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ABSTRACT

Estimates the expected present discounted value (EPDV) of future payouts on both immediate and deferred annuities are sensitive to the discount rate used to value future payment streams and assumptions about future mortality rates. This paper illustrates this with respect to annuities that were available in the US retail insurance market in 2020. The spread between the interest rates on Treasury and corporate bonds was high by historical standards as a share of the riskless Treasury yield during much of 2020, making the choice of discount rate more consequential than in the past. The EPDV estimates also depend on whether the rapid but since-attenuated decline in US old-age mortality rates during the 1990s and early 2000s is extrapolated to future decades. The “money’s worth” is the EPDV divided by the annuity’s purchase price. Our central estimates, using discount rates drawn from the corporate BBB yield curve and future mortality rates that combine a Society of Actuaries individual annuitant mortality table with projections of future mortality improvements from the Social Security Administration, suggest money’s worth values for annuities offered to 65-year-old men and women of about 92 cents per premium dollar. Recent Department of Labor rulemaking requires defined contribution plan sponsors to provide participants with estimates of the annuity income stream that their plan balance could purchase. These estimates, like EPDVs, are also sensitive to both prospective rate of return and mortality rate assumptions.

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Annuity markets attract the attention of economists and financial planners because they offer individuals a way of insuring against longevity risk, one of the most important late-life threats to financial security. In the United States, Social Security provides most retirees with an inflation-indexed annuity. Workers who are covered by defined benefit pension plans, which were more common three decades ago than today, typically receive guaranteed nominal annuity payments, in some cases with partial indexation for inflation.

Relatively few individuals who accumulate assets in defined contribution plans, or who accumulate substantial non-pension financial wealth, choose to annuitize. A large literature has considered whether this is consistent with optimizing behaviour in a stochastic lifecycle model. Explanations for the low rate of annuitization include the presence of a bequest motive for many of those with significant retirement wealth, recently studied by Lockwood (2018), the risk of late-life medical costs that are best addressed with a pool of non-annuitized wealth as in Reichling and Smetters (2015), adverse selection in the annuity market that leads insurers to price products in a way that is unattractive for many potential buyers as studied by Finkelstein and Poterba (2004) and others, mortality pessimism as in O'Dea and Sturrock (2020) and Solomon (2021), and the role of Social Security, Medicare, and Medicaid in providing a guaranteed consumption floor regardless of how long one lives. A number of empirical studies have explored the potential role of adverse selection in annuity pricing, including Canon and Tonks (2004), Mitchell, Poterba, Warshawsky, and Brown (1999), and Verani and Yu (2020). These studies compare expected present discounted value of future payouts on annuity products with their purchase price, typically finding that the "money's worth ratio," the ratio of the value of future payouts to the premium, falls below one. Adverse selection is one explanation for this finding, although Cannon and Tonks (2016) point out that it is difficult to distinguish selection from other pricing-relevant considerations such as regulatory requirements for capital reserves.

The 2019 Setting Every Community Up for Retirement Enhancement (SECURE) Act increases the salience of annuities as a way drawing down the accumulated assets in defined contribution plans. It requires retirement plan administrators to provide participants with two illustrations each year of the lifetime income stream that their current account balance could purchase. One must show the potential payouts associated with a single life annuity, and the other the payouts from a joint and survivor annuity. In August 2020, the Department of Labor (DOL) issued an Interim Final Rule directing plan administrators to calculate these potential payouts using the interest rate on a 10-year Treasury bond and a gender-neutral mortality table developed by the IRS. Rather than relying on the market prices of retail annuity products, this calculation estimates the annuity payout that a hypothetical at-cost insurer could offer annuitants if it could earn the return on a 10-year Treasury bond for the length of the annuity contract, and if it did not incur any other costs of supplying annuities. Estimates of the money's worth of existing retail annuities and of the potential annuity payouts to a DC plan participant both depend on an assumed rate of return at which future payments are discounted, and an assumed mortality table that describes the probability that an annuitant will be alive at various future dates.

This paper illustrates the sensitivity of money's worth ratios for retail annuities to both discount rate and mortality rate assumptions by focusing on policies that were offered in the U.S. market in June 2020. It also explains how uncertainties that have been recognized in the annuity valuation literature apply to the calculation of potential annuity payouts. One important distinction between retail annuity products and the hypothetical product described by the DOL guidance is that retail annuities are priced differently for men and women, while the annuities offered in retirement plans must be gender-blind. In the retail annuity market, women of a given age receive lower payouts per year per premium dollar than their male counterparts due to their lower average mortality rates at all ages. Annuities offered in qualified retirement plans on a unisex basis provide higher payouts to women, and lower payouts to men, than the payouts that they would receive if gender was considered in pricing.

Most previous empirical work on annuity markets, like the new DOL regulations, focuses on annuities that begin paying policyholders shortly after the date of purchase. These are known as single premium individual annuities (SPIAs) or their closely-related joint-and-survivor counterparts. Recently, deferred annuities have begun to attract interest for their potential role in providing longevity insurance. Deferred annuities are annuity contracts with a substantial period of time between the purchase date and the date on which payouts commence. 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 annuity that would begin payouts at age 85. The market for deferred annuities is currently small; we estimate that the money's worth values for these products are lower than for immediate annuities.

This paper is divided into eight sections. The first describes our framework for calculating the expected present discounted value of the payouts associated with an annuity product and its corresponding money's worth. The next three sections describe our data sources for annuity prices, the discount rates that apply to future payouts, and the assumed mortality rates for potential annuity buyers. Section five presents our estimates of the money's worth of immediate annuities and compares the payouts on retail annuities that are available in the market with the break-even calculations from the DOL algorithm. Section six reports on the share of the expected value of an annuity contract that is life-contingent, relative to the share that is guaranteed, for several annuity products with guarantee periods. The seventh section estimates the money's worth of deferred annuities; in general these estimates are lower than the estimates for immediate annuities. There is a brief conclusion.

1. Framework for Annuity Valuation

For retail annuity products that are currently offered by US insurance companies, we observe the initial premium as well as the monthly payout that the buyer will receive. We estimate the expected present discounted value (EPDV) of the stream of future payments, and define the money's worth of the policy as the ratio of the EPDV to the policy's premium. Past estimates of money's worth ratios have typically fallen between 0.80 and 0.95, with variation over time and as a function of the valuation assumptions. Koijen and Yogo (2015) report on a short period of time during the global financial crisis of 2009 when some insurers offered annuity policies with money's worth values greater than unity as a means of raising regulatory capital. Even when the EPDV is less than the purchase price, risk-averse potential annuitants may be prepared to purchase these products because they offer insurance against longevity risk.

We simplify our valuation calculations by assuming that annuities make two payouts each year, each equal to six promised monthly payments. We use $V_b(A)$ to 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. When purchased outside a retirement account, annuity payouts are taxable; we consider that case, but begin with, and focus on, purchases in retirement accounts. If the funds used to purchase the annuity were paid out of the account as a lump sum, they would be taxed at the individual's ordinary income tax rate. When the individual receives annuity payments from the retirement account, they are also taxed at this rate. As long as the annuitant's marginal income tax rate remains constant for his remaining lifetime, and the relevant discount rate is the pre-tax rate of return such as the interest rate on a bond held in a qualified plan account, the money's worth ratio is independent of the tax rate:

(1) $$V_b(A) = \sum_{j=0}^{240-2b} \frac{A * P_{b,j}}{(1+i_j)^j}.$$

We assume that the annuitant will not live beyond the age of 120, which means that b-year-old annuity buyer cannot receive more than 240 – 2*b payments. Our calculations are insensitive to shortening the maximum assumed lifespan to 115, 110 or 105 years.

Equation (1) shows that $V_b(A)$, depends on three inputs: the payouts associated with the annuity contract, the discount rates that are used to compute the present discounted value, and the survival probabilities that determine the likelihood that an annuitant will receive a given future payment. $P_{b,j}$ denotes the probability that an individual who purchases on annuity at age b will still be alive j half-years later, and i_j denotes the nominal pre-tax discount rate for a cash flow received j half-years after the date of the annuity purchase. We assume that the first annuity payout takes place six months after purchase. Our valuation exercises focus on annuities with constant nominal payout streams, but the same framework could be applied to annuities that offer payouts with a fixed nominal escalation schedule or other time-varying payout streams. To apply this framework to inflation-indexed annuities, estimates of future inflation rates, as well as nominal interest rates, would also be needed.

