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Keywords

pensions, state-sponsored pensions, retirement savings, annuities, tontines, pooled annuities, assurance fund, budget constraint, underfunding

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This paper explains how state governments could create new low-cost lifetime assurance funds to help provide retirement income security for millions of private-sector workers who currently lack pension coverage. Basically, an assurance fund operates like a mutual fund held within a defined contribution plan, but with the added features of mortality pooling and fully-funded lifetime payouts. As we envision them, assurance funds would be offered as annuity-like investment options on the new investment platforms being created by states like Oregon, California, and Maryland that offer their citizens the opportunity to participate in state-sponsored retirement savings plans. Adding an assurance fund could effectively turn these retirement savings plans into lifetime pensions. To ensure their sustainability, assurance funds would operate under a strict budget constraint and be organized as either tontines or pooled annuities.

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State-sponsored Pensions for Private Sector Workers: The Case for Pooled Annuities and Tontines

This paper explains how state governments could create new low-cost lifetime assurance funds to help provide retirement income security for millions of private-sector workers who currently lack pension coverage and how these governments could do so with minimal risk. An assurance fund operates like a mutual fund held within a defined contribution (DC) plan, but with the added features of mortality pooling and fully-funded lifetime payouts. As we envision them, assurance funds would be offered as annuity-like investment options on the new investment platforms being created by states like Oregon, California, and Maryland that offer their citizens the opportunity to participate in state-sponsored retirement savings plans (see, e.g., Pension Rights Center 2020; AARP Public Policy Institute 2020). Adding an assurance fund could effectively turn these retirement savings plans into lifetime pensions. Participants in these state-sponsored pensions could allocate their contributions between regular mutual funds and these new assurance funds, and, in partnership with various private-sector investment and record-keeping companies, the state-sponsored pension would manage and invest those designated contributions and make the appropriate payouts to retirees and their beneficiaries.

To ensure their sustainability, assurance funds would operate as either tontines or pooled annuities—sometimes referred to as participating annuities.[1] The term ‘assurance’ is used to differentiate these products from ‘insurance’ products, in that while they do pool longevity risk, they are not based in any way on the principle of indemnity or a contract of risk transfer. Like commercial annuities, assurance funds would provide lifetime income, but unlike commercial annuities, assurance funds would not guarantee a precise level of that income. Instead, assurance funds would adhere to a strict budget constraint that requires them to remain fully funded at all times.[2] As a result, assurance fund payouts would vary as necessary to ensure their sustainability.

Not only would assurance funds be sustainable, they would also be efficient.[3] In particular, assurance fund payouts would be significantly higher than payouts from traditional mutual funds. This follows naturally from the fact that assurance funds rely on the survivor principle—that the share of each participant, at death, is enjoyed by the surviving participants, resulting in higher payouts to survivors for as long as they live. Additionally, assurance funds should enjoy higher average payout rates than comparable commercial annuities, because assurance funds would have no need for reserves and would do away with the expense of compensating insurance companies for taking on any risk.

In a world with substantial levels of undersaving, economic efficiency is vital. Moreover, underfunding is a slippery slope, because once a hole develops, there is always a chance that it could grow deeper, and deeper holes are increasingly difficult to escape. Truly sustainable solutions must always remain fully funded, because to tolerate underfunding is to invite sustainability risk. Assurance fund income would not be fixed, and it would not be guaranteed. Rather, it would be variable and nonguaranteed. But it would always be *fully funded* and, therefore, *fully sustainable* … forever.

The useful properties of assurance funds extend beyond state-sponsored pensions in the United States. Indeed, the assurance-fund model could extend to other countries and to private-sector retirement plans, as well. For example, a country like Chile, which has a well-established annuity market, could include assurance funds in its universal DC pension system to provide its citizens a flexible alternative to the current choices of traditional programmed withdrawals or traditional annuities (OECD 2019a). A country like Colombia, which lacks a deep annuity market due to policies that discourage private insurers from participating, might introduce assurance funds as a relatively fast, low-cost alternative to developing an annuity market (OECD 2015).

