discusses the implications of our findings for the potential use of deferred annuities in accumulation vehicles such as lifecycle funds. There is a brief conclusion.

1. Framework for Annuity Valuation

Conditional on the monthly payout that an annuitant will receive, it is possible to compute the EPDV of the stream of prospective future payments. To simplify the valuation calculations, we assume that annuities make two payouts each year, each equal to six promised monthly payments, and that the first payout is made six months after the date of purchase. We let $V_b(A)$ denote the EPDV of a life annuity that makes two payments of A dollars each year and that is purchased by an individual of age b. The EPDV depends on the payouts associated with the annuity contract, the discount rates that are used in the calculation, and the survival probabilities that determine the likelihood that an annuitant will receive a given future payment. We focus on annuities purchased in retirement accounts, so all future payouts are assumed to be taxable as ordinary income. Since a lump sum payout from the account equal to the purchase price of the annuity would face the same tax treatment, provided the annuitant's marginal income tax rate remains constant throughout the payout period, the money's worth ratio is not affected by the buyer's marginal income tax rate.[3] The relevant discount rate, i_j, is also the before-tax discount rate in this setting: it is the rate of return available to the annuitant on investments in their retirement account that have the same risk profile as the annuity payout stream.

If the probability that an annuitant who purchases a single-premium immediate annuity (SPIA) at age b survives for j half-years is given by $P_{b,j}$, and i_j denotes the nominal pre-tax discount rate for cash flows received j half-years after the annuity purchase, the EPDV is:

(1) $$V_b(A) = \sum_{j=1}^{240-2b} \frac{A*P_{b,j}}{(1+i_j)^j}.$$

This formula assumes that the annuitant will not live beyond the age of 120; a b-year-old annuity buyer cannot receive more than 240 – 2*b semi-annual payments. The calculations presented below are insensitive to shortening the maximum assumed lifespan to 115, 110 or 105 years. Equation (1) could also be applied, with minor modification, to value annuities that offer payouts with a fixed nominal escalation schedule or other time-varying payout streams. To value inflation-indexed annuities, estimates of future real interest rates would also be needed.

The money's worth ratio equals $V_b(A)$ divided by the policy premium, which is usually normalized to $100,000 in the data on SPIAs and DIAs. When $\frac{V_b(A)}{100,000} < 1$, the difference can be interpreted as the price of longevity insurance as a share of the policy premium. Past estimates of this ratio have typically fallen between 0.80 and 0.95, with variation over time and as a function

3 When purchased outside a retirement account, annuity payouts are taxable under complex provisions that recognize that payments include a return of principal as well as capital income. The buyer's discount rate in this case must also be net of taxes.

of the valuation assumptions, particularly the assumed mortality table.[4] Even when EPDVs fall below premium costs, risk-averse individuals may choose to purchase annuities because they insure against longevity risk.

Another way to summarize the cost of longevity insurance is to calculate the internal rate of return (IRR), the discount rate ρ at which the annuity's EPDV would equal its purchase price:

(2) $$100{,}000 = \sum_{j=1}^{240-2b} \frac{A * P_{b,j}}{(1+\rho)^j}.$$

The IRR is particularly helpful when comparing the investment returns on annuities and other financial products.[5]

2. Annuity Prices and Discount Rates

EPDVs are a function of SPIA and DIA payouts, discount rates, and mortality rates.

2.1 Annuity Payouts

We focus on EPDV calculations for SPIAs and DIAs that were available for purchase on May 2, 2024 in the US retail market. We consider products that were priced on the website www.immediateannuities.com, which compares the offerings of eight large US insurance companies. There is some variation in the number of companies reporting prices for any particular policy. All of the policies feature a $100,000 premium and offer a fixed nominal payout, with or without a guarantee period. For DIAs, the income stream commences either 10 or 20 years after the purchase date. The policies are "non-participating," meaning that the benefit payments are fixed and guaranteed, and do not depend on the insurance company's subsequent experience with mortality, investment returns, or expenses. We consider policies offered in New York, a state in which gender-specific pricing is permitted; some states ban such pricing for retail annuities.[6] In New York, women of a given age receive lower annual payouts than their male counterparts due to their lower average mortality rates at all ages.

4 Koijen and Yogo (2015) note that during the global financial crisis of 2009, some insurers briefly offered policies with EPDVs above their premia as a means of raising regulatory capital.
5 Brown, Kling, Mullainathan, and Wrobel (2008) find that whether annuities are framed as investment products or insurance products appears to affect consumer demand.
6 Group annuities that are offered in qualified retirement plans, which are covered by the Employee Retirement Income Security Act of 1974 (ERISA), must offer the same payouts to men and women of a given age. This makes payouts to women higher, and to men lower, than with gender-differentiated pricing.

For an immediate annuity purchased for $100,000 by a 65-year-old man, the average monthly payout in May 2024 was $638, with eight companies in the sample. The payouts ranged from a high of $649 to a low of $624 – a range of just under 4 percent of the average. Some of this variation may be due to the different investment ratings of the various insurers, although the monthly payouts do not align closely with company ratings. The firm offering the highest payout, Penn Mutual, is rated A+ by A.M. Best, Aa3 by Moody's and A+ by Standard and Poor's. The firm with the lowest payout, American National, was A rated by Moody's and Standard and Poor's. A firm's underwriting practices and firm-specific circumstances such as capital availability may affect pricing decisions. In the absence of information on the volume of annuity sales by each company, we construct payout values A as the equal-weighted means of the payout rates of the products offered by the sample firms.

Table 1 reports the average annual payout, computed as 12 times the monthly payments, for a SPIA with no guarantee period, a SPIA that guarantees payments for 20 years, either to the annuitant or a designated beneficiary, and for a DIA that begins payments either 10 or 20 years after purchase. For each product, the table shows the payout for a contract purchased by a man and a woman at ages 55, 65 and 75, as well as a joint life annuity purchased by a married couple in which both members are the same age. The joint-life policy pays the same benefit for as long as either member of the couple is alive. Our valuation analysis focuses primarily on individual annuities, although SOA (2012) reports that roughly half of annuities sold are joint and survivor.

SPIA pricing varies with the buyer's age and gender in expected ways. The average annual payment for a male 65-year-old annuitant is $7,656, about 4% greater than the $7,356 for a woman of the same age, and 15% greater than the payout on a joint-and-survivor annuity purchased by a 65-year-old couple. The annual payout rises with the age of the annuitant. The increase is 18% between ages 55 and 65, and 31% between 65 and 75, for a male annuitant, reflecting the greater annual mortality risk between 65 and 75 than between 55 and 65. Opting for a 20-year guarantee period reduces the annual payout for a 65-year-old man by 8.8% but by only 6.9% for a similar-aged woman. A 65-year-old woman is more likely than a 65-year-old man to survive to age 85, so the guarantee provision is less likely to affect her stream of payouts. SPIAs with guarantees place less of the premium at risk of loss in the event of the buyer's unexpectedly early death than do no-guarantee products.

Table 1 also shows that the male/female annuity payout differential varies with age. At age 55, for SPIAs, men receive annuity payouts that are about 2.7% higher than those for women. This difference rises to 4.1% at 65 and to more than 7% at 75. These payment patterns largely reflect differential mortality patterns, especially in the first decade after annuity purchase. The percentage difference in remaining life expectancy between men and women is greater at age 75 than at age 55.

Table 1 also presents information on the average payouts associated with deferred annuities, purchased either at age 55 or age 65, with payouts beginning in either 10 or 20 years. The average policy with a premium of $100,000 promises a 65-year-old man a $60,240 annual payout beginning at age 85, but only 29% as much -- $17,400 -- if the payouts start at age 75. The larger payout on the longer-deferred annuity reflects the time value of money – the insurer can invest the proceeds in the first case for two decades without making payouts, while for only one decade in the second case – and the smaller likelihood that a 65-year-old man will still be alive at 85 than that he will be alive at 75. The Society of Actuaries' annuitant mortality table, described in more detail below, indicates that a 65-year-old man has a 90% chance of living to 75 and a 68% chance of living to 85. The corresponding survival probabilities for a 65-year-old man with the mortality risk of the population at large, as reported by the Social Security Administration, are 80% and 48%, respectively.

The DIA payouts for policies that begin payouts at a certain age are decreasing in the age of purchase. For men, for example, the payout starting at age 75 is $29,448 when a $100,000 DIA is bought at age 55, compared with $17,400 when purchased at 65. For any purchase age/payout age combination, the DIA payout for women is lower than that for men, reflecting the greater likelihood of the annuitant surviving to advanced ages.

The sample of firms reporting DIA prices is smaller than that for SPIAs, and the price dispersion is greater. For a 65-year-old male, the highest SPIA quote is only 3% above the average, whereas for a DIA with a 10-year (20-year) deferral period, the highest payout is 5% (8%) higher. This may be due to disparities across companies' assumptions about long-term mortality improvements and prospective rates of return. The EPDV of a DIA is more sensitive to these assumptions than the EPDV for a SPIA. The greater dispersion of DIA prices suggests a potentially higher return to comparison shopping for these policies as compared to SPIAs. This disparity will be important when we consider the potential role of DIAs in the accumulation phase of retirement saving.

2.2 Discount Rates

The EPDV calculation requires a term structure of discount rates. A key consideration in the choice of discount rates is the riskiness of the annuity payout stream. If payouts are risky, they should be discounted at a higher rate than if they are nearly risk-free. The historical experience with annuity payouts suggests a very low default rate, particularly for top-rated insurance companies. Beyond their own capital reserves, insurance companies are required to participate in various state-level guaranty associations. Hartley (2024) describes these associations and the backstop they provide, including insuring annuity holders for up to $250,000 if the insurer cannot meet its obligations.