The ratio of $V_b(A)$ to the policy premium is the money's worth ratio. When the estimate of the EPDV is below the annuity's purchase price, the difference can be interpreted as the price of longevity insurance as a share of the policy premium. Another way to summarize this divergence is by calculating the internal rate of return, the discount rate at which the annuity's estimated EPDV would equal its purchase price. For an annuity with a purchase price of \$100,000 and a semi-annual nominal payment of A, this discount rate is the value ρ that solves the equation

(2) $$100{,}000 = \sum_{j=0}^{240-2b} \frac{A * P_{b,j}}{(1+\rho)^j}.$$

While this is a high-order polynomial equation, it is monotone in ρ for non-negative values, which typically yields a single real positive solution. When no positive solution exists, we report the negative solution with the smallest absolute value.

Equation (2) can be modified to estimate, instead of the discount rate ρ, a return premium or discount, δ, relative to the term structure of discount rates for riskless cash flows, that will equate the EPDV calculation with the annuity's purchase price. For example, with the yield curve for U.S. Treasury bonds as the riskless discount rate series, we can write

(3) $$100{,}000 = \sum_{j=0}^{240-2b} \frac{A*P_{b,j}}{(1+i_j^{Treasury}+\delta)^j}.$$

Comparing the implicit rate of return or the implicit risk premium on annuities with other investment opportunities is an alternative to the money's worth ratio for measuring the cost of longevity insurance. Brown, Kling, Mullainathan, and Wrobel (2008) suggest that the demand for annuities can be affected by whether these products are presented to potential buyers as insurance products that offer income for life, or as investment products offering a particular rate of return. The income-for-life framing leads most naturally to the money's worth as a summary measure, while the rate of return formulation leads toward the implied rate of return approach.

When an annuity is purchased outside a tax-qualified retirement account, using after-tax funds in a taxable account, the EPDV-to-premium ratio is no longer independent of the individual's tax rate. The discount rate must be measured after-tax, and the annuity payouts must be valued on an after-tax basis. The tax code recognizes that part of the stream of annuity payouts is a return of the annuitant's premium, which is not taxed, and that part reflects a return on capital since the insurance company has the opportunity to invest the premium and returns some of the resulting earnings to the policyholder. As explained in Brown, Mitchell, Poterba, and Warshawsky (1999), the Internal Revenue Service (IRS) determines the fraction of each annuity payment that represents taxable income by computing the expected number of years (T') over which the annuitant can expect to receive benefits. This calculation uses the IRS Individual Annuitant (Unisex) Mortality Table. Conditional on T', the IRS specifies an <u>inclusion ratio</u> (λ), the fraction of each annuity payment that is deemed to result from the insurer's earnings. For example, for an annuity with a \$100,000 premium that makes payments twice each year, $\lambda = 1 - \frac{100000}{2*A*T'}$. The annuitant must report 100λ% of each annuity payout as taxable income for the first T' years of annuity ownership. After that, since all of the annuitant's capital is deemed to have been returned, the full value of all future annuity payouts is considered taxable income. Long-lived annuitants thus experience an increase in the tax burden on their annuity payouts late in life.

Assuming that the annuitant faces a combined federal and state marginal income tax rate of τ, the tax-adjusted expression for annuity value (V_b') is:

(4) $$V_b'(A) = \sum_{j=0}^{2*T'} \frac{(1-\lambda*\tau)*A*P_{b,j}}{(1+(1-\tau)*i_j)^j} + \sum_{j=2*T'+1}^{240-2b} \frac{(1-\tau)*A*P_{b,j}}{(1+(1-\tau)*i_j)^j}.$$

This expression assumes that the marginal income tax rate on the income from the asset associated with the discount rate is the same as that on annuity income, as it would be if the asset was a taxable bond.

An increase in the marginal income tax rate in equation (4) has two offsetting effects on the EPDV of an annuity contract. First, it decreases the after-tax net income from each annuity payment, with a larger effect on payments after T' years than before. An increase in the tax rate thus reduces the numerator of the EPDV. Second, holding constant the pre-tax discount rate, an increase in the tax rate reduces the after-tax discount rate, which raises the EPDV. Whether the result of a rate increase is a rise or a decline depends on the discount rate. At low discount rates, the denominator effect is small, so a rise in the tax rate lowers the EPDV, but at higher discount rates, since the tax rate applies to the full value of the discount rate but only to part of the payout stream, it is possible for a tax rate increase to raise the EPDV.

2. Information on Annuity Prices and Payouts

We illustrate the sensitivity of EPDV calculations by focusing on retail annuity policies that were available for purchase in June 2020 and that were included in the *Annuity Shopper*, which compiles information on the offerings of 17 large U.S. insurance companies. The policy data were collected on June 19, 2020. We focus on single premium, immediate, non-participating annuities with a fixed nominal payout, as well as otherwise similar policies in which the income stream is deferred from the purchase date by 10 or 20 years. We consider policies with an initial premium of $100,000. The policies are "non-participating:" the benefit payment is fixed and guaranteed, and it does not reflect the insurance company's subsequent unanticipated experience with mortality, investment returns, or expenses. The number of companies in the sample varies across policies.

For an immediate annuity purchased for $100,000 by a 65-year-old man, the average monthly payout was $479 across the 16 companies offering that product. The payouts ranged from a high of $498 to a low of $458 – a range of just over 8 percent of the average. Some of this variation may be due to the different investment ratings of the various insurers. The firm offering the highest payout, Pacific Life, is rated A+ by A.M. Best, A1 by Moody's and AA- by Standard and Poor's. The firm with the lowest payout, Jackson National, receives the same ratings, A+ and A1 respectively, from both Best and Moody's, but a higher A+ rating from S&P. The firm's underwriting practices and firm-specific circumstances such as capital availability can affect pricing decisions. We lack information on the volume of annuity sales by company, so we summarize the prices for a given policy with a simple arithmetic average of the prices for the firms offering that policy.

Table 1 reports the average annual premia for three immediate annuity products: a single premium immediate annuity (SPIA) that pays the same nominal benefit for as long as the buyer is alive; the same product with a 20-year-certain provision that guarantees payments for 20 years, either to the annuitant or a designated beneficiary; and a graduated annuity with payouts that grow at a 3% nominal rate each year. In our valuation analysis, we focus exclusively on level-payout annuities. For each product type, we report the price for an annuity purchased by a man, a woman, and a married couple seeking to receive benefits for as long as either of the buyers is alive – a "joint and survivor annuity." The first panel shows SPIA pricing. There is variation by age, gender of the buyer, and across three product types. The average annual payment for a male 65-year-old annuitant is $5,748, about 6% greater than the $5,424 for a woman of the same age, and 29% greater than the payout on a joint-and-survivor annuity purchased by a 65-year-old man with a 60-year-old spouse.

The prices in Table 1 display a number of expected patterns. The annual payout rises with the age of the annuitant. The increase is 26% between ages 55 and 65, and 39% between 65 and 75, for a male annuitant, reflecting the greater annual mortality risk between 65 and 75 than between 55 and 65. A graduated annuity offers a smaller initial payout, 29% less for a 65-year-old man, than a level annuity. Opting for a 20-year guarantee period reduces the annual payout for a 65-year-old man by 9.4% 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 the insurer's stream of payouts to a woman than to a man. The payout on a 20-year-certain joint and survivor policy for a 65-year-old man and his 60-year-old wife is only 0.5% less than a policy with no guarantee, since the chance that one of the two will live for at least 20 years is very high. Annuity products that provide guaranteed payouts for a certain number of years place less of the policy-holder's premium at risk of loss in the event of an unexpectedly early death; they involve less longevity insurance than SPIAs without guarantees.