Lifetime Assurance Funds

A lifetime assurance fund is essentially a DC pension plan designed to pay out what it can—no more and no less—in an objective manner that is fully disclosed to all participants. Economically, an assurance fund always abides by a strict budget constraint, in that the expected present value of the payouts must always equal the present value of the fund's assets. An assurance fund can do this because it relies on the principle of mortality risk pooling, and, assuming that the pool of investors is large enough, the assurance fund is able to discount future payouts by the probability that the pool's members will be alive to receive those payouts. The budget constraint effectively means that assurance funds are always grounded in economic reality, which we believe makes them an attractive option for states and retirees alike.

Through an assurance fund pool, members diversify and share longevity risk among themselves. The investment balance of each investor is accounted for individually and reflects actual market values.[4] Participants in a retirement plan that offers assurance funds may make their own investment decisions within the set of assurance funds provided by the plan administrator, and their accounts are credited with their investment returns as usual. That is, a given retirement plan might offer a few different assurance funds in the same way that it offers a few different traditional mutual funds. In fact, these same mutual funds could serve as the underlying investments used by the assurance funds. For example, if a plan offered five different mutual funds as investment choices, it could elect to offer the same five investment choices as assurance funds.[5]

Contributions to these assurance funds would be irrevocable in order to enforce the condition that the risk-sharing arrangement is for life. In return, investors would receive mortality credits for as long as they live: living investors would divide the assets in the accounts of the investors that die. These mortality credits would be in addition to the investment returns on the underlying investment assets. As we envision them, the payouts from assurance funds would vary over time to ensure that the actuarial expected value of each investor's future lifetime payouts always matches the current value of her account balance. In short, the payouts from assurance funds will vary according to investment performance and mortality experience, because those are the two factors that affect the investor's balance.

Assurance funds compared to traditional mutual funds. Assurance fund payouts would be higher than the amounts that could be safely withdrawn from traditional mutual funds. The reason is that assurance funds offer not only investment returns, but also mortality credits. The return advantage to long-lived survivors would be especially significant because, as we will show, mortality credits would increase significantly with age.

Investments in assurance funds would differ in a major way from investments in mutual funds in that an investor in an assurance fund would *never* be allowed to withdraw her contributions (or her investment earnings or mortality credits). The situation is identical to a commercial life annuity: once the premium is paid, there is no refund. Instead, a participant in an assurance fund would only receive payouts according to the lifetime-payout method that she elected. For example, a typical participant in an assurance fund could elect to receive relatively level monthly payments starting at her planned retirement age—say, age 65 (if she is alive then)—until her death. Alternatively, she could elect escalating payouts (say, to offset inflation) that would start lower (at age 65) but would end up much higher, the longer she survives. Either way, the payouts to survivors from an assurance fund would be significantly higher than the payouts from a regular investment due to the mortality credits.

Assurance funds compared to traditional life annuities. Assurance fund payouts should also be higher than the payouts from a commercial life annuity. Assurance fund payouts would follow directly from: 1) the investment returns on the underlying investment portfolio; 2) the mortality experience of the assurance fund pool; and 3) the payout method that a member elects, which could be designed to be level or escalating. Because the assurance fund sponsor would make no guarantees, it would only charge a trivial fee to administer the program; and no money would ever need to be set aside for insurance company reserves or risk-taking. All in all, assurance fund payouts would mimic the high payouts that would come from being able to buy an actuarially-fair variable income annuity (VIA), which by some estimates could be 10 or 15 percent higher than what a typical commercial life annuity would pay.[6]

Tontines and Pooled Annuities

As mentioned, assurance funds would be structured as either tontines or pooled annuities. This section explains how simple tontines work and then goes on to show how an assurance fund could be engineered as a tontine or pooled annuity.