If annuity payouts are riskless, or the buyer views them as so, they can be discounted using the yield curve for US Treasury bonds. This assumes that a prospective annuitant could invest retirement plan assets in such bonds, which seems reasonable since mutual fund complexes and brokerage firms offer fixed-income products that invest in Treasury bonds.

Previous studies have made varying assumptions with regard to discount rates: MPWB use discount rates on corporate bonds, while Cannon and Tonks (2016) use government bonds. While insurance companies typically hold risky assets in the portfolios that back their promised payments,[7] from the perspective of an annuity buyer, the key consideration is the riskiness of the promised payouts. Because annuities are protected by state-level guaranty funds, their risk, from the buyer's perspective, is lower than the risk of the portfolio of the insurer selling the annuity. For this reason, we focus on riskless discount rates from the Treasury yield curve in our benchmark analysis, but we also report results using corporate BBB yields to permit comparison with prior research. Using corporate rather than Treasury bond yields reduces our estimated EPDV values. If insurance companies view something like the corporate BBB yield as a measure of the rate of return that they can earn on their investments, then EPDVs calculated with these yields may be closer to what firms think of as their cost of production for annuities.

7 Weinlich (2024) reports that insurance company portfolios consist of approximately 50% bonds, 30% stocks and 20% other assets, such as real estate. Approximately 60% of a typical bond portfolio is rated A and above, 35% is rated BBB, and 5% BB or below.

We also report EPDVs using a third set of discount rates: those offered on 'bonds' issued by insurers that are not mortality contingent. Most insurers who sell life-contingent annuities also offer products known as "term annuities." They provide the buyer with a level payment for a fixed number of periods. This instrument is a variant on a bond, with the principal repaid over the life of the contract rather than at maturity. The price of a term annuity is not affected by the age or gender of the buyer. In May 2024, for the 17 companies with term annuity prices reported on the immediateannuities.com website, the average monthly (annual) payment for a 20-year period certain product was $645 ($7,740). The internal rate of return that equates this payout stream to $100,000 is 4.58%, a value that is slightly lower than Treasury yields at the time. The lower-than-Treasury yield may offer some insight into the valuation that buyers place on the convenience factor of purchasing a level stream of nominal monthly payments for a fixed period, rather than having to construct a laddered portfolio of Treasury bonds that would provide the same date-specific payments.

When an insurance company offers SPIAs, DIAs, and term annuities, a consumer wishing to purchase a SPIA with a 20-year guarantee could do so by purchasing a SPIA-with-guarantee, or by purchasing a 20-year period certain annuity as well as a DIA that will begin longevity-contingent payouts in 20 years. Aligning the two payout amounts, those for the DIA and the term annuity will replicate a SPIA with guarantee. In the absence of administrative costs for issuing insurance contracts, and potential differences between the degree of adverse selection in the set of buyers for the SPIA and DIA contracts, one might expect that these two approaches to buying a future income stream would have the same cost.

In practice, they do not. For most of the companies that offered all three policies in May 2024, the cost of buying the deferred annuity and the term annuity exceeds that of the SPIA-with-guarantee. Consider the products offered by American General, the first company in alphabetical order offering all three products. Its SPIA with a 20-year guarantee for a 65-year-old male pays $582/month for a $100,000 premium, and its 20-year fixed term annuity pays $645/month for a $100,000 premium. To provide $582/month for the next 20 years, a buyer would therefore need to spend (582/645)*$100,000 = $90,232. American General's 20-year deferred annuity for a 65-year-old man promises $5,020 per month beginning at age 85 for a $100,000 purchase price. To secure $582 per month starting at age 85, a buyer would need to purchase a DIA costing (582/5020)*$100,000 = $11,594. Thus, the income stream that could be purchased for $100,000 with a SPIA-with-20-year guarantee would cost $101,826 (=90,232 + 11,594) if purchased by assembling the DIA and the term certain product.[8] Similar calculations in 2021 and 2022, when interest rates and annuity payouts were lower, showed even larger cost disparities.

The discount rates used to calculate EPDVs are based on yields-to-maturity at various horizons. For Treasury and BBB corporate bonds, we collected yield data at maturities of 6 months, 1 year, and 2, 3, 5, 7, 10, 20, and 30 years. For term annuities, we collect prices at 5,10, 15, 20 and 25 years and compute the implied IRR. The data were collected on May 2, 2024, when the yield on 10-year (30-year) corporate BBB bonds was 5.87% (6.01%) compared with 4.58% (4.74%) for U.S. Treasuries. The yields-to-maturity on period certain annuities for the 10- and 25-year horizons were 4.06% and 4.77% respectively.

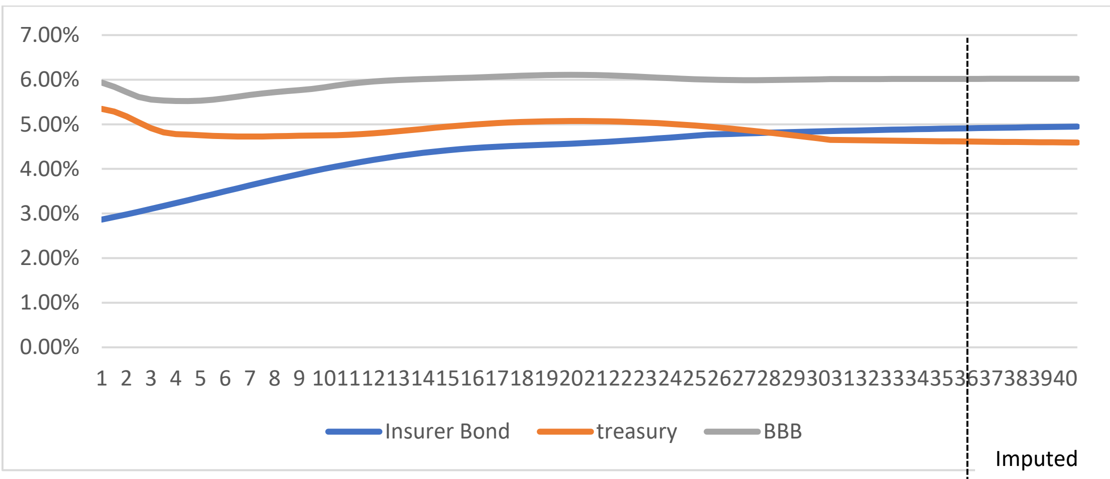
Yields to maturity for maturities between those with reported interest rates are interpolated using a cubic spline; the result is a yield curve, in half-year intervals, for maturities of up to 30 years (25 for term annuities). Some annuity payouts may occur after these long maturities. We impute yields to maturity at longer horizons by assuming that the six-month forward rates at all maturities beyond 30 years (25 for term annuities) equal the average of the forward rates at maturities between 15 and 30 years (15 and 25 for term annuities). As the maturity being imputed rises, the imputed discount rate converges toward the average short-term forward rate during that 15-year (10-year) window. Discount rates at maturities beyond 30 years do not have a substantial effect on the EPDV calculations.

Figure 1 plots the May 2024 yield curves for Treasury bonds, term annuities, and the Bloomberg BBB-rated corporate bond index. The BBB yield is about 50 basis points above the Treasury yield at very short maturities, and about 100 basis points higher at ten years and at most longer maturities. The gap widens as maturities approach 30 years. The implied yields on term

8 It is possible that the costs of issuing and administering policies make buying two policies rather than one an inefficient way to generate the desired income stream, and that is what the pricing indicates. Another possibility is that the DIA market attracts a more selected set of buyers than the SPIA-with-guarantee market. If only 65-year-olds in excellent health purchase DIAs, then the EPDV calculated with mortality rates for all annuitants understates the actual value for the DIA-buying population. Our findings below suggest that it is difficult for DIA buyers to predict their mortality far into the future; the role of administrative and other costs in annuity sales therefore warrants further exploration.

annuities are more than 200 basis points below the Treasury yield at short maturities, but the disparity declines as the maturity rises.

Figure 1: Yield Curves: US Treasuries, Corporate BBB Bonds, and Term Annuities, May 2024



Notes: "BBB" refers to yields on BBB-rated corporate bonds. Yields for durations up to 30 years (Treasury and BBB bonds) and 25 years (term annuities) are interpolated using a cubic spline fit to reported interest rates. Yields at longer durations are imputed as described in the text.

3. Mortality Rates and Selection into Annuity Purchase

The survival probabilities $P_{b,j}$ in equation (1) describe the future mortality experience of current annuity buyers, so they are necessarily forecasts based on past data. If $q_{a,t}$ denotes the probability that an individual of age a at the beginning of half-year t dies during that half-year, and $P_{b,j}$ is the probability that a $b/2$-year-old annuity buyer (b is age in half-years) who buys at $t = 0$ survives for at least j half-years, then

(3) $$P_{b,j} = \left(1 - q_{b,0}\right)\left(1 - q_{b+1,1}\right) \dots \left(1 - q_{b+j-1,j-1}\right).$$

We assume that $P_{b,240-2*b} = 0$ for all b, and we use January, 2024 as t = 0 in our calculations, assuming that mortality rates prevailing in May 2024 were the same as those in January.

Mortality among annuitants is lower than mortality in the general population. This is likely due to two factors. First, as Waldron (2007), Chetty et al. (2016), and others show, age-specific mortality rates decline with economic status. Annuity buyers are economically more successful than average, since they have accumulated significant financial resources; this should translate into lower-than-average mortality. Second, conditional on net worth, those who purchase annuities in the retail market may have some information suggesting that they are healthier than average, or at least know that they are not facing any current life-threatening health conditions. This would also result in a mortality rate below the population average.