Table 1 also shows that the male/female annuity payout differentials change with age. At age 55, men receive annuity payouts that are about 4% higher than those for women. This difference rises to 6% at 65 and to more than 9% at 75. These payment patterns largely reflect differential mortality patterns, especially in the first decade after annuity purchase, for men and women of different ages.

Annuity payouts as a fraction of the policy premium decline when interest rates drop and when mortality rates fall. The substantial decline in nominal interest rates over the last 15 years has been associated with lower payouts. The average annual payout on an SPIA for a 65-year-old man was $5,748 in June 2020, compared to $6,456 in June 2015, $7,344 in June 2010, and $7,740 in June 2005. The yield on a 10-year Treasury bond, which averaged 0.73% in June 2020, was 2.36% in June 2015, 3.20% in June 2010, and 4.00% in June 2005.

The unusual financial market developments during the second quarter of 2020, primarily associated with the pandemic-induced disruption in financial markets and the Federal Reserve's response, raise concerns about the representativeness of findings based on June 2020. As we were completing this project, annuity payout data collected on January 8, 2021 became available. Annuity payouts declined between June 2020 and January 2021. The average annual payout on an SPIA for a 65-year old man dropped 3.3%, from $5,748 to $5,556. There was a similar drop, from $5,424 to $5,244, for 65-year-old women. This may reflect gradual pricing adjustment to low interest rates. Corporate BBB yields declined between June 2020 and January 2021, while Treasury yields rose.

3. Discount Rates

Estimating the value of the stream of future payouts associated with an annuity requires a term structure of discount rates. A key consideration in the choice of discount rates is the riskiness of the annuity payouts, which bears on how a consumer would discount them. Riskier payouts should be discounted at a higher rate, reflecting a risk premium.

Annuity payments are not riskless. Although companies participate in various state-level reinsurance pools, it is possible, although rare, for an insurance company to default on its promised payouts. A riskless interest rate, such as the yield on US Treasury bonds, understates the appropriate discount rate. If the stream of annuity payments is about as risky as the assets held in the general accounts of the insurance companies that offer these products, then the yield curve for corporate bonds may be more appropriate.

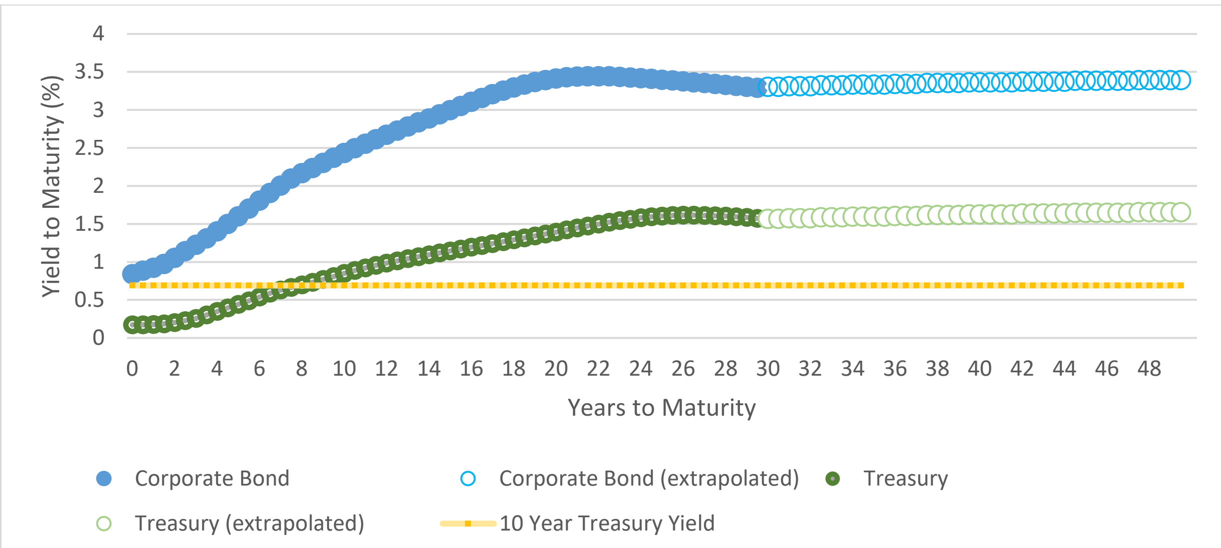
Most insurance companies invest their policy reserves in assets with greater risk, and greater expected return, than Treasury bonds. S&P Global (2020) reports that at year-end 2019, bonds accounted for 74% of the assets held in life insurance companies' portfolios. Mortgages and other real estate investments represented another 14%, and 5% of the portfolios were held in alternative investments such as venture capital and private equity. Stocks (1%), cash and short-term notes (3%), and alternative investments and contract loans (8%) comprised the remainder of the portfolios. Among the bond holdings, only 8.9% of the portfolios were held in government bonds; the balance was in corporate bonds (46.6%) and other privately-issued credit instruments.

To illustrate how assumptions about the risk premium used in discounting affects EPDV estimates, we present calculations using two interest rate term structures: one for U.S. Treasury bonds and the other for high-grade corporate bonds. For each case, we collect data on yields-to-maturity (YTMs) at various maturities (6 months, 1 year, then 2, 3, 5, 7, 10, 20, and 30 years) in mid-June 2020. For corporate bonds, we use the Bloomberg average yield on corporate bonds rated BBB+, BBB and BBB-. S&P Global (2020) reports that, of the corporate bonds held in life insurance company portfolios in 2020, 59% were rated between A and AAA, 35% were BBB, and 6% were rated below BBB. The BBB yield curve thus reflects somewhat greater risk than the median bond in the insurers' portfolios. By presenting results using both BBB corporate and Treasury yield curves, we illustrate the range of values that can result from different discount rate assumptions. . To provide some perspective on the risk premium associated with the different yield curves, we note that on June 19, 2020, the date when annuity prices were collected, the 10-year corporate BBB yield was 2.37%, and the 30-year BBB yield was 3.29%. For AA-rated bonds, the values were respectively 1.60 and 2.67%; for Treasuries, 0.85 and 1.57%. These differences have an important impact on EPDV calculations.

We interpolate between the maturities at which we observe yields using a cubic spline. This generates a yield curve, in half-year intervals, for maturities of up to 30 years. Because some annuity payouts may be more than 30 years after the policy purchase date, we need to extrapolate the observed yield curves to longer maturities. We do this using the slope of the IRS corporate bond yield curve (IRS (2020)) that is used for pension valuation purposes. This yield curve assumes that the forward six-month interest rate for all six-month intervals more than 30 years in the future equals the average six-month interest rate for all maturities between 15 and 30 years. We compute the change in the IRS yield curve between the 30-year maturity and all longer maturities, and add that value to the 30-year Treasury and 30-year BBB interest rate values, respectively. The changes in the yields beyond the 30-year maturity in the IRS yield curve are small, so in practice, this approach is very close to assuming that the 30-year yields for Treasury and BBB corporate bonds apply to all longer maturities. In addition, the discount factors for very long maturities do not have a substantial effect on EPDV calculations.

Figure 1 plots the June 2020 yield curves for Treasury bonds and the Bloomberg BBB corporate bond index. It includes a horizontal line at 69 basis points, the value of the 10-year

Figure 1: US Treasury and Corporate BBB Yield Curves, June 2020.



Notes: Solid green and blue circles are interpolated from the Treasury and Corporate BBB yield curves. Open circles extrapolate the average forward rate from years 15 to 30 to all years beyond 30. The yellow horizontal line at 0.69% is the yield on a 10-year Treasury bond, which is the rate that the DOL requires in the calculation of potential annuity income.

Treasury yield on June 19, 2020. This is the discount rate specified by the algorithm that DOL requires defined contribution plan sponsors to use in calculating potential annuity payouts for their participants. The Treasury yield curve is below the BBB yield curve at all maturities, with a typical risk premium of more than 150 basis points. This risk premium is somewhat greater than the average of the last two decades, reflecting the slow recovery from pandemic-related bond market disruptions earlier in the year. The option-adjusted spread between high-grade corporate bond yields and Treasury yields was 207 basis points in June 2020, compared to 139 in January 2020 and 185 in July 2020. This suggests that the differences between the money's worth findings using Treasury and corporate yields may be somewhat larger for June 2020 than in an average month over the last decade, although the direction of the differences will not be affected by the narrowing of the risk premium on corporate bonds. Between June 2020 and January 2021, the next date when annuity payout data were collected, the yield on the 10-year Treasury bond rose 45 basis points, to 1.3% from 0.85%, while the yield on 10-year corporate BBB bonds was nearly unchanged at 2.194 (January) and 2.184 (June).