A simple tontine. In the simplest type of tontine, a set of investors contributes equally to buy a portfolio of investments to be awarded entirely to the last surviving investor (Cooper 1972: 1−2). Alternatively, the balances of those who die can be divided up and redistributed to the surviving investors more frequently. The latter type of tontine can be used to develop new financial products that would provide reliable, pension-like income for retirees, like tontine annuities, tontine pensions, and individual tontine accounts (see, e.g., Forman and Sabin 2016; Forman and Sabin 2015; Fullmer 2019; Fullmer and Sabin 2019a; Sabin 2010; Milevsky and Salisbury 2015; Goldsticker 2007; Newfield 2014).

At the outset, imagine that *1,000* 65-year-old retirees each contributed $1,000 to an investment fund that purchased a $1,000,000 Treasury bond paying four percent interest coupons. The bond will generate $40,000 interest per year, which is split equally among the surviving investors of the tontine. A custodian holds the bond, and because the custodian takes no risk and requires no capital, the custodian charges a trivial fee. If all the investors lived through the first year, each would receive a $40 dividend from the fund ($40 = $40,000 / 1,000). If only 800 original investors were alive a decade after the tontine started (when the survivors are age 75), then each would receive a $50 dividend ($50 = $40,000 / 800). If only 100 were alive two decades after that (when the survivors are 95), then each would receive a $400 dividend ($400 = $40,000 / 100). Later, when only 40 remain, each would receive a $1,000 dividend ($1,000 = $40,000 / 40). If the terms of the tontine called for liquidation at that point, then each of the 40 survivors would also receive a liquidating distribution of $25,000 ($25,000 = $1,000,000 / 40).

More advanced tontines. Most retirees would likely prefer reasonably level benefits throughout their retirement years, rather than benefits that increased sharply at the very end of their lives. Fortunately, it is possible to design tontines with payouts that are expected to remain level, on average, throughout retirement or, alternatively, with payouts that increase gradually throughout retirement, say, to offset inflation (see, e.g., Forman and Sabin 2015; Milevsky and Salisbury 2015).

Tontines would be of little practical interest if the way that they redistributed forfeited balances was not fair to all investors. A growing set of 'fair tontine design' articles have examined the ways and conditions in which tontines can indeed offer fair, equitable bets to all investors (e.g., Sabin 2010; Forman and Sabin 2015; Milevsky and Salisbury 2015; Donnelly et al. 2014). Indeed, tontines can be designed to offer fair bets for all investors even if they are of different ages, genders, invest different amounts at different times, use different investment portfolios, and elect different types of payouts. Furthermore, and crucially, fair tontines can be open-ended and perpetual. The key is to redistribute forfeited balances to the survivors in a very precise manner that reflects each survivor's individual account balance and probability of death. For example, Forman and Sabin (2015) showed how a tontine fund can fairly accommodate investors of different ages and account balances by deriving so-called 'fair-transfer-plan weights.' Tontine schemes can also be designed to permit investors to individualize their underlying investments and payout choices (Forman and Sabin 2015; Fullmer and Sabin 2019a).

Pooled annuities. The term 'pooled annuities' generally refers to insurance-company annuities offered without any insurance company guarantees (Donnelly 2015; Piggott et al. 2005).[7] Instead, the annuitants bear all of the risks. For example, if the annuitant population lives longer than projected, everyone's payouts would go down. Like fair tontines, pooled annuities can be carefully designed to provide fair bets to all annuitants.

Pension Sustainability Challenges

The quest for retirement security faces significant challenges in virtually every country across the globe. These challenges involve both the saving/accumulation and the dissaving/decumulation phases of the retirement lifecycle.

Demographics and economics. One challenge involves aging demographics in the form of increasing life expectancy and a lower ratio of workers to retirees. At the same time, low and even negative interest rates have dramatically increased the cost to finance retirement. Further, the uncertainty associated with longevity risk—both idiosyncratic (the diversifiable portion) and systematic (the non-diversifiable portion)—adds to the challenge by making the cost more uncertain. Simply put, retirement is expensive, and the act of promising *specific/exact* retirement benefits is both risky and expensive.