We follow past research in reporting the EPDV of annuities from two perspectives: that of an individual in the general population, and that of a typical annuity buyer. The former uses $\{P_{b,j}\}$ values from the population mortality table, while the latter uses data from the annuitant mortality table. For the mortality table for the U.S. population, we use the cohort mortality tables developed by the Social Security Administration (SSA) (2024). For annuities offered to 65-year-olds in 2024, the relevant mortality table is that for the 1959 birth cohort; other corresponding birth cohorts are used for annuity buyers at other ages. The SSA mortality tables embed projections of future mortality improvements. The mortality rates in the SSA tables, which are presented for each year of age, are converted to half-yearly probabilities by assuming that mortality is constant throughout each year of life so that $(1 - q_{1/2})^2 = (1 - q)$.

Projected cohort mortality tables based on the historical experience of the annuitant population are published by the SOA. The most recent comprehensive analysis is the Individual Annuitant Mortality (IAM) 2012 table, described in American Academy of Actuaries / SOA (2011), which provides cohort mortality tables for annuity buyers in 2012, along with recommended mortality improvement factors that can be used to project mortality rates for subsequent years. These factors place substantial weight on the rapid mortality decline experience of the late 1990s to extrapolate the improvement in mortality rates from 2004, the last year of data underlying the SOA 2012 table.

The rate of mortality improvement for older individuals in the US has varied over time. This is evident in the cohort mortality tables published by the SSA. For men, life expectancy at age 65 was 13.8 years in 1970, 14.7 years in 1980, 16.0 years in 1990, 17.3 years in 2000, and 18.2 years in 2010. (SSA 2024 Cohort Life Tables) For nearly four decades, life expectancy at age 65 rose by roughly a year per decade. This experience informed the SOA projections. However, this progress has slowed. The SSA reported life expectancy for 65-year-old men was 18.7 years in 2019, on the eve of the COVID-19 pandemic. The rate of improvement between 2010 and 2019 was about half that of earlier decades. The data for women show a less pronounced pattern, but also indicate some decline in mortality improvement.

The time-varying rate of mortality improvement raises the possibility that different analysts might project different prospective mortality rates. If the base year for annuitant mortality rates is 2012, with mortality rates $\{q_{a,2012}\}$, and the mortality improvement factor for age $a + t$ in year s is $g_{a+t,s}$, then projected mortality for an $a + t$ year-old in year $2012 + t$ is

(4) $$q_{a+t,2012+t} = q_{a+t,2012} * \prod_{s=1}^{t}(1 - g_{a+t,2012+s}).$$

The SOA assumes a time-invariant but age-specific rate of mortality improvement for the post-2012 period, i.e. $g_{a+t,s} = g_{a+t}$. The SSA, in contrast, assumes a faster rate of mortality improvement until 2044 than in later years. These disparities have only small effects on EPDVs.

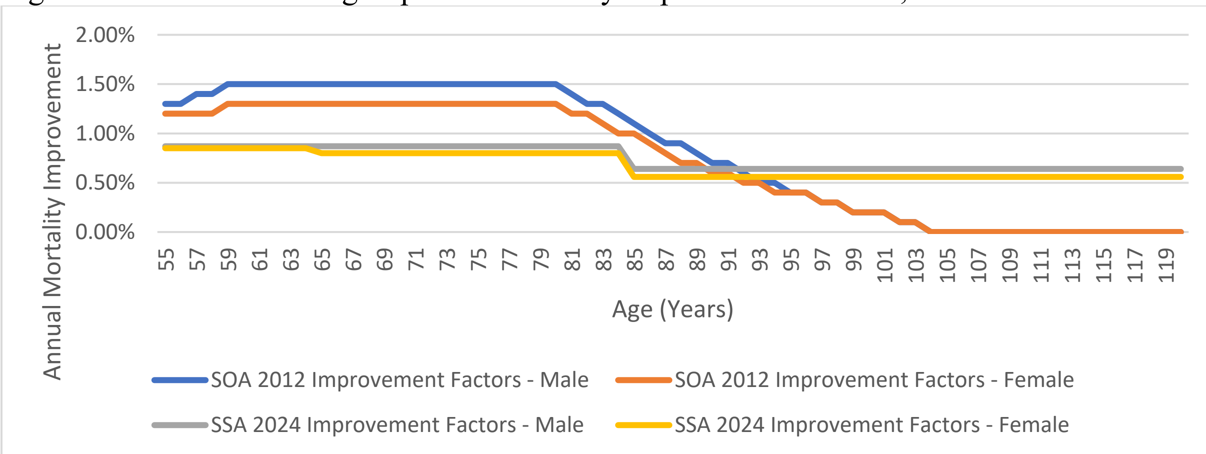
Table 2 reports projected population and annuitant mortality rates for men and women who were 65 years old in 2024. The absolute difference between the annuitant and population mortality rates increases with age, but the proportional difference shrinks. For a male annuity-buyer who is 65 years old in 2024, for example, the projected mortality rate at age 85 is 0.047, while for an average individual in the population the mortality rate projected by SSA is 0.080. There are similar, but smaller, differences for women. The disparity between the mortality rates in the 2024 SSA and SOA cohort tables arises mostly from different historical levels of mortality between the population at large and annuity buyers, but there are also differences in the assumed rate of mortality improvement in future years. The SOA mortality rates in 2012 were based on observed mortality through 2004, while the SSA table uses mortality information through 2021.

SSA mortality rates reflect not only the slowdown in the rate of mortality improvement in the last decade and a half, but also capture mortality elevation associated with the COVID-19 pandemic. The effect of the pandemic can be illustrated by tracking changes in the SSA's age-specific mortality rates in recent years. In 2022, when the SSA relied on mortality experience through 2019, the mortality rate for a 65-year-old man was projected to be 0.0160 – 16 deaths per 1,000 men. In 2023, drawing on data through 2020, the first pandemic year, this value was 0.0189. For 2024, informed by data from both 2020 and 2021 as well as evolving views of the longer-term effects of COVID-19 on mortality rates, this mortality rate was 0.0199. The SOA mortality rate projections do not reflect any information on the effects of COVID-19.[9]

Table 3 reports, and Figure 2 plots, the mortality improvement factors associated with both the SOA and the SSA cohort mortality tables. The SOA assumes a rate of mortality

9 The effect of the COVID-19 pandemic on future mortality rates for the U.S. elderly population remains an open question. Mortality rates could remain elevated as a result of ongoing exposure to the COVID-19 virus or as a result of scarring, but a survey by Stryker and Rudolph (2022) suggests that many analysts expect modest effects and a gradual return toward pre-pandemic mortality rates.

Figure 2: SOA and SSA Age-Specific Mortality Improvement Factors, Post-2024



Source: SSA (2024), Table 2.2 "Intermediate Alternative', and SOA (2011) Exhibit III, "Projection Scale G2". This figure shows the SSA improvement assumptions through 2044; the rate of improvement is lower beyond that year. SOA assumes the same rate of improvement in all future years.

improvement that is about 1.5 times that of the SSA for men, and 1.35 for women. The SOA improvement factor, 1.46% per year for men aged 65-84, implies that after 20 years, the age-specific mortality rate is 0.745 times the mortality rate in the base year. SSA, by contrast, assumes an age-specific mortality rate in 20 years of 0.819 times the base year value. Beyond age 90, SSA assumes greater mortality improvements than SOA, but the rate of mortality improvement for ages 65-84 has a larger impact on EPDV calculations than the rate of improvement at older ages.

4. Mortality Selection among Annuity Buyers: Variation by Contract Age

Shoven and Walton (2023) observe that one potential benefit of buying a deferred annuity is that buyers may have less information about their potential future mortality risk than their near term risk. Hence, insurers would not need to charge as large a selection premium for a deferred annuity as for an immediate annuity. It is not clear *a priori* whether the buyers of immediate or deferred annuities are likely to be more highly selected. On one hand, if individuals have less information about their mortality risk a decade or two into the future than about their near-term mortality, then those who purchase deferred annuities may have mortality experience as they approach the age at which payouts begin that is closer to that of the general population than to that of immediate annuitants buying annuities at that time. Nevertheless, private information about near-term mortality will affect the probability that buyers are still alive when payouts begin. On the other hand, if deferred annuity buyers can predict their mortality many years into the future, or if annuity purchase is driven by persistent correlates of longevity such as wealth, then deferred annuity buyers could be drawn from the longest-lived segment of the population, a group even more selected than immediate annuity buyers.

To shed light on the question of whether annuity buyers' private information decays over time, we analyze data from the SOA Individual Annuity Experience Study (IAES). It combines data from 21 insurers covering the years 2009 – 2013 and includes 4.5 million contract-years and over 230,000 deaths. The data record the age and sex of the annuitant, the number of years since annuity purchase, the amount annuitized, whether the annuity included a guarantee or deferral period, and whether the annuity was part of a joint purchase.

We calculate the ratio of actual deaths in each year to expected deaths for annuitants of a given age whose annuities have been in force for a particular length of time. We estimate the expected mortality rate for each age-sex combination up to age 100 by tabulating the actual mortality in the IAES dataset. At ages above 100, we follow SOA2012 and assume a 40% mortality rate. Our estimated mortality rates differ from those in the SOA2012 table, which was constructed using mortality experience through 2004 and assumed more rapid than actual mortality improvement. Observed mortality between 2009 and 2013 in the IAES sample is 118.5% of that predicted by the SOA2012 table.