Discounting future annuity payouts using the Treasury yield curve is likely to overstate the EPDV of an annuity, because annuity payments are likely to be riskier than the yield on Treasury bonds. Similarly, the BBB yields probably overstate risk and apply too high a risk premium. It follows that the DOL recommendation that pension plan administrators use the 10-year Treasury rate when calculating potential annuity payouts may understate the payments that could be available to future retirees, since it understates both the risk and the expected return associated with the assets in insurance company portfolios. If insurance companies assume that they can earn a return in excess of the Treasury return, then they could offer an annuity payout greater than what the DOL calculation will suggest.

4. Mortality Rates

Estimating the EPDV and the associated money's worth requires a cohort mortality table that includes projections of future mortality rates for an individual of a given age at the time of annuity purchase. These projections, which underlie the survival probabilities $P_{b,j}$ in equation (1), are an important source of uncertainty. Let $q_{a,t}$ denote the probability that an individual of age a at the beginning of half-year t will die during that half-year. We define $t = 0$ to be July 2020, so the first half year is the latter half of 2020. $P_{b,j}$ 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:

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

We set $P_{b,240-2*b} = 0$, for all b.

Different subgroups of the population exhibit different mortality rates. There is substantial evidence that mortality among annuitants is lower than mortality in the general population. This is likely due to two factors. First, Waldron (2007), Chetty et al. (2016), and others show that age-specific mortality rates are a declining function of economic status. Annuity buyers in both the retail and group annuity markets are drawn from an economically-more-successful than average part of the population, so they would therefore be expected to display lower-than-average mortality. Second, conditional on net worth, those who purchase individual annuities in the retail market may know that they are healthier than average, or at least know that they are not facing any current life-threatening health conditions. This would also lead to observed mortality below the population average.

Past research has reported the money's worth of annuities from two perspectives: that of an individual in the general population, and that of a typical annuity buyer. The former involves valuing the stream of future annuity payouts using the survival rates associated with the population mortality table, while the latter involves using an annuitant mortality table. We follow this tradition in presenting EPDV calculations using both a cohort mortality table corresponding to annuitants, and a cohort mortality table corresponding to the population at large. We compare the mortality rates in these tables with those in the unisex mortality table compiled by the IRS, recommended by the DOL for use by pension plan administrators.

When constructing EPDV measures that would apply to the U.S. population at large, we use the cohort mortality table compiled by the Social Security Administration (SSA) Office of the Actuary in 2019. For example, to value annuities offered to 65-year-olds in 2020, we use the mortality rates for the 1955 birth cohort. We choose other birth cohorts for annuities purchased by individuals at other ages. The SSA mortality tables embed projections of the future rate of mortality improvement.

When constructing EPDV measures from the perspective of annuitants, we use annuitant mortality tables constructed by the Society of Actuaries (SOA). These mortality tables are based on the historical experience of annuitants. SOA's most recent comprehensive annuitant mortality table is the Individual Annuitant Mortality (IAM) 2012 table, which is described in American Academy of Actuaries / Society of Actuaries (2011). It provides cohort mortality tables for annuity buyers in 2012, along with a recommended set of mortality improvement factors that can be used to project mortality rates for later years. The factors imply substantially more rapid decline in post-2012 mortality rates than has been observed in recent years, or than the SSA projects for future years. We construct an SOA cohort annuitant mortality table for 2020 by applying the SOA's recommended mortality improvement factors to the 2012 table.

Table 2 shows the projected population and annuitant mortality rates for men and women who were 65 years old in 2020. The mortality rate for a 65-year-old male annuitant, 0.0080 (eight tenths of one percent), is roughly half the mortality rate for the population at large

(0.0152). The absolute difference in the two sets of mortality rates grows at older ages, but the proportional difference contracts. At age 85, for example, a current 65-year-old male annuitant is projected to face a mortality rate of 0.061, while for a randomly-selected 65-year-old in the population, the analogous value is 0.095. The general pattern of differences between the population and the annuitant tables is similar, but smaller, for women.

The disparity between the mortality rates in the 2020 SSA and SOA cohort tables arises from different historical levels of mortality between the population at large and annuity buyers as well as different assumed rate of mortality improvement. The SOA mortality rates in Table 2 are the result of projecting the 2012 table, which is based on observed mortality rates through 2004, forward for eight years using the SOA mortality improvement factors. The SSA cohort mortality table is based on death rates observed through to 2017, along with projections for subsequent years. To illustrate the role of mortality improvement factors, consider the mortality rate for an age a individual in a given group, such as the group of annuitants in 2012. If we denote this mortality rate as $q_{a,2012}$ and the constant mortality improvement factor for age $a + t$ is g_{a+t}, then the projected mortality in year $2012 + t$ is

(6) $$q_{a+t,2012+t} = q_{a+t,2012} * (1 - g_{a+t})^t.$$

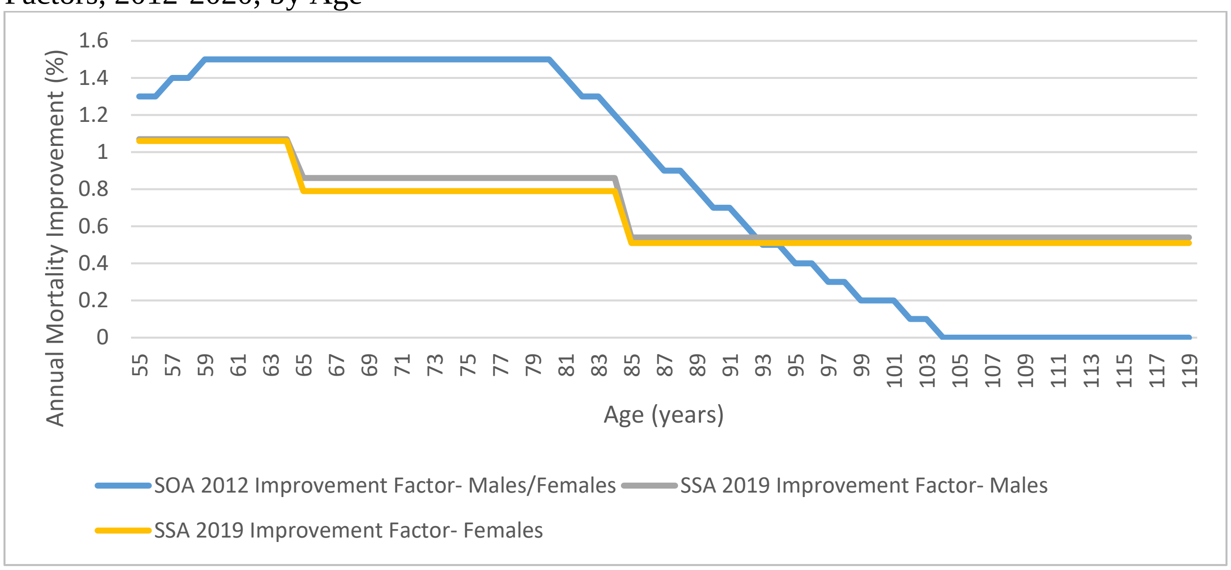
The rate of mortality improvement has varied over time and across ages within the elderly population. These varying patterns are reflected in the changes over time in age-specific life expectancy at retirement age. We illustrate these by focusing on the white population, because consistent mortality data are available for the longest time for this group. For white men, life expectancy at age 65 was 13 years in both 1960 and 1970. It rose to 14.3 years in 1980, 15.2 in 1990, and 16.2 in 2000. The large gains during the 1970s had many sources. Improved control of hypertension and an associated reduction in cardio-vascular mortality is identified by Cutler, Glaeser, and Rosen (2009) as a leading factor. Between 2000 and 2010, life expectancy rose 1.6 years, even faster than in the 1970s, rising 1.6 years to 17.8 years in 2010. But in subsequent years, it rose more slowly. In 2017, the last year for which the Center for Disease Control (CDC) reports complete statistics, it was 18.1 years. The life expectancy increase of only 0.3 years over a span of seven years suggests that the increase for the 2010-20 decade will be the slowest since the 1960s. The pattern for white women also shows rapid life expectancy gains in the 1970s, from 16.9 years to 18.6 years, but more modest gains in the 2000-

2010 period, from 19.2 to 20.3 years. The gain from 2010-2017 was also just 0.3 years. For women as for men, 2010-2019 was marked by slower mortality reduction than previous decades.