For this reason, it is not surprising that, despite the advantage of mortality risk pooling, economies of scale, and professional management, many defined benefit pension (DB) plans have disappeared, while many of those that remain are significantly underfunded (Forman 2020). Indeed, private-sector DB plans in the United States were underfunded by $401.3 billion at the end of the first quarter of 2020, at which time the plans were 89 percent funded, while state and local US government pension plans were underfunded by $4.9 trillion and were just 45 percent funded (Board of Governors of the Federal Reserve System 2020). Other analysts using different data sources offer different estimates of public plan funding status, but generally agree that such plans are significantly underfunded in the aggregate (see, e.g., Aubry et al. 2018).

The shift from defined benefit to defined contribution plans. DB pension promises create liabilities that must be hedged or otherwise reserved against. The cost of this liability management ultimately reduces the amount that could otherwise be paid out to pensioners. One response to these costs and risks has been to shift the burden of retirement funding from institutions to individuals—largely by replacing DB plans with DC plans (see, e.g., Staff of the Joint Committee on Taxation 2016; Mackenzie 2010; Zelinsky 2004).

This shift towards DC plans, of course, presents other challenges. One significant issue is that DC plans in the United States and many other countries operate primarily as tax-advantaged savings vehicles rather than lifetime income vehicles (Staff of the Joint Committee on Taxation 2019). Also, unlike DB plans, DC plans usually make distributions as lump sum or periodic distributions rather than as lifetime pensions. Unfortunately, most individuals lack the financial literacy, acumen, and skills to effectively manage the drawdown of retirement savings over their highly uncertain lifespans (Lusardi and Mitchell 2014).

While it is true that individuals may elect to convert a portion of their savings into lifetime income by purchasing commercial life annuities, this is only true for those who live in countries in which life annuities are available in good supply. Yet even in countries with well-developed annuity markets, a demand problem often still exists, in that people rarely choose to buy annuities voluntarily (American Academy of Actuaries 2015). This is true even though annuitization would appear to be in the best economic interest of most people. Economists refer to this as the 'annuity puzzle' (Benartzi et al. 2011). Accordingly, many retirees within a DC system forgo any form of longevity protection and instead take their chances that they will not outlive their assets.

Inadequate access is another problem. Large segments of the population—for example, those that work in the informal economy or otherwise for small employers that do not provide retirement plan benefits—lack access to convenient ways to save efficiently and adequately. For example, as of March of 2019, just 71 percent of US private-sector workers had access to employer-sponsored pension plans, and only 56 percent of US private-sector workers participated (US Department of Labor, Bureau of Labor Statistics 2019). The probability of pension coverage is greater for older workers, for whites, for highly educated workers, for full-time workers, for higher-income workers, and for workers at larger firms (Copeland 2014). Participation in IRAs is even lower than participation in pensions; for example, while 36 percent of US households had an IRA in mid-2019, only around 12 percent of households made contributions to their IRAs in 2018 (Holden and Schrass 2019).

The Role for State-sponsored DC Pensions

Ultimately, the risk of failure for retirees in the DC system may fall on society (and largely, on governments). It is in everyone's interest, therefore, to ensure that the retirement system functions efficiently. To that end we note that commercial life annuities have some of the same problems mentioned above regarding DB pensions, namely, guaranteeing a specific amount of income creates liabilities for the guarantor that must be hedged and reserved. Those guarantees can be achieved only at a cost, and that cost reduces the benefits that can be paid out to annuitants.

Assurance funds represent a low-cost alternative that can benefit states by providing them with an economically efficient way to provide retiring workers with universal access to pension-like lifetime income. Moreover, states would benefit in that assurance funds would be sustainable in perpetuity because they would never risk underfunding. Of course, a prerequisite is to ensure that workers have access to a retirement savings system in the first place, and states are increasingly taking a role in providing that access.

Expanding coverage with universal pensions. To expand pension coverage, many countries have established universal pensions—or at least universal retirement savings programs. Those that mandate participation enjoy high participation rates, while those that are voluntary naturally have lower participation rates (OECD 2019b).