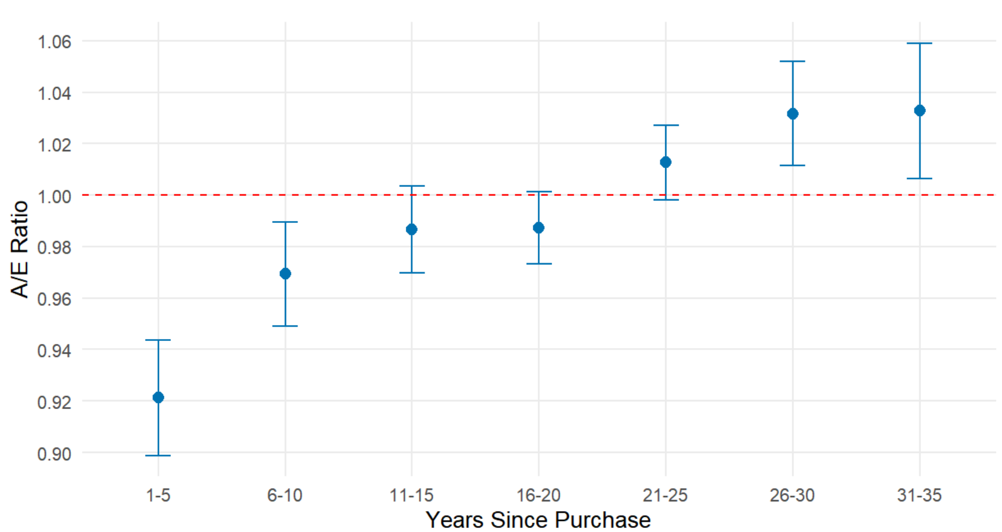
We investigate the 'term structure' of adverse selection by computing the ratio of the sum of actual deaths in our dataset to the sum of predicted deaths, where the predicted deaths are calculated using the mortality rates that we estimate for the full IAES sample.[10] We measure the mortality experience of the study population underlying the SOA2012 table, namely annuity owners in the 2000-2004 period. Because the dataset is partially aggregated, we do not observe the actual years of exposure to mortality risk at each age. However, since expected deaths = mortality rate × exposure, we can compute exposure from expected deaths (reported in the data) divided by mortality (from the SOA2012 table). We also compute mortality by age and sex per year of exposure. This becomes our measure of duration-agnostic expected mortality.

---

10 We compute standard errors under the assumption that expected deaths are certain, so in each age-gender cell, $SE_{Actual} = \sqrt{Var(Actual)/N}$ and the confidence interval has width $1.96 \times \frac{SE_{Actual}}{Expected}$.

We stratify annuitants by contract duration and compute the ratio of actual to expected mortality, which compares realized mortality in different years of the contract, for the same age and sex, to a duration-independent expected mortality rate. Figure 3 shows that the degree of selection declines with the length of time since annuity purchase. In the five years following purchase, annuitants' observed mortality rate is about 0.92 times the expected mortality rate for all annuitants of their age and sex. This ratio rises as the contract continues, and after 20 years, the observed mortality is slightly higher than the expected mortality for all annuitants. Recall that expected mortality is calculated from the experience of all annuitants in an age/sex category, regardless of their contract age. For newly-purchased annuities, observed buyer mortality is lower than that of all annuitants, a group that includes new as well as "experienced" annuitants.

Figure 3 – Actual/Expected Annuitant Mortality by Years since Annuity Purchase

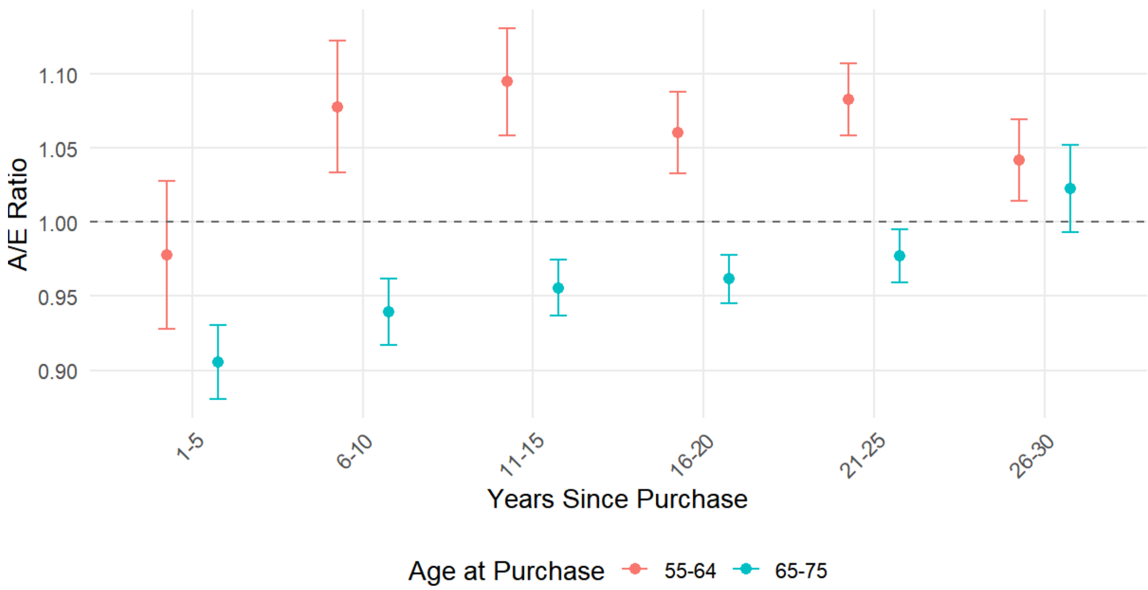


Note: Authors' calculations based on the Society of Actuaries' Individual Annuity Experience Study which covers 4.5 million contract-years over the years 2009-2013. Bands show 95% confidence intervals.

Over time, the relative mortality of a given cohort of annuity buyers rises relative to that of all annuitants. After 30 years, the observed mortality experience of the cohort is 1.03 times the expected all-annuitant mortality – annuitants whose contracts have run for a shorter time have relatively lower mortality rates. This pattern is consistent with annuitants knowing that they have no pressing health concerns when they purchase an annuity, but with that knowledge becoming less relevant as time passes and health shocks are realized.

When we further disaggregate by stratifying Actual/Expected Mortality by each annuitant's current age, gender, time since purchase, and age at purchase, we find greater variation in mortality rate by time since purchase for older (65-74) than younger (55-64) annuity buyers. Figure 4 shows these results, which are consistent with those in their late 50s and early 60s having less information on what their health status and mortality risk will be in ten years than those who buy annuities in their late 60s and early 70s. Because those in the older group may be considering annuity purchase at an age when many chronic conditions have developed, they may have more predictive information for their mortality a decade ahead.

Figure 4: Actual/Expected Annuitant Mortality by Years Since Purchase and Age at Purchase



Note: Authors' calculations based on the Society of Actuaries' Individual Annuity Experience Study which covers 4.5 million contract-years over the years 2009-2013.

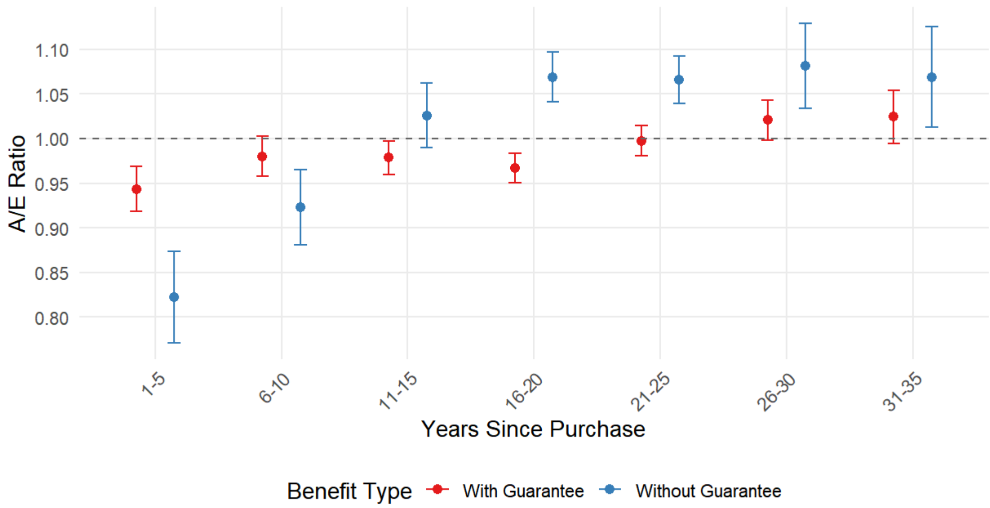
The findings in Figure 4 suggest that buying a deferred annuity can mitigate selection to some degree. When the payouts are in the distant future, the annuity buyer's mortality is less adversely selected than when payouts begin in the early contract years. This does not imply, however, that an insurer can ignore the initial selection effects when pricing a deferred annuity. The probability of receiving a deferred annuity payment depends on the mortality rates in all years up to the start of payouts. Since a new annuity buyer has lower mortality risk than the average annuitant in the first few years after contract purchase, their cumulative survival probability to the age at which payouts begin will be higher than the annuitant mortality table suggests.

The annuitant mortality rate for a 65-year-old male, the rate presented in the SOA2012 mortality table, combines the mortality experience of 65-year-old annuitants who bought their annuities at various ages. Those who bought at age 45 are mixed together with those who have just purchased. The former, now 20 years into their annuity payouts, have relatively higher mortality than the latter, whose information on health status is current. The mix of recent and long-holding annuitants varies systematically with age; at age 85, a larger fraction of annuitants have held their annuity for many years than at younger ages. An annuity priced according to a blended table that ignores duration may capture the mortality experience of a young prospective buyer reasonably well, but it may underestimate the value of an immediate annuity to an older buyer. For the latter, favorable selection may create a divergence from the mortality experience of other annuitants of that age.

To explore the importance of the 'term structure' of selection in annuity valuation, we adjust the baseline SOA2012 mortality table using the multiplicative factors shown in Figure 3 and label this the "SOA Annuitant Mortality Table with Term Structure Adjustment". It is important to note that at the ages for which we consider annuity purchases, the underlying mortality rate is quite low. At age 65, for example, the one-year mortality rate for a man is 0.0075 in the SOA table. Figure 3 suggests multiplying this by a factor of about 0.92 for the first few years after purchase. This reduces the mortality rate to 0.0069 – a substantial percentage change but a very small absolute change. The absolute change is what matters for pricing.