The historical variation in the rate of mortality improvement implies that different forecasts of the future rate of improvement are possible, depending on the weights placed on the historical experience in different periods. Table 3 reports the mortality improvement factors associated with both the SOA and the SSA cohort mortality tables, along with summary information on past mortality improvement factors. Figure 2 displays the age-specific pattern of SOA and SSA improvement factors.

Mortality rates between the ages of 65 and 84 are a key determinant of the EPDV values for annuities purchased at age 65. Figure 2 shows that in 2012, SOA projected annual mortality improvement of 1.44% for this age range, which implies that after 20 years, the mortality rate at

Figure 2: Society of Actuaries and Social Security Administration Mortality Improvement Factors, 2012-2020, by Age



Source: SSA (2019), Table 2.2 “Intermediate Alternative’, and SOA (2011) Exhibit III, “Projection Scale G2”

a given age is 0.748 times the mortality rate in the base year. SSA, by contrast, assigns a 0.86% per year improvement factor, which translates to an age-specific mortality rate in 20 years of 0.841 times the base year value. Beyond age 85, SSA assumes mortality improvement of 0.54% per year, which is more rapid that the SOA assumption of 0.30% per year. The post-85 rate of mortality improvement has relatively modest effects on the EPDV estimates.

The SOA projections appear to place substantial weight on the rapid mortality decline experience of the 2000-2009 period, while the SSA projections place greater weight on the slower long-term rate of mortality improvement, especially post-2009. The rate of mortality improvement since 2009 has not matched the rate in the previous two decades. As a result, SOA's projected mortality rate improvement for a 65-year-old man in 2017 is lower than the actual rate, and its projected rate for 2020 is lower than SSA's projected rate for 2020 (using more recent actual mortality data and thus a slower rate of mortality rate decline). Neither the SOA nor the SSA projections incorporate any information on the impact of the COVID-19 pandemic on prospective mortality rates. Early estimates of the impact of the pandemic on life expectancy, such as Andrasfay and Goldman (2021) and Arias, Tejada-Vera, and Ahmad (2021), raise the possibility of substantial impacts.

To recognize that annuitants have lower mortality rates than individuals drawn from the population at large, as does the SOA mortality table, while also recognizing that the rate of mortality improvement post-2009 has been substantially lower than that projected in the SOA (2012) analysis, we create a "modified SOA mortality table" that begins with the 2012 IAM table but then applies the SSA rates of projected age-specific mortality improvement for the years after 2012. This modified SOA table captures the level differences in annuitant and population mortality while also projecting rates of mortality improvement that are close to those observed in the last decade.

The SOA and SSA mortality tables present separate information for men and women, reflecting the higher mortality rate at all post-retirement ages for men. The IRS mortality table that DOL directs retirement plan sponsors to use for making illustrative lifetime income calculations is a unisex table that is used to value the liabilities of defined benefit (DB) pension plans. It is based on the SOA (2014) mortality table for DB plan participants, which separates men and women and also distinguishes those who are receiving benefits from those who are still working and accumulating benefits. The IRS applies the mortality improvement factors for the 2014 tables in SOA (2018) to construct gender-specific mortality tables for DB plan participants in 2020. It creates a weighted average of the participant and beneficiary tables for men, and a separate weighted average table for women, based on the relative sizes of these groups, and then combines the two gender-specific tables in an equally weighted average. The supporting documentation associated with this table, reported at IRS (2020), indicates that it should be used without any allowance for future mortality improvement. The absence of mortality improvement factors in the IRS table means that it may lead to over-estimation of feasible annuity payouts. Mortality improvements raise life expectancy, and longer lives translate into lower feasible annuity payouts.

The last column of Table 2 shows the unisex mortality rates from the DOL-recommended mortality table. For women, the mortality rates in this column fall between the SOA (annuitant) and SSA (population) mortality rates. At age 65, for example, the SOA annuitant table shows a mortality rate of 0.0062, compared with 0.0079 in the IRS table – nearly 25% higher. The population mortality rate for women at age 65 is 0.0093, higher than the IRS value. For men, the mortality rate at age 65 in the IRS table (0.0079) falls just below the value in the SOA table (0.0080) and well below the population mortality rate (0.0152). This is because the IRS table averages the mortality rates for men and women, and the mortality rates for women at all ages in Table 2 are lower than those for men. By age 70, however, the absence of any annual mortality improvement in the IRS table leads the IRS mortality rate (0.0129) to exceed the mortality rate for men in the SOA table (0.0118). This pattern continues for older ages. The values in the IRS table are always lower than the population mortality rates for men.

5. Estimates of EPDV and Implicit Discount Rates for Immediate Annuities

We now use the annuity prices, discount rates, and mortality tables described in the last three sections to estimate the EPDVs and implicit discount rates for a subset of the annuity products described in Table 1. Since the annuity policies that we consider have purchase prices of $100,000, the money's worth ratio in each case is EPDV/$100,000. We also relate the potential annuity payout calculation outlined in the DOL regulatory guidance to these measures.

5.1 Money's Worth for SPIAs

The first panel of Table 4 presents EPDV estimates for the no-tax case, corresponding to annuity purchase in a retirement account. We focus our discussion on the findings for 65-year-olds; the pattern of results is similar for buyers of other ages. The calculations show the difference in the EPDV calculated using a population and an annuitant mortality table. The EPDV is substantially lower when the calculation is based on the population mortality table, compared to either the SOA or the modified SOA annuitant mortality table. The EPDV is also much higher when the Treasury yield curve is used to set the discount rate, than when the discount rates correspond to the BBB corporate yield curve. If the corporate AA yield curve is used instead of the BBB yield curve, the values would be between the BBB and Treasury values.

The results for a 65-year-old male annuity buyer illustrate these patterns. The lowest EPDV in the row, $80,694 (a money's worth of 0.81) corresponds to the population mortality table and the corporate BBB yield curve. This value suggests that the expected cost of longevity protection is nearly 20% of the policy premium. When the population mortality table is replaced with the SOA annuitant mortality table, the estimated EPDV rises to $94,379, for money's worth value of 0.94. When the SOA annuitant mortality table is updated using the SSA mortality improvement factors rather than the SOA factors, a change that implies slower prospective mortality rate decline, the estimated EPDV falls to $92,581 and the expected cost of longevity protection is just over 7% of the premium. This is the combination of discount rates and mortality rates that we consider our benchmark case.

When the Treasury yield curve is used to construct the discount rates for future annuity payouts, the EPDV estimates with the SOA mortality table and the modified SOA mortality table are both greater than $100,000. The estimates using the population mortality table rise substantially and result in money's worth values above unity in a few cases. For instance, for 65-year-old men, when the SOA mortality table is combined with the Treasury yield curve, the estimated EPDV is $114,260. If an insurance company expected to earn the Treasury yield on its investments and expected the mortality experience of its annuitants to follow the SOA mortality table, it would expect to lose money on the policies offered to men and women at all of the ages shown in Table 4. An alternative interpretation is that insurers expect to earn a rate of return that exceeds the riskless Treasury rate, and therefore they will be able to earn enough to make future annuity payments and earn a positive profit. The EPDV estimates using the corporate BBB yield curve are consistent with this view. They yield money's worth values, with either the SOA or modified SOA mortality table, of between 0.91 and 0.95. Replacing the corporate BBB yield curve with the corporate AA yield curve, the resulting EPDVs are roughly midway between the Treasury and BBB results: $100,763 for 65-year-old men, and $100,646 for 65-year-old women. The choice between the AA and the BBB yield curve changes the estimated price of longevity insurance by about eight percent.