The United States has a voluntary pension system that is not universal (Forman and Mackenzie 2013). Although the US federal government has not adopted a universal pension system, several state governments have begun to create their own universal systems for workers not covered by employer-sponsored pensions (Pension Rights Center 2020; AARP Public Policy Institute 2020; Gale and John 2018). A general theme is to encourage individuals to save in individual retirement accounts through automatic payroll deduction unless workers opt out.

Moreover, workers who opt-out may automatically be reenrolled each year, again with the opportunity to opt out (i.e., automatic reenrollment). The automatic escalation of their annual contribution rate is also a possibility. Such automatic enrollment features will almost certainly lead to high participation rates and to higher levels of retirement savings (OECD 2012). Contributions are often invested in a sensible default investment option such as a target-date fund, unless a worker elects otherwise (IRC § 404(c); US Department of Labor, Employee Benefits Security Administration 2013).[8]

The Oregon retirement savings plan for private-sector workers. While several states are in the process of setting up state-sponsored retirement savings plans for the private-sector workers (Pension Rights Center 2020; AARP Public Policy Institute 2020), the state of Oregon is the furthest along (VanDerhei 2019). As of December of 2019, at least 54,000 Oregonians at some 3,637 businesses were enrolled (Stites 2019).

Oregon started its OregonSaves program in 2017 to provide a means of retirement saving for private-sector employees who were not eligible for an employer-sponsored plan (OregonSaves 2020). The program requires that Oregon employers without employer-sponsored plans automatically enroll their employees into payroll-deduction Roth IRAs managed by OregonSaves. The default contribution rate is five percent, although employees can opt out. Moreover, employee contributions are automatically increased by one percent each year until they reach 10 percent, unless the employee opts out.

OregonSaves uses a private-sector program administrator for recordkeeping and other functions. Investor accounts are held as Roth IRAs, so contributions made in 2020 were limited to $6,000 (or $7,000 for individuals over the age 50). Contributions to these Roth IRAs are not deductible, but investment earnings are tax-exempt and withdrawals are tax-free. The first $1,000 of a worker's contributions are invested in a money market or capital preservation fund (OregonSaves 2020). Further contributions are automatically invested in a target-date fund. OregonSaves also offers a growth fund alternative. OregonSaves charges an annual asset-based fee of around one percent to pay for the administration of the program and the operating expenses charged by the underlying investment funds. This fee is quite high although perhaps not surprisingly given that the program is so new and has not yet achieved significant economies of scale. Presumably, the fee level will drop significantly as the program continues to grow.

From universal savings accounts to universal pensions. While expanded access to retirement savings plans is certainly helpful, these state-sponsored plans often lack a mechanism to turn retirement savings into lifetime retirement income. Thus, they act more like universal savings accounts than universal pensions. While individuals might use a portion of their savings to purchase commercial life annuities in the open market, there is reason to doubt that they would for the annuity-puzzle reasons already mentioned. There is also reason to doubt that individuals would voluntarily purchase annuities even if states were to make them available within their state-sponsored plans.

Still, individuals might be more willing to annuitize if they could do so at lower cost, with greater transparency, and with more investment choices; and that is exactly what assurance funds could provide. The trade-off for lower cost would be that assurance-fund payouts would not be guaranteed but would instead vary over time—with investment and mortality experience—in a way that would always ensure that the assurance fund is fully funded and that payouts would be made over the lifetimes of all participants. In short, lifetime income would be *assured* but not *insured*.

The Management and Operation of a State Assurance Fund

Each state's assurance-fund operation could look a lot like today's state-run 529 educational savings plans. In Oklahoma, for example, the state has contracted with a subsidiary of TIAA to be the Oklahoma 529 College Savings Plan manager, and the plan offers participants a choice of nine different TIAA investment options that vary in their investment strategy and degree of risk (Oklahoma 529 College Savings Plan 2019). Of course, there is no reason why a state-sponsored pension could not separately contract for record-keeping and investment-fund management services (e.g., to select the best investment managers for each type of assurance fund).

Noting that a number of the Oklahoma 529 College Savings Plan funds are offered with fees of just 30 basis points, we anticipate that state-sponsored assurance funds could likewise be offered at a fee of as low as 30 basis points, consisting of around 10 basis points in fund management fees for assets managed passively and about 20 basis points for other administrative expenses (Forman and Sabin 2015).