One annuity feature that we have not focused on so far is the presence of a guarantee period, a provision that promises the annuitant or the annuitant's heir's payouts for a fixed length of time regardless of the annuitant's longevity. Selection may be different for products with and without guarantees. Figure 5 shows the actual/expected mortality ratios for annuitants who purchased contracts with and without guarantee periods. The difference between the mortality of recent annuity buyers and long-holding annuitants – the slope of the term structure – is greater for those who purchase annuities without a guarantee. This pattern is consistent with Finkelstein and Poterba's (2004) finding of differential selection across annuity product types. It reflects the more limited importance of prospective mortality in determining the return to purchasing an annuity with a guarantee period relative to one without.

Figure 5 – Actual/Expected Annuity Mortality by Years since Purchase and Annuity Type



Note: Authors' calculations based on the Society of Actuaries' Individual Annuity Experience Study which covers 4.5 million contract-years over the years 2009-2013.

5. EPDV Estimates for SPIAs and DIAs

We use the information on annuity payouts, mortality rates, and discount rates from the foregoing sections to calculate EPDVs. All the annuities we consider have purchase prices of $100,000, so the money's worth values are EPDV/100,000.

5.1 EPDVs for SPIAs

Table 4 presents EPDV estimates for SPIAs using three different mortality tables: the population mortality rates from SSA, the SOA 2012 mortality table, and the "term structure adjusted" SOA 2012 table. Those calculated using the population mortality table are significantly lower than those calculated using the annuitant mortality table, and those calculated using the BBB yield curve are significantly lower than those using the Treasury yield curve, since BBB yields are higher than Treasury yields. The results for a 65-year-old male annuity buyer illustrate these patterns. In our benchmark case, which combines the Treasury yield curve and the annuitant mortality table, the EPDV is $100,864. The corresponding value using the population mortality table and the Treasury yield curve, $87,323, is significantly lower. The expected cost of longevity protection for an individual facing population-wide mortality rates and believing that the annuity payouts are nearly riskless is about 13 percent of the annuity purchase price; for someone who believes that he faces annuitant mortality rates, the expected value of payouts is very close to the premium.

Adjusting the annuitant mortality curve for the 'term structure' effects described above has a small impact on the EPDV calculation. For a SPIA bought by a 65-year-old male, the EPDV changes from $100,864 (SOA table) to $101,208 (term-structure adjusted table), an increase of about 0.3 percentage points. The percentage change is similar with the corporate BBB yield curve. These relatively small differences are due to the fact that even though we find evidence of differences in mortality rates as a function of the time since the annuity product was purchased, in the early years after purchase, the mortality rates are relatively low, so even modest percentage differences result in small absolute changes in the mortality table.

The EPDV values for women are similar to those for men. For the benchmark case of a 65-year old using the Treasury discount rate, the EPDV using the SOA mortality table, $100,632, is very close to that for men ($100,864). The disparities between the values for men and women are somewhat larger in the case of corporate BBB discount rates, although still typically less than one percent of the EPDV.

One potentially puzzling finding in Table 4 is that for many products, when the Treasury yield curve is used to discount future annuity payouts and the annuitant mortality table is used to determine longevity, estimated EPDVs are greater than the annuity premium. What does this imply about the profitability of these products, since our calculations do not allow for any commission costs for the agents who sell annuities, any taxes on the insurance companies that offer annuity products, or a number of other costs that might reduce the profit from selling annuities? Are insurers expecting to lose money, in a present-value sense? A likely resolution is that insurers invest the premium payments in risky assets with expected returns that are above Treasury-bond returns. The presence of state guaranty pools and the possibility of government support for the insurance industry in the case of a system-wide shock to capital reserves suggest that the appropriate discount rate for potential annuity buyers, at least those with annuity purchases below the state insurance caps, is lower than the cost of capital for insurance companies. If insurance companies' internal profitability calculations assume expected returns closer to corporate BBB yields than to Treasuries, then these products may generate profits. When the EPDVs are calculated with the SOA mortality table, and the BBB yield curve is used for discounting, the highest EPDV is $92,037, and the lowest is $88,683. These values suggest that insurers could cover costs that we have not considered and still break even.

The results in Table 4 illustrate the proposition that retail clients may be prepared to accept returns below those generated by the insurers' portfolios. Consider the EPDVs in Table 4 that are calculated using discount rates equal to the interest rates implicit in insurers' term annuity offerings. Even though the implied IRR on term annuities is less than the riskless Treasury return, insurers still find buyers for term annuities, and insurers are not likely to be using the discount rates implicit in those products as their cost of capital.

Although we focus primarily on the EPDV of annuity payouts, when evaluating annuities as investment products, the internal rate of return (IRR) is a useful metric. We shift the Treasury interest rate curve by a constant factor to generate an EPDV of $100,000. For a SPIA offered to a 65-year-old man, valued using the SOA mortality table, the IRR is 8.5 basis points above the Treasury curve. The IRR for same annuity valued with the SSA table is 145 basis points below Treasuries. For women aged 65, the IRR values are similar: 6 basis points when using the SOA table and -89 basis points when using the SSA table. The IRR using the annuitant table, in both cases, is slightly higher than the ten-year Treasury yield, but the values using the SSA table are well below. Shoven and Walton (2023) also report IRRs for SPIAs at age 65, and find values below the 10-year Treasury yield.

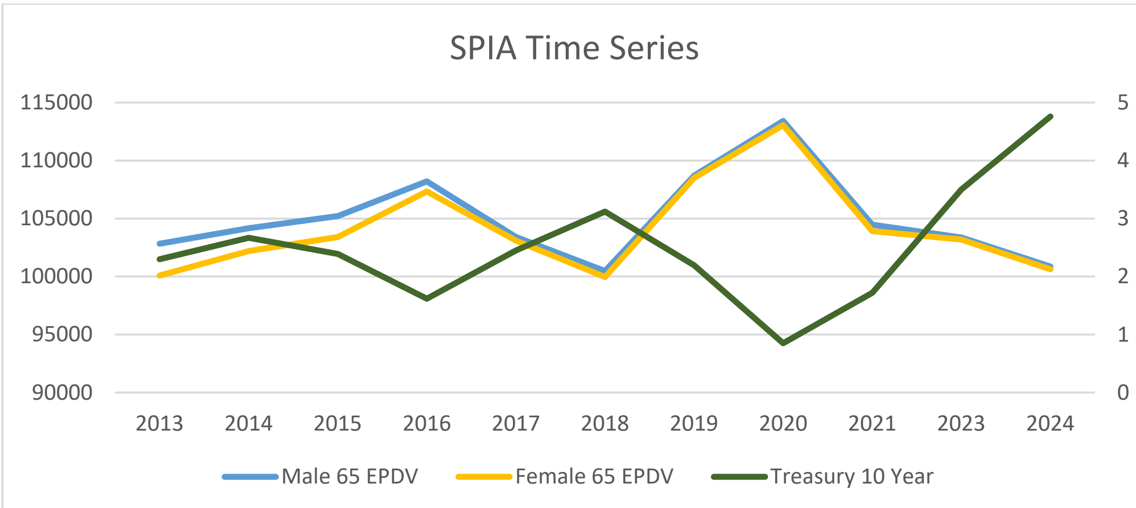
Our analysis focuses on SPIAs that were available at a point in time: May 2024. There is substantial variation over time in the average annual payout offered on SPIAs; the payouts per premium dollar track nominal interest rates closely. The substantial decline in nominal interest rates between 2000 and 2020 was associated with falling annuity payouts, and the interest rate rebound since 2022 has been associated with rising payouts. The average annual payout on a $100,000 SPIA for a 65-year-old man was $7,656 in May 2024, compared with $5,556 in January 2021, $6,456 in June 2015, $7,344 in June 2010, and $7,740 in June 2005. Calculations similar to those in Table 4 for other years reveal that EPDVs are more stable than annuity payouts in the face of interest rate fluctuations.

Figure 6 shows the historical evolution of the EPDVs for SPIAs for 65-year-old men and women since 2012, in each year discounting with Treasury yields.[11] Nominal Treasury yields,

11 Pre-2022 annuity prices are drawn from the *Annuity Shopper*, a twice-a-year online publication. More recent data come from its successor, the website immediateannuites.com.

proxied by the 10-year bond yield, increased by almost 400 basis points between 2020 and 2024; EPDVs fell by about 10 percent over the same period. The evidence is consistent with Charupat,

Figure 6: Time Series Variation in EPDVs, 2012-2024, Men and Women at Age 65



Note: Entries correspond to the EPDVs for 65-year-old men and women, calculated using the SOA mortality curve and the Treasury yield curve. Data are from mid-year except for 2021, when they are from January, and 2024, when they are from May.

Kamstra, and Milevsky's (2015) finding that annuity prices react slowly as interest rates change, and more quickly to rate increases than decreases.

5.2 EPDVs for DIAs

The EPDV of deferred annuities can be calculated using the same approach that we apply to SPIAs. The payout stream of the DIA begins later, which makes valuation more sensitive to the assumed discount rate. For a SPIA purchased at age 65, payouts received in the first two decades account for most of the value. For a SPIA purchased by a 65-year-old man, the EPDV using the Treasury yield curve and SOA mortality is $100,864 and $12,027 of that value – 12% of the policy's value – is associated with payouts after the age of 85. The analogous calculation for a 65-year-old woman indicates that post-85 payouts account for 14% of the SPIA's EPDV. This is why the premium for a deferred annuity is much lower – less than one fifth – of the premium for a SPIA delivering the same annual payout amount.

Table 5 presents EPDV calculations for DIAs purchased by men and women between the ages of 55 and 75 and beginning payouts after 10 or 20 years. Three results are noteworthy. First, the money's worth of a DIA is more sensitive to discount rate assumptions than the money's worth of a SPIA. This can be seen from the greater disparity in the EPDV values between the Treasury and the corporate BBB yield curves for DIAs than SPIAs. For a 65-year-old man, a deferred annuity beginning at age 85 has an EPDV of $77,317 when valued using the corporate BBB yield curve, and of $102,014 when valued using Treasury yields. The disparities are similar for women at age 65, $74,949 and $99,714 respectively. The difference in the EPDV between the Treasury and corporate BBB valuation is larger if the 20-year-deferred annuity is purchased at age 55 than age 65.