If we set the discount rate equal to the 10-year Treasury yield in June 2020, in the spirit of the DOL guidance for plan administrators, the EPDV results are similar to those for the

Treasury yield curve. For example, for a 65-year-old man, the EPDV with the SOA mortality table in this case is $118,875, and with the population mortality table, it is $99,599. The results for women are similar, with EPDV estimates of $120,621 and $106,049 respectively. This suggests that the use of the 10-year Treasury yield may understate the expected return that insurers assume in setting their retail annuity prices, a point that is likely to apply to individual or group annuities sold to DC plan participants as well.

To address the concern raised earlier about the unusual bond market conditions in June 2020, we evaluated the robustness of our findings by applying our valuation algorithm to the recently-released January 2021 annuity payout values. We combined that payout data with Treasury and corporate BBB yield curves on January 8, 2021, and we used the same mortality tables as for the June 2020 calculations. The increase in Treasury yields over this seven-month period results in a lower EPDV estimate using the modified SOA mortality curve: $103,459 for 65-year-old men, and $103,888 for 65-year-old women. Using the BBB yield curve, the EPDV values also decline, but this is because of the change in the monthly annuity payout rather than a rise in the discount terms. Using the modified SOA mortality table, the January 2021 EPDV with the BBB yield curve for 65-year-old men is $90,690 (compared with $92,579 in June 2020); that for 65-year-old women is $90,289 (compared with $92,097 in June 2020).

The results in Table 4 illustrate the quantitative importance of replacing the SOA mortality improvement assumption with the SSA assumption to generate the "modified SOA" table. The estimated EPDV for a 65-year-old man is between 1 and 3% lower, depending on the discount rate chosen, with the modified SOA table instead of the SOA table. The effect of using the modified table is similar for other age and gender categories as well. For a 65-year-old woman, for example, with the corporate bond yield curve, the EPDV value with the SOA mortality table and the SOA improvement factors is $93,179, compared to $92,097 with the modified SOA mortality table.

Our analysis has focused on the valuation of annuities in a pre-tax setting, but some retail annuities are purchased in taxable accounts. The lower panel of Table 4 presents results for the after-tax case, assuming that the annuitant's marginal tax rate is 25 percent. The pattern of EPDV values is very similar to that for the no-tax case, with EPDVs in excess of $100,000 when we combine the SOA mortality table or the modified SOA mortality table with the Treasury yield curve, and money's worth values between 0.91 and 0.96 when we combine the BBB yield curve with either of these mortality tables. A close comparison of the results in the upper and lower panel of the table reveals some differences, related to the level of the discount rate and its interaction with the tax rate. The EPDV estimates using the 25% marginal tax rate are higher than those in the no-tax case for the BBB yield curve, but they are lower when the discount rates are drawn from the Treasury yield curve. This is because, at low discount rates such as the Treasury yields, the tax rate does not have much effect on the discount rate, but it does reduce the payout stream. At higher discount rates such as the BBB yield curve, the effect of a 25% tax on the discount rate is sufficient to increase the present value of the payout stream.

5.2 Implied Discount Rates for SPIAs

The implied discount rates introduced in equations (3) and (4) ask what discount rate would be needed on the part of an insurer offering this product if the level of monthly annuity payouts, and the $100,000 policy premium, represented a zero-profit product offering. Table 5 presents estimates of both the constant nominal discount rate ρ, and the risk premium above the Treasury yield curve, δ, that would result in a money's worth value of unity for each policy. The results corresponding to the SOA annuitant mortality table for a 65-year-old man show that, with an annual discount rate of 2.35%, or a risk premium of 117 basis points above the Treasury yield curve, the policy would "break even" and generate an EPDV of $100,000. The constant nominal discount rate is somewhat lower, 2.16%, for the modified SOA mortality table, and substantially lower, 0.65%, for the population mortality table. With the population table, the risk premium relative to the Treasury yield curve is negative. If insurers believed the mortality experience of their annuity buyers would reflect the population mortality curve, then they could offer the current payouts for 65-year-old men, and break even, even if their portfolio returns were lower than those currently associated with the Treasury yield curve.

The implicit risk premium calculations provide a useful way of understanding the money's worth values above unity in Table 4. For 65-year-old men, when we use the SOA mortality table and the Treasury term structure, the estimate of the EPDV is $114,260. For 65-year-old women, the value is $113,934. When we use the BBB corporate term structure, these EPDV values drop to $94,379 and $93,179 respectively. The implied risk premium calculations indicate how much the Treasury yield curve would need to be increased to bring the EPDV values to $100,000: 117 basis points for men, and 109 basis points for women. Thus, the Treasury yield curve appears to understate by more than one percentage point the rate of return that insurers are implicitly using in pricing their retail annuity offerings. This understatement would be smaller if the calculation was based on the January 2021 data, when the Treasury yield is substantially higher.

5.3 Potential Annuity Payouts and the DOL Algorithm

The implied discount rate calculation is related to the DOL guidance for plan administrators, which specifies computing the potential annuity payout DC plan participants can expect using the 10-year Treasury interest rate and the IRS unisex mortality table. In our formulation, the potential payout is the value A_{DOL} that solves the equation

$$100{,}000 = \sum_{j=0}^{240-2b} \frac{A_{DOL} * P_{b,j}^{IRS}}{(1+i^{Treasury,10\,Year})^{j}}. \tag{6}$$

The survival probabilities are drawn from the IRS mortality table and are the same for men and women in DC pension plans. For a 65-year-old plan participant, the resulting value for June 2020 is an annual payout of $5,136. By comparison, the average value of the SPIA offerings in Table 1 was $5,748 for men, and $5,424 for women. The DOL calculation is thus about 5% below the average annuity premium available in the individual annuity market for women, and nearly 12% below for men. Applying the same algorithm at age 75, the potential annuity payout is $7,968 per year; the average values in Table 1 are $8,016 for men and $7,344 for women.

The calculations in the last subsection suggest that the Treasury yield curve may understate the rate of return insurers assume in pricing annuities by about one percentage point. If we repeat the calculation for the potential payout using the DOL guidance, but assume that the discount rate equals the 10-year Treasury yield plus 1 percent, the potential payout for a 65-year-old plan participant would rise from $5,136 to $5,762, a 12% increase, and the potential payout for a 75-year-old would rise from $7,968 to $8,616, an 8% increase. These calculations illustrate the impact of using a riskless rate of return as the discount rate in the DOL guidance. An open question is whether plan participants, who might anticipate payouts similar to those computed using the DOL-determined approach, would be able to purchase annuities that offer higher payouts when they reach retirement age.

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

Although the foregoing analysis emphasized single-premium immediate annuities without any guarantee period, in practice, annuities with guarantees are more popular than those without. Brown, Poterba, and Richardson (2021) 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.

The EPDV framework can be used to illustrate 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? Using the SOA mortality table and the BBB corporate yield curve for discounting, we value the payouts of an SPIA-with-20-year-guarantee purchased by a 65-year-old man. Table 1 reports that the annual payout on this contract is $5,208 per year, compared with $5,748 for an SPIA with no guarantee. The present discounted value of the payouts in the first 20 years – the guaranteed period – is $81,550. The EPDV of the contract, including the life-contingent payouts beyond the 20-year window, is $93,291. Thus 87% of the value of this "annuity contract" is associated with its bond-like component. For a 65-year-old woman purchasing an SPIA with a 20-year-guarantee period, 85% of the value comes from the bond-like component because the woman is more likely than her male counterpart to outlive the guarantee period.