Example. Suppose that a state opens a state-sponsored pension plan with the following features and options, which we simplify for the sake of brevity. Accounts are opened for new enrollees in the form of individual retirement accounts (IRAs). Employers lacking qualified retirement plans would be required to offer these IRAs to their employees via payroll deduction. Any employees not covered by an employer-sponsored plan would be automatically enrolled in the state-sponsored pension.[9] Employee contributions are automatically invested in the state-sponsored pension's default investment option at a default contribution rate, although employees may opt out, elect a different investment option, and elect a different contribution rate at any time. For simplicity, assume that the state-sponsored pension offered three low-cost diversified investment options: a global equity fund, an investment-grade bond fund, and a set of diversified target-date funds (the default option). For clarity, let us refer to participant balances in these investments as 'regular' accounts, to differentiate them from balances they may hold in 'assurance fund' accounts, discussed next.

To give participants the option to receive payouts in the form of a lifetime pension, the state could offer assurance funds as an additional investment option. Although contributions are defaulted into a regular investment account, participants have the option to instead direct any portion of their contributions into an assurance fund.[10] Similarly, they may transfer any portion of their regular account balances into an assurance fund at any time.

Contributions to assurance funds may be directed into any of the three low-cost investment options available in the regular investment accounts. In the simplest case, monthly payouts from the assurance fund would begin at age 65. Participants would have a choice about whether their payout stream included a growth factor, i.e., whether their payouts mimic a uniform level-payment annuity or an escalating annuity.

Some participants might want to invest in an assurance fund from the very start of their careers, so that they could begin receiving (and compounding) mortality credits earlier, and consequently, end up with larger retirement accounts balances. Others might instead prefer to wait until closer to retirement before deciding to invest in an assurance fund. This latter approach would sacrifice some mortality credits and account growth, but it would leave participants with the option to bequeath funds if they were to die before retirement.

A Simple Illustration

Suppose that a hypothetical worker elects to begin making retirement account contributions to the global equity fund starting on his 35th birthday, and this fund's expected return net of fees is seven percent per year. His salary at age 35 is \$50,000 a year, and it increases at the rate of four percent each year. He contributes 10 percent of his salary each month.

Our hypothetical worker decides to put half of each month's contribution into a regular investment account and the other half into an assurance fund account (i.e., 5 percent of his salary into each), directing both contributions into the same underlying global equity fund. If he dies before age 65, he would forfeit the balance in his assurance fund account, while the balance in his regular investment account would go to his designated beneficiaries.

In this example, the assurance fund makes forfeiture redistributions based on the 2012 Individual Annuity Mortality (IAM) Basic Table (Society of Actuaries 2020). Mortality credits are allocated each year by multiplying the account balance of each member who survived the year by a 'mortality yield' that accounts for the fair redistribution of forfeited account balances from those who died during the year to those who survived the year.[11]

Table 1 shows how the balance of each of his two accounts would grow each year with the simplifying assumption that the rate of return on his investments is always seven percent each year and that members die and forfeit balances at exactly the rate predicted by the mortality table. Column 1 shows the worker's age, and column 2 shows his salary—starting at \$50,000 when he is 35 years old and growing by four percent a year until it reaches \$155,933 when he is 64. Columns 3 through 5 show how his regular investment account grows over the course of his working years. Column 3 shows his contribution amounts; column 4 shows the amount of his investment returns; and column 5 shows how the balance in his regular investment account would grow to \$376,598 by the end of the year that he turns 64.[12]

[*Table 1 here*]

Columns 6 through 9 show how the same contributions would grow in an assurance fund account. Column 6 shows that his contributions to the assurance fund account are the same as his contributions to his regular investment account (i.e., 5 percent of salary into each account). Column 8 shows his share of the mortality credits that surviving workers earn when other workers in the assurance fund die.[13] These mortality credits grow over time, not only because the account balance is growing, but also because the worker's death probability upon which they are based grows with age. Column 7 shows the higher investment returns that the assurance fund earns because those investment returns would be based on account balances that include those mortality credits. Finally, column 9 shows how the balance in our hypothetical worker's assurance fund account would grow to $403,072 by the end of the year that he turns 64.