Second, when valued using the Treasury yield curve and the annuitant mortality table, the EPDVs for DIAs are similar to those for SPIAs. When payouts are valued using the corporate BBB term structure, the EPDVs are substantially lower than the corresponding values for SPIAs, a finding that emerges when we use the SOA mortality table and is even stronger with the SSA table. Similarly, the disparity between DIA valuation using population and annuitant mortality curves is significantly larger than the analogous disparity for SPIAs. While the difference was $13,541 (men at age 65) and $9,036 (women at 65) in the case of SPIAs, the differences are $42,998 (men at 65) and $31,175 (women at 65) for DIAs. The comparatively low money's worth values for these products raise the question of whether they are attractive for typical retirees.

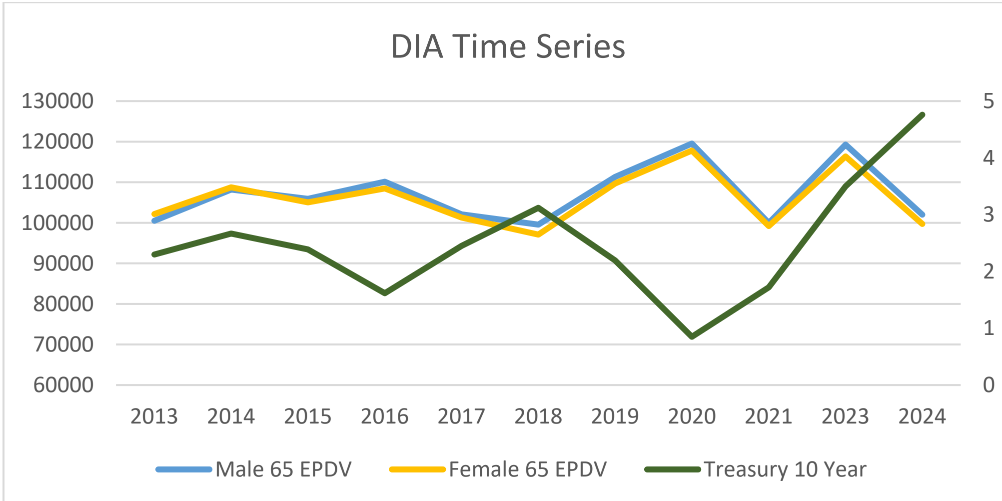
Horneff, Maurer, and Mitchell (2020) suggest that there are lifetime utility gains to retirees who purchase deferred annuities as to insure against the risk of living unexpectedly long. They assume that DIAs are priced "at cost" using the annuitant mortality table and a riskless interest rate of 1%. This imposes an EPDV equal to the premium for a buyer facing annuitant mortality risk. Their expected utility calculations, however, use the population mortality table, which implies a much lower EPDV from the perspective of their annuity buyers. Their findings imply that even with EPDVs well below the purchase price, DIA buyers can still achieve utility gains. This is a reflection of the cost of uninsured late-life consumption risk in the absence of other annuity markets, which MPWB (1999) and others point out can be highly dependent on access to other sources of annuity-like income such as Social Security.

Third, the "term structure" mortality adjustment described above has relatively little effect on DIA valuation. Comparison between Tables 4 and 5 does not suggest systematically higher EPDVs for DIAs than for SPIAs. Our findings are consistent with less selection for those who buy payout streams that begin further into the future, but the absolute mortality differences are small.

DIAs have much longer duration than immediate annuities. The duration of a SPIA sold to a 65-year-old man (woman), calculated using Treasury yields and the annuitant mortality table, is 9.9 (10.3) years, while that of a DIA that begins payouts at age 85 is 24.8 (24.2) years. Insurers face greater risk with DIAs than SPIAs of medical progress or other unexpected developments that affect longevity. These risks, as well as long-term capital market risks, are difficult to hedge, and may lead annuity sellers to demand a risk premium from buyers. In addition, the longer duration of DIAs may be relevant for investment management. Insurers may be able to take advantage of long-duration investment opportunities with the funds that back DIAs but not SPIAs. However, the supply of such opportunities may be limited. Verani and Yu (2024) note that about 90% of all corporate bonds are issued with maturities of ten years or less. Insurance company portfolio managers may struggle to find bonds with attractive risk and return attributes and long enough duration to match the liability stream of a deferred annuity.

Just as for SPIAs, the substantial variation over time in interest rates has been associated with some variation in the Treasury-yield-discounted EPDVs for DIAs. Figure 7 shows these EPDVs have been between $100,000 and $120,000 since 2013. As in Figure 6, there is some evidence of particularly high EPDVs in periods right after interest rate declines. This could be due to inertia in repricing or to insurance companies assuming that they would be able to generate higher-than-Treasury returns over the course of the contract period. The EPDVs in both Figures 6 and 7 were higher in 2022, when interest rates were rebounding from their 2020 lows, than in 2024. This is consistent with Shoven and Walton (2023), who analyze annuity prices from 2022. They find systematically higher EPDVs for deferred annuities than we find for 2024. Our findings on the EPDVs of DIAs relate to the discussion in Blanchett (2014), Scott (2008), and elsewhere about the role of deferred annuities in retirement portfolios.

Figure 7: Time Series Variation in EPDV of Deferred Annuities



Notes: Entries correspond to EPDV for DIAs beginning payouts at age 85, sold to 65-year-old buyers, using *Annuity Shopper* pricing data and the annuitant mortality table. Data are from mid-year except for 2021, when they are from January, and 2024, when they are from May.

6. Guarantee Provisions and Exposure to Life-Contingent Income Streams

Although our analysis focuses primarily on SPIAs and DIAs, there are a range of other annuity products that account for a larger share of annuity sales. These include cash-back annuities, which promise to repay the annuitant or the annuitant's heirs the full amount of the nominal premium with a one-time payment if the sum of payments at the time of the annuitant's death falls short of the premium, escalating annuities, which promise rising nominal payouts, typically at 3% per year, and guaranteed income annuities that promise to make payments for a fixed length of time, typically 10 or 20 years, regardless of whether the annuitant lives that long. Brown, Poterba, and Richardson (2025) report that at TIAA, a large provider of retirement income for workers in the non-profit sector, more than three quarters of annuitants select an annuity with a guarantee period.

Table 6 presents findings for the EPDV of SPIAs with a guarantee period. We refer to these products as guaranteed income annuities (GIAs). When discounted with the Treasury yield curve and using the SOA mortality table, the values are similar to those in Table 4. The range of values for men and women, aged 55 and 65, is between $100,261 (men at 65) and $101,814 (women at 55). Adjusting for the "term structure" of mortality again has a relatively modest effect; shifting from the Treasury yield curve to the corporate BBB yield curve, or from the SOA to the population mortality table, reduces the EPDVs significantly, just as it did for SPIAs.

The EPDV framework can be used to calculate the extent to which guarantee provisions in annuity contracts alter the balance between a life-contingent payment stream and a certain payout stream such as that associated with a bond. An annuity with a 50-year guarantee period, purchased by a 65-year-old man, is effectively a bond, and not a life-contingent contract. But what if the annuity provides a 20-year guarantee period? We compare a SPIA with a 20 year guarantee for a 65-year-old man with a SPIA without guarantee, using the SOA mortality table and the Treasury yield curve. The valuation equation comparable to equation (1) for a SPIA with a guarantee of 20 years, or 40 payments in our twice-per-year simplification, is

(5) $$V_{b,guarantee}(A) = \sum_{j=0}^{39} \frac{A'}{(1+i_j)^j} + \sum_{j=40}^{240-2b} \frac{A' * P_{b,j}}{(1+i_j)^j}$$

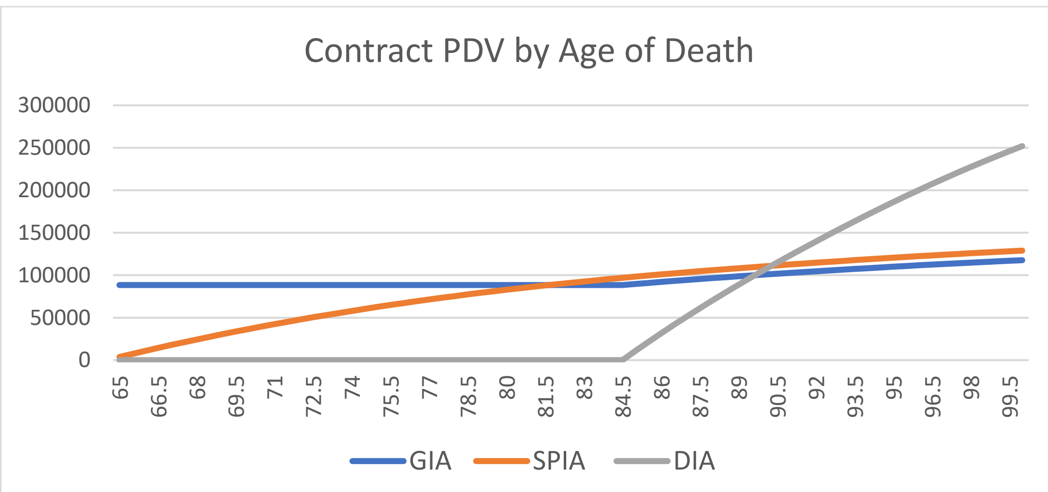
For annuities available in May 2024, the annual payout on the contract with the 20-year guarantee (A') is \$6,984 per year, compared with \$7,656 (A in equation (1)) for a SPIA with no guarantee. For the contract with the guarantee period, the EPDV of the payouts in the first 20 years – the guaranteed period – is \$88,434. The EPDV of the contract, including the life-contingent payouts beyond the 20-year window, is \$100,261. Table 4 showed that the EPDV of a SPIA with no guarantee period was \$100,864. Thus 88% of the value of the guaranteed annuity is associated with its bond-like component. For a 65-year-old woman purchasing a 20-year GIA, 86% of the value comes from the bond-like component because the woman is more likely than her male counterpart to outlive the guarantee period.