A key attraction of the guarantee period is that it reduces the likelihood that the annuitant and his or her heirs will receive very limited payouts from the annuity contract. Using the modified SOA mortality table and the corporate BBB 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, and 11% chance of dying before receiving $50,000. The annuitant must live to age 69.5 to pass the first milestone, and 74.5 to pass the second. If a 65-year-old man with a 60-year-old spouse purchases a joint-and-survivor annuity, by comparison, the chance that payouts cease before they cumulate to a present discounted value of $25,000 ($50,000) is only 0.2% (1%). This reflects the insurance value provided by payouts contingent on either of two individuals being alive. The required longevity is reduced somewhat if we ask "how long must the annuitant survive to receive payouts equal to one-quarter, or one-half, of the EPDV of his or her policy?" For the individual annuity purchased by a 65-year-old male, the estimate of the EPDV using the modified SOA mortality table is $92,581. A male annuitant who lives to 69 will have received 25% of the EPDV, and one who lives to 73.5 will have received 50%.

With a 20-year guarantee period, the annuitant is protected from the risk of receiving payouts worth only a small fraction of the annuity premium. This protection comes at the cost of a lower annual annuity payout, namely, 9.4% 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; it replaces a completely life-contingent contract with one that is largely a fixed-income bond.

7. Deferred Annuities

Our analysis so far has focused on immediate annuities, but there is growing interest in deferred annuities – products that do not pay annuitants anything for a period that may span several decades, and then provide income only in late life. Table 6 presents information on the average payouts associated with deferred annuities, purchased either at age 55 or age 65, and starting payouts at either age 75 or age 85. The average policy with a premium of $100,000 promises a 65-year-old man a $31,856 annual payout if the payout stream begins at 85, but just over one third as much -- $11,175 – if the payouts start at age 75. The much larger payout on the longer-deferred annuity reflects the time value of money – the insurance company 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 the a 65-year-old man will still be alive at 85 than that he will be alive at 75. The modified SOA annuitant mortality table indicates that a 65-year-old man has a 90% chance of living to 75 and a 69% chance to 85. The corresponding survival probabilities in the population mortality table are 81% and 49%, respectively; in the SOA annuitant mortality table, they are 89% and 66%. These probabilities are particularly sensitive to the assumed rate of mortality improvement, so the relatively rapid rate assumed in the SOA table has an important impact on these values.

The payouts from deferred annuities that start at a given age are larger when they are purchased at a younger age. For men, the payout at 85 is $41,617 when the deferred annuity is bought at 55, compared with $31,856 when the policy is purchased at 65. For any purchase age/payout age combination, the deferred annuity payout for women is lower than that for men, reflecting the greater likelihood of the annuitant surviving to advanced ages.

We estimate the EPDV of deferred annuities using the same approach that we applied for immediate annuities. We only consider the case of deferred annuities purchased in retirement accounts. To frame the results, we estimate the component of the EPDV of an immediate annuity, purchased by a 65-year-old man that is associated with payouts at age 85 and later. The EPDV of the annuity, valued using the corporate BBB term structure and the modified SOA mortality table, is $92,581. The EPDV of the post-85 stream is $12,958, or 14% of the policy's value. The analogous calculation for a 65-year-old woman indicates that the post-85 payouts account for 16% of the immediate annuity's EPDV. Using the Treasury yield curve in place of the corporate, all EPDV values increase, and the share of the value associated with post-85 payouts also rises. It is 18% for men and 21% for women. These summary measures underscore the earlier point that most of the value in an immediate annuity contract purchased at age 65 is attributable to payouts made before the annuitant reaches age 85, even if the Treasury yield curve is used for discounting.

Table 7 presents estimates of the EPDV for the various deferred annuity products shown in Table 6. The table suggests three conclusions. First, the money's worth of a deferred annuity is more sensitive to discount rate assumptions than the money's worth of an immediate annuity. This can be seen from the greater disparity in the EPDV values in Table 7 in the columns corresponding to the Treasury and the BBB corporate yield curves, compared to the analogous columns in Table 4. For a 65-year-old man, a deferred annuity beginning at age 85 has money's worth of 0.77 when valued using the BBB yield curve, and of 1.21 when valued using the Treasury curve. The disparities are even larger for women and for men who purchase deferred annuities at earlier ages. By comparison, in Table 4, the money's worth for an immediate annuity for a 65-year-old man was 0.94 (BBB curve) and 1.14 (Treasury curve).

A second conclusion is that the money's worth values for the deferred annuities are lower than the corresponding values for immediate annuities, when valued using the corporate BBB yield curve. The money's worth values associated with the entries in the last column of Table 7, with the BBB yield curve and the modified SOA mortality curve, are all between 0.69 and 0.82. By comparison, the corresponding values in Table 4 are between 0.90 and 0.92.

The lower EPDV for the deferred annuities may reflect insurers' reluctance to offer long-duration policies with substantial risk of medical progress or other unexpected developments before payouts begin. It is also consistent with more pronounced selection in the market for deferred annuities, with only the healthiest individuals at age 65 choosing to purchase deferred annuities. The risk of such selection for the insurer depends on whether potential buyers have meaningful information about their likelihood of living for several decades. Deferred annuities may also expose insurers to greater risk of asset-liability mis-match risk, because they have much longer duration than immediate annuities. For a 65-year-old man (woman), we estimate the duration of the payouts associated with an immediate annuity, using the BBB yield curve and the modified SOA mortality table, to be 10.4 (11.0) years. By comparison, the duration of a deferred annuity for a 65-year old buyer is 24.9 years (mane) and 25.4 years (woman). Verani and Yu (2020) note that about 90% of all corporate bonds are issued with maturities of ten years or less. This may make it difficult for portfolio managers at insurance companies to identify bonds with attractive risk and return attributes and long enough duration to match the liability stream of a deferred annuity.

Third, when deferred annuities are valued using the population mortality table and the BBB yield curve, the money's worth values are no greater than 0.51 and are sometimes as low as 0.41. The comparatively low money's worth values for these products raises the same question that has been asked when immediate annuities appear to have money's worth values below unity: are they unattractive for typical retires? Horneff, Maurer, and Mitchell (2020) assume that deferred annuities are priced to be actuarially fair (money's worth of unity) using the annuitant mortality table and a riskless interest rate of 1%. When they calculate the consumer's expected utility, however, they use the population mortality table.

The finding that the EPDV of a deferred annuity is well below its purchase price does not preclude the conclusion that buying such annuity can raise consumer welfare. Mitchell, Poterba, Warshawsky, and Brown (1999) found that, even when the money's worth of immediate annuities was on the order of 0.80, buying such annuities could improve lifetime expected utility when retirees lack other sources of annuity-like income. Those findings were sensitive, however, to the presence or absence of an income stream like Social Security. The money's worth estimates in Table 7 suggest the value of further exploration of pricing and valuation of deferred annuity contracts.

8. Conclusion

This paper presents new evidence on the relationship between the purchase price and the expected present discounted values of payouts on immediate annuities. We illustrate this by calculating EPDV for products that were available in the U.S. in June 2020. Our preferred specification, combining s discount rates drawn from the term structure of BBB corporate bond yields with a modified version of the individual annuitant mortality table developed by the

Society of Actuaries, yields an immediate annuity money's worth ratio for 65-year-old buyers is between 0.90 and 0.95. The June 2020 estimates are between 0.92 and 0.93; when we update the calculations to January 2021, the values are slightly lower, between 0.90 and 0.91. The money's worth ratios are substantially lower, between 0.79 and 0.85, if we use the population mortality table rather than the annuitant mortality table to assess survival probabilities.

When we apply discount factors based on the Treasury yield curve, we find to construct discount factors, money's worth values are greater than unity – suggesting that that the present value of expected future payouts is greater than the premium cost. We do not interpret this as suggesting that insurance companies expect to lose money on their annuity offerings, but rather, view it as evidence that these companies assume a portfolio return greater than the Treasury yield in valuing their future payout liabilities. The substantial excess of the EPDV over the policy premium may in part reflect pandemic-related dislocations in the Treasury bond market in June 2020. Repeating the same calculations in January 2021, using annuity payout data for that month and corresponding Treasury yield curve data, still generates money's worth values greater than unity, but they are closer to that value.

We also compute the EPDV for deferred annuities, policies purchased by individuals in their 50s or 60s which pay benefits from age 85. The money's worth ratios for these annuities are lower than those for immediate annuities, ranging between 0.69 and 0.82. The disparities between these values and the comparable measures for immediate annuities are unlikely to be explained by adverse selection, since the degree of private information for prospective annuitants with regard to their long-term survival prospects is likely to be more limited than their private information about near-term mortality risks.