Table 7 reports the share of the payouts from a 20-year GIA that are life contingent, when purchased by men and women at ages 55 and 65, valued using the discount rates and mortality tables that we considered in Table 4. For our benchmark cases of 65-year-old men and women, the life-contingent share is never greater than 14 percent for women or 12 percent for men. These findings underscore that annuities with guarantee periods are much closer to term annuities than to purely life-contingent products in which dying soon after purchase results in much lower payouts to the annuitant and his or her heirs.

The guarantee period reduces the likelihood that the annuitant and his or her heirs will receive very limited payouts as a result of early death of the annuitant. Using the SOA mortality table and the Treasury yield curve, we calculate that a 65-year-old man purchasing a \$100,000 SPIA with no guarantee period has a 4% chance of dying before he receives payouts with a present discounted value of \$25,000 (this requires living to age 70), and an 11% chance of dying before receiving \$50,000 (this requires living to age 75). The protection of the guarantee period eliminates the risk of such low payback, but comes at the cost of a lower annual annuity payout, namely, 8.8% less in the case of a 65-year-old male annuitant. By electing to purchase an annuity with a guarantee period, the buyer not only alters the level of the payout but also changes the nature of the product being purchased, replacing a completely life-contingent contract with one that is largely a fixed-income bond.

Annuity contracts with some guarantee features are more popular than those without any assured level of payouts. Two of the most popular products currently are the lump sum refund annuity, a policy that promises to pay the annuitant's beneficiaries the difference between the purchase price and the cumulated sum of benefit payments if the annuitant dies before receiving $100,000 in total nominal benefits, and the annuities with a guarantee period that we analyzed

Figure 8: Realized Annuity PDV by Age of Death



Notes: Each curve shows the PDV of all payments received from a $100,000 annuity product if the annuitant dies at the age shown on the horizontal axis.

above. Figure 8 shows the present discounted value of the payouts that an annuitant and his heirs receive, as a function of his date of death, for various policy choices. For an annuity with a guarantee period, this value is not affected by the annuitant's date of death when it occurs in the first twenty years after purchase – his heirs continue to receive payouts until the twentieth year after purchase. If the annuitant lives more than 20 years, the PDV rises with each additional year. For a SPIA without a guarantee, in contrast, the PDV is low if the annuitant dies soon after the contract purchase. If he lives longer, the PDV rises, and the rate of increase per year is greater than that for a SPIA with a guarantee because the annual payout is larger. For DIAs, the

PDV of income received is zero until the annuitant reaches age 85, but after that, the present discounted value rises much more quickly with each additional year of life than for either the SPIA or GIAs, because the DIA annual payout is much larger.

7. Implications for Deferred Annuity Purchases before Retirement

Although research on annuity products has focused largely on the demand by households at the point of retirement, a number of financial institutions have recently introduced lifecycle funds that include deferred annuities. These products involve the purchase of annuities, in various ways, during the wealth accumulation period prior to retirement. Kephart, Lamas, and Look (2024) report that a number of financial institutions now offer "target date with annuity" accumulation products, in most cases offering annuities from more than one insurer.

Shoven and Walton (2023) find that for someone who plans to purchase an annuity at retirement, buying deferred annuities on the way to retirement can yield a higher stream of post-retirement income than investing in Treasury bonds. This could be true even if the IRR on both the DIA and the SPIA fall below the Treasury yield; it is a statement about the implied IRR during the accumulation period before SPIA purchase. We find a similar result using data that were collected two years after theirs and focusing on average annuity policies rather than the one with the highest payout. We compare, for a 55-year-old, two strategies: a) invest the principal for 10 years and then buy a SPIA at age 65, when we assume current annuity prices will prevail, and b) buy a 10-year DIA immediately. To equalize the returns on these strategies, the principal must earn 5% in the intervening 10 years. This IRR is about 25 basis points higher than the 10-year Treasury yield on the date our data were collected.

Our baseline calculations focus on the EPDVs or IRRs of deferred annuities as standalone products, not in relation to a SPIA bought 10 years into the future. We find that for the average DIA in the marketplace, the EPDV calculated with the population mortality table falls below the purchase price, which means that the IRR is below the yield on Treasury bonds. We suspect that the highest-vs.-average difference accounts for much of the disparity, particularly because there is greater heterogeneity in DIA payouts than in SPIA payouts. When we calculate IRRs using the annuitant mortality table, we find that the IRR on a DIA is slightly higher than the 10-year Treasury yield. If we did our analysis for the highest-payout DIA, the IRR would be higher still.

In October 2025, the ImmediateAnnuities.com website reports quotes from eight companies offering individual annuities. The quotes are state-specific; for the state of New York, for example, the range between the highest and lowest monthly payouts for a SPIA offered to a 65-year-old man is from \$583 to \$655 – a range of about 12 percent of the payout. For DIAs, for which there are fewer quotes available, the difference is more than 17 percent. This suggests that which firm an annuitant buys from matters more in the deferred annuity market than in the SPIA market.

8. Conclusion

This paper presents new estimates of the expected present discounted value (EPDV) of payouts on a range of annuity products, including both immediate annuities, the primary focus of past research, deferred annuities, which are attracting growing attention, and guaranteed annuities, which provide some longevity insurance but with payouts that are less longevity-contingent than immediate or deferred annuities. It focuses on products that were available in the US retail market in May 2024. For both immediate and deferred annuities, when the mortality experience of annuity buyers, as measured by the SOA Annuitant Mortality Table, is combined with discount rates from the Treasury yield curve, the EPDV is very close to the purchase price and in some cases slightly greater. If we use the mortality table for the population at large, however, the EPDV falls to about 90 percent of the premium for immediate and less than 80 percent for deferred annuities. Deferred annuity valuations are more sensitive than immediate annuity valuations to discount rate and mortality rate assumptions. The duration of deferred annuities is substantially longer than that of immediate annuities, and insurance companies may find it more difficult to hedge both mortality and return risk over long horizons.

These results confirm earlier findings of the disparity between annuity valuation for typical annuitants and the population at large; adverse selection is therefore a potential explanation for the annuity puzzle. Because deferred annuity valuations are more sensitive than immediate annuity valuations to the choice between population and annuitant mortality rates, selection may be a greater factor in the deferred annuity market. A key question, however, is whether adverse selection is significant enough to make annuities unattractive for an average retiree. For immediate annuities, the difference between the EPDV and the annuity premium is within the range for which some earlier studies, such as MPWB (1999), find expected welfare gains from purchase, especially if there are no government-provided annuities like Social

Security. For deferred annuities, the EPDV-to-premium disparity is larger; but the findings in Horneff, Maurer, and Mitchell (2020) suggest that there may still be expected welfare gains.

The expected internal rate of return on both immediate and deferred annuities, calculated using the annuitant mortality table and the average prices for both annuities in the marketplace, is comparable to or slightly above the 10-year Treasury yield. For a prospective annuitant with mortality prospects closer to the population at large, however, the expected IRR on a deferred annuity is substantially below the Treasury yield, a finding that underscores the key role of mortality rate assumptions in annuity valuation. Shoven and Walton's (2023) recent analysis of whether an individual who plans to purchase an annuity at retirement should consider buying a deferred annuity, rather than investing in Treasury bonds, raises a new question about the timing of annuity purchase, deferred versus immediate, for prospective annuitants. They find that in the decade preceding retirement, a retirement saver facing the population mortality table who purchases the highest payout deferred annuity available in the market can earn a pre-retirement return higher than that on Treasury bonds. Our findings confirm this result for the pre-annuitization period, but our estimates of the IRR on DIAs as standalone purchases are lower than theirs. Part of this is due to their focus on a buyer who purchases the annuity with the highest payout, while we assume an equal-weighted basket of all annuities in the marketplace.

This paper also presents new evidence on how the mortality experience of annuity buyers is affected by the length of time since they purchased their annuities. Recent annuity buyers exhibit lower mortality risk than those of the same age and sex who bought annuities years ago, a finding that is consistent with private information about health and mortality risk being less accurate at longer forecast horizons. However, these disparities are not large enough to significantly affect the EPDV calculations.

Our findings on the expected present discounted value of annuity payouts relate to recent policy reforms designed to draw retirees' attention to the annuity market. The 2019 Setting Every Community Up for Retirement Enhancement (SECURE) Act requires retirement plan administrators to provide their participants with yearly illustrations of the annuitized lifetime income stream that their account balance could purchase. The regulatory guidance associated with this Act requires calculations of the payouts on a single life annuity and on a joint and survivor annuity, with the payouts chosen to break even when discounted at the 10-year Treasury yield and assuming mortality experience is described by a unisex mortality table for defined benefit pension plan participants. This algorithm generates a hypothetical annuity stream, but it may not coincide with the income available from policies that plan participants can purchase in the private market. Life expectancy in the defined benefit participant mortality table is longer than in the population table but shorter than in the annuitant table. Understanding the relationship between the estimated payouts calculated by plan administrators, and the actual payouts available in the annuity market, is important for analyzing the extent to which the calculation provides retirement plan participants with an accurate guide to future income streams.