Finally, we consider the recent regulatory directive from the Department of Labor that instructs sponsors of defined contribution pension plans to calculate the potential lifetime income stream that plan participants can purchase with their accumulated balances. The regulations outline a procedure for calculating the potential annuity payout assuming that future benefits are discounted at the 10-year Treasury yield, and participant mortality can be described by a unisex mortality table for defined benefit pension plan participants. Our findings suggest that the use of the Treasury yield in this calculation may understate the income stream that will be available to future retirees.

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Table 1: Cross-Company Average Annual Annuity Payouts, Per $100,000 Premium, June 2020

	Age 55	Age 65	Age 75
Single Premium Immediate Annuity (SPIA)			
Men	$4,572 (16)	$5,748 (16)	$8,016 (16)
Women	$4,404 (16)	$5,424 (16)	$7,344 (16)
Joint and Survivor (Male of Column Age, Female Spouse 5 Years Younger)	n/a	$4,440 (16)	$5,568 (16)
SPIA, 3% COLA			
Men	$2,892 (10)	$4,068 (13)	$6,312 (13)
Women	$2,688 (9)	$3,756 (13)	$5,652 (13)
Joint and Survivor	n/a	$2,844 (11)	$4,008 (11)
SPIA, 20 Year Guarantee			
Men	$4,428 (17)	$5,208 (17)	$5,856 (17)
Women	$4,296 (17)	$5,052 (17)	$5,772 (17)
Joint and Survivor	n/a	$4,416 (17)	$5,292 (17)

Source: *Annuity Shopper*, July 2020. 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 20-year term annuity (no life contingency) from the 17 firms in the sample was $5,964, and for a 30-year term annuity was $4,500.

Table 2: Population and Annuitant Mortality Rates for 65-Year-Old Men and Women in 2020

	SSA 2019 Cohort Table, Birth Year 1955	SOA Annuity 2012 Table updated to 2020 with SOA mortality improvements	SOA Annuity 2012 Table updated to 2020 with SSA mortality improvements	IRS Unisex Pension Liability Valuation Table, 2020
Men				
65	0.0152	0.0080	0.0084	0.0079
70	0.0220	0.0112	0.0118	0.0129
75	0.0341	0.0185	0.0195	0.0217
80	0.0557	0.0327	0.0345	0.0385
85	0.0947	0.0609	0.0637	0.0694
90	0.1613	0.1155	0.1170	0.1259
95	0.2581	0.1993	0.1971	0.2043
Women				
65	0.0093	0.0062	0.0064	0.0079
70	0.0147	0.0091	0.0095	0.0129
75	0.0240	0.0143	0.0149	0.0217
80	0.0416	0.0248	0.0259	0.0385
85	0.0727	0.0502	0.0523	0.0694
90	0.1287	0.0936	0.0943	0.1259
95	0.2137	0.1576	0.1562	0.2043

Source: Authors' calculations as described in equation (6) with SOA mortality improvements drawn from SOA (2011) Exhibit III, "Projection Scale G2," and SSA mortality improvements from SSA (2019), 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 2020. The entries for 75-year-olds, for example, correspond to mortality rates expected to prevail in 2030.

Table 3: Selected 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	2002 onwards	2016 onwards
Male	50-64	2.28	1.92	1.15	-0.29	1.33	1.07
	65-84	1.46	1.23	2.42	0.86	1.44	0.86
	85+	1.56	-0.32	1.49	0.37	0.3	0.54
Female	50-64	1.72	1.09	1.46	-0.46	1.19	1.06
	65-84	2.03	0.43	1.71	0.72	1.29	0.79
	85+	2.06	-0.43	1.16	0.16	0.4	0.51

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

	SSA (2019) Population Mortality Table Updated with SSA Improvement Factors		SOA (2011) Annuitant Mortality Table updated with SOA Improvement Factors		SOA (2011) Annuitant Mortality Table updated with SSA Improvement Factors	
	Treasury Yields	Corporate BBB Yields	Treasury Yields	Corporate BBB Yields	Treasury Yields	Corporate BBB Yields
Panel A: Estimates Assuming Tax Rate = 0						
Men Age 55	$101,451	$81,326	$118,950	$92,566	$116,417	$91,010
Men Age 65	95,030	80,649	114,260	94,379	111,717	92,581
Men Age 75	85,938	77,494	106,901	94,254	104,837	92,559
Women Age 55	107,496	84,736	119,479	92,150	117,977	91,213
Women Age 65	100,209	83,738	113,934	93,179	112,438	92,097
Women Age 75	89,724	79,811	106,538	92,911	105,457	91,984
Panel B: Estimates Assuming Tax Rate = 0.25						
Men Age 55	97,797	82,491	114,303	94,346	111,953	93,601
Men Age 65	91,972	81,321	109,705	95,151	107,390	93,358
Men Age 75	83,715	77,725	102,632	93,834	100,769	92,216
Women Age 55	104,200	86,831	115,416	94,669	114,023	93,687
Women Age 65	97,697	85,464	110,238	94,980	108,867	93,899
Women Age 75	86,683	79,736	101,616	92,210	100,632	91,327

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 June 2020 as reported in Table 1.

Table 5: Implied Discount Rates (ρ) and Risk Premium Relative to Treasury Yield Curve (δ) that Result in Money's Worth Values of 1.0 (EPDV = Purchase Premium)

	SSA (2019) Population Mortality Table Updated with SSA Improvement Factors		SOA (2011) Annuitant Mortality Table updated with SOA Improvement Factors		SOA (2011) Annuitant Mortality Table updated with SSA Improvement Factors	
	ρ	δ	ρ	δ	ρ	δ
Men Age 55	1.398	0.106	2.49	1.17	2.35	1.04
Men Age 65	0.65	-0.49	2.35	1.17	2.16	0.98
Men Age 75	-1.15	-2.07	1.79	0.84	1.55	0.59
Women Age 55	1.82	0.50	2.49	1.16	2.42	1.08
Women Age 65	1.19	0.02	2.30	1.09	2.18	0.98
Women Age 75	-0.39	-1.36	1.74	0.74	1.62	0.62

Source: Authors' calculations based on equations (2) and (3) in text.

Table 6: Cross-Company Average Annual Deferred Annuity Payouts, Per $100,000 Premium, June 2020

	Purchased at Age 55		Purchased at Age 65	
	Male	Female	Male	Female
Deferred Annuity Payouts Beginning at Age 75	$14,981	$13,544	$11,175	$10,074
Deferred Annuity Payouts Beginning at Age 85	$41,617	$34,786	$31,856	$26,351

Source: *Annuity Shopper*, July 2020. There are ten firms in the sample for all product classes.

Table 7: Estimates of the EPDV of Deferred Annuity Payouts, Per $100,000 Premium

	Population Mortality Table		SOA (2012) Annuitant Mortality Table		Modified SOA (2012) Annuitant Mortality Table	
	Treasury Yields	Corporate BBB Yields	Treasury Yields	Corporate BBB Yields	Treasury Yields	Corporate BBB Yields
Panel A: Deferred Annuity Beginning at Age 75						
Men Age 55	$89,433	$55,218	$130,931	$79,444	$123,743	$75,190
Men Age 65	86,014	63,493	118,490	85,684	113,923	82,531
Women Age 55	101,155	61,833	130,245	78,435	126,183	75,972
Women Age 65	93,972	68,536	117,259	84,055	114,698	82,243
Panel B: Deferred Annuity Beginning at Age 85						
Men Age 55	74,314	41,230	138,883	76,105	127,031	69,455
Men Age 65	68,048	43,667	120,940	76,911	113,120	71,815
Women Age 55	89,483	49,193	137,120	74,555	131,106	71,043
Women Age 65	79,535	50,694	119,249	75,351	115,370	72,719

Source: Authors' calculations using equation (1) and mortality rates and yield curves as described in the text, along with payouts on deferred annuity contracts in June 2020 as reported in Table 6.