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Table 1: Cross-Company Average Annual Annuity Payouts, Per $100,000 Premium, May 2024

	Age 55	Age 65	Age 75
Single Premium Immediate Annuity (SPIA)			
Men	$6,468 (8)	$7,656 (8)	$10,068 (8)
Women	$6,300 (8)	$7,356 (8)	$9,408 (8)
Joint and Survivor (Male and Female of Equal Age)	$5,880 (8)	$6,636 (8)	$8,136 (8)
SPIA, 20 Year Guarantee			
Men	$6,264 (8)	$6,984 (8)	$7,644 (8)
Women	$6,156 (8)	$6,852 (8)	$7,572 (8)
Deferred Income Annuity (DIA), 10 Year Deferral Period			
Men	$12,468 (8)	$17,400 (8)	N/A
Women	$11,808 (8)	$15,960 (8)	N/A
DIA, 20 Year Deferral Period			
Men	$29,448 (7)	$60,240 (6)	N/A
Women	$26,676 (7)	$50,352 (6)	N/A

Source: *immediateannuities.com*, May 2024. Each entry reports the average value of 12 times the monthly payout amount for the set of annuities included in the sample. Numbers in parentheses denote the sample size for each product class. Note that the average annual payout on a 10-year fixed-term annuity (no life contingency) from the 8 firms in the sample was $12,264, and for a 25-year fixed-term annuity (offered by 8 firms in the sample) was $6,888.

Table 2: Population and Annuitant Mortality Rates for 65-Year-Old Men and Women in 2024

	Men		Women	
	SSA 2024 Cohort Table, Birth Year 1959	SOA Annuity 2012 Table updated to 2024	SSA 2024 Cohort Table, Birth Year 1959	SOA Annuity 2012 Table updated to 2024
65	0.0160	0.0075	0.0094	0.0058
70	0.0204	0.0098	0.0133	0.0081
75	0.0306	0.015	0.0215	0.0119
80	0.0474	0.0246	0.0353	0.0194
85	0.0800	0.0467	0.0626	0.0395
90	0.135	0.0942	0.1086	0.0786
95	0.2093	0.174	0.1755	0.1375

Source: Authors' calculations as described in equation (6) with SOA mortality improvements drawn from SOA (2011) Exhibit III, Table 2.2 "Intermediate Alternative.' The entries in each column reflect the mortality rates at future ages for individuals who are 65 years old in 2024. The entries for 75-year-olds, for example, correspond to mortality rates expected to prevail in 2031.

Table 3: Comparisons between SOA and SSA Older-Age Mortality Improvement Projection Factors and Historical Population Experience

	Age Group	Historical Data				SOA Projection	SSA Projection	
		1968-1982	1982-1999	1999-2009	2009-2016	Post-2002	Pre-2044	Post-2044
Male	50-64	2.28	1.92	1.15	-0.29	1.33	1	1.05
	65-84	1.46	1.23	2.42	0.86	1.46	0.99	0.79
	85+	1.56	-0.32	1.49	0.37	0.28	0.6	0.53
Female	50-64	1.72	1.09	1.46	-0.46	1.19	0.97	1.05
	65-84	2.03	0.43	1.71	0.72	1.27	0.92	0.73
	85+	2.06	-0.43	1.16	0.16	0.25	0.54	0.5

Source: Historical data on mortality improvement rates are drawn from SSA (2019). SOA (2011) reports the assumed rates for the annuitant mortality table, and SSA (2019) the values for the SSA mortality table.

Table 4: Estimates of the EPDV of Immediate Annuity Payouts, Per $100,000 Premium

	Men			Women		
	Age 55	Age 65	Age 75	Age 55	Age 65	Age 75
SSA (2024) Population Mortality Table Updated with SSA Improvement Factors						
Insurer Implied Yield Curve	95,879	93,064	87,894	99,874	97,578	91,495
Treasury Yield Curve	90,541	87,323	82,676	94,542	91,596	85,946
Corporate BBB Yield Curve	80,526	79,881	77,693	83,327	83,158	80,265
SOA (2011) Annuitant Mortality Table Updated with SOA Improvement Factors						
Insurer Implied Yield Curve	107,249	107,425	105,433	107,123	107,064	104,992
Treasury Yield Curve	101,768	100,864	98,936	101,826	100,632	98,456
Corporate BBB Yield Curve	89,039	91,066	92,037	88,683	90,416	91,168
SOA (2011) Annuitant Mortality Table with Term Structure Adjustment						
Insurer Implied Yield Curve	107,405	107,802	n.a.	107,221	107,353	n.a.
Treasury Yield Curve	101,910	101,208	n.a.	101,913	100,893	n.a.
Corporate BBB Yield Curve	89,168	91,380	n.a.	88,764	90,657	n.a.

Source: Authors' calculations using equation (1) and mortality rates and yield curves as described in the text, along with payouts on immediate annuity contracts in May 2024 as reported in Table 1.

Table 5: Estimates of EPDV of DIA Payouts, Per $100,000 Premium

	Men		Women	
	Age 55	Age 65	Age 55	Age 65
Deferred Income Annuity Beginning in 10 Years				
SSA (2024) Population Mortality Table Updated with SSA Improvement Factors				
Insurer Implied Yield Curve	85,343	78,675	90,988	85,411
Treasury Yield Curve	80,674	73,073	86,740	79,851
Corporate BBB Yield Curve	65,205	61,178	69,452	66,376
SOA (2011) Annuitant Mortality Table Updated with SOA Improvement Factors				
Insurer Implied Yield Curve	104,519	104,909	103,024	103,130
Treasury Yield Curve	99,757	97,868	98,974	96,837
Corporate BBB Yield Curve	79,213	80,981	78,157	79,667
SOA (2011) Annuitant Mortality Table with Term Structure Adjustment				
Insurer Implied Yield Curve	104,535	105,378	103,473	103,840
Treasury Yield Curve	99,730	98,287	99,066	97,135
Corporate BBB Yield Curve	79,247	81,352	78,242	79,937
Deferred Income Annuity Beginning in 20 Years				
SSA (2024) Population Mortality Table Updated with SSA Improvement Factors				
Insurer Implied Yield Curve	74,696	62,021	82,476	71,281
Treasury Yield Curve	73,641	59,016	82,150	68,539
Corporate BBB Yield Curve	53,817	45,250	59,404	52,072
SOA (2011) Annuitant Mortality Table Updated with SOA Improvement Factors				
Insurer Implied Yield Curve	105,599	106,225	102,751	102,854
Treasury Yield Curve	105,494	102,014	103,415	99,714
Corporate BBB Yield Curve	75,649	77,317	73,645	74,949
SOA (2011) Annuitant Mortality Table with Term Structure Adjustment				
Insurer Implied Yield Curve	105,260	106,294	103,049	103,170
Treasury Yield Curve	105,082	102,029	103,408	99,653
Corporate BBB Yield Curve	75,431	77,378	73,654	74,946

Source: Calculations using equation (1) as described in the text.

Table 6: Estimates of the EPDV of Annuity Payouts with Guarantee Periods, Per $100,000 Premium

	Men with 20 Year Guarantee		Women with 20 Year Guarantee	
	Age 55	Age 65	Age 55	Age 65
SSA (2024) Population Mortality Table Updated with SSA Improvement Factors				
Insurer Implied Yield Curve	100,760	101,817	102,497	102,571
Treasury Yield Curve	94,982	95,276	96,907	96,089
Corporate BBB Yield Curve	84,385	86,567	85,388	86,870
SOA (2011) Annuitant Mortality Table Updated with SOA Improvement Factors				
Insurer Implied Yield Curve	107,334	106,942	107,187	106,880
Treasury Yield Curve	101,757	100,261	101,814	100,332
Corporate BBB Yield Curve	89,029	90,285	88,675	89,983
SOA (2011) Annuitant Mortality Table with Term Structure Adjustment				
Insurer Implied Yield Curve	107,346	106,950	107,189	106,878
Treasury Yield Curve	101,766	100,263	101,813	100,323
Corporate BBB Yield Curve	89,039	90,292	88,677	89,983

Source: Authors' calculations using equation (1) and mortality rates and yield curves as described in the text, along with payouts on immediate annuity contracts with guarantee provisions available in May 2024 as described in Table 1.

Table 7: Share of EPDV for SPIAs with Guarantee Periods that is Life Contingent

	Men with 20 Year Guarantee		Women with 20 Year Guarantee	
	Age 55	Age 65	Age 55	Age 65
SSA (2024) Population Mortality Table Updated with SSA Improvement Factors				
Insurer Implied Yield Curve	16%	7%	19%	9%
Treasury Yield Curve	16%	7%	20%	10%
Corporate BBB Yield Curve	14%	6%	16%	8%
SOA (2011) Annuitant Mortality Table Updated with SOA Improvement Factors				
Insurer Implied Yield Curve	21%	12%	22%	13%
Treasury Yield Curve	22%	12%	23%	14%
Corporate BBB Yield Curve	18%	10%	19%	11%
SOA (2011) Annuitant Mortality Table with Term Structure Adjustment				
Insurer Implied Yield Curve	21%	12%	22%	13%
Treasury Yield Curve	21%	12%	23%	14%
Corporate BBB Yield Curve	18%	10%	19%	11%

Source: Authors' calculations as described in the text using mortality rates and yield curves as described in the text, along with payouts on immediate annuity contracts with guarantee provisions available in May 2024 as described in Table 1.

Table of Acronyms

DIA	Deferred Income Annuity
EPDV	Expected Present Discounted Value
ERISA	Employee Retirement Income Security Act
GIA	Guaranteed Income Annuity
IAES	Individual Annuity Experience Study
IAM	Individual Annuity Mortality
IRR	Internal Rate of Return
LIMRA	Life Insurance Marketing and Research Association
MPWB	Mitchell, Poterba, Warshawsky, and Brown
PDV	Present Discounted Value
SECURE	Setting Every Community Up for Retirement Enhancement
SOA	Society of Actuaries
SOA2012	Society of Actuaries 2012 Individual Annuitant Mortality Projections
SPIA	Single-Premium Immediate Annuity
SSA	Social Security Administration