All in all, Table 1 shows that while an equal amount is contributed to each account each year, when our hypothetical worker reaches retirement at age 65, his regular investment account balance will be just $376,598, while his assurance fund account balance will be $403,372 (7.1 percent higher) as a result of accumulating and reinvesting the mortality credits attributable to the deaths of workers who did not live to age 65.

Table 2 follows this worker's assurance fund account after he retires at age 65, assuming that he elects a uniform (non-escalating) payout option. Of course, the payouts will stop when he dies, so the example illustrates the case of a long-living participant who lives to age 120. The payouts are computed as a life annuity using the simple formula $s \,/\, \ddot{a}$, where s is his balance at the start of the year, and $\ddot{a}$ is his current 'annuity factor.' This annuity factor represents the expected present value of $1 paid at the start of this year and every subsequent year for the duration of his lifetime, with future payments discounted to the present using an assumed annual interest rate.[14] The assumed annual interest rate is computed as $(1 + r) / (1 + g) - 1$, where r is the expected rate of return on the investor's portfolio and g is the selected payout growth rate. In this example, r is seven percent and g is zero, so the assumed annual interest rate is seven percent. This calculation ensures that the present value of the future payouts will equal the present value of the account, and thereby be sustainable for as long as the investor lives.[15] If it happens that the investments earn exactly seven percent in every subsequent year and that members die and forfeit balances at exactly the rate predicted by the mortality table, the investor's payout will have the same value $s\ /\ \ddot{a}$ every year until it is finally exhausted at age 120.

[*Table 2 here*]

Column 1 of Table 2 shows the age of our hypothetical retiree, and column 2 shows the balance in his account at the beginning of each year. Column 3 shows that, having elected the uniform payout option, he can expect to receive a level payout of $36,264 a year from age 65 until he dies at age 120. Column 4 shows his investment returns each year; column 5 shows his mortality credits each year; and column 6 shows how the ending balance of his account will fall from $396,376 at the end of the year that he turns 65 to $36,264 at the end of the year that he turns 119 and to $0 at age 120. In passing, it is worth noting that mortality credit yields are relatively small early in a worker's career but tend to grow steadily with age to the modest level of nearly one percent per year at retirement, and eventually growing very large at advanced ages—to over 13 percent per year at age 90 and over 40 percent per year at age 100 (a bit less for women than for men, since women generally have lower death probabilities at each age).

Similarly, Table 3 shows what the payouts would be if our hypothetical retiree had instead elected escalating payouts based on a 2.5 percent per year growth rate (modestly approximating an inflation-adjusted annuity). In this case, the assumed annual interest rate used to calculate the annuity factor is $(1 + r) / (1 + g) - 1 = (1 + 0.07) / (1 + 0.025) - 1 \approx 4.39$ percent. As before, this calculation ensures that present value of the future payouts will equal the present value of the account—i.e., the payouts are fully funded and sustainable for life. Column 3 of Table 3 shows how his payouts would increase by 2.5 percent a year from $29,195 at age 65 to $113,534 at age 120.

[*Table 3 here*]

Table 4 illustrates the case in which a retiree starts with the same $403,372 balance at age 65 and tries to withdraw the same level of payouts as in column 3 of Table 2 (uniform payouts from an assurance fund account), but this time makes those withdrawals *from a regular investment account*. With a regular investment account, withdrawals must stop when the account balance goes to zero, which in this case occurs at age 84. Unfortunately, age 84 is only around the median age of death that a 65-year-old male retiree could expect—in other words, there is a substantial chance that he would outlive the assets in his regular investment account. Similarly, although not shown here, we found that if a retiree instead tried to withdraw the same level of payouts as in column 3 of Table 3 (escalating payouts from an assurance fund account) from his regular investment account, that regular investment account would be depleted at age 85.

[*Table 4 here*]

Of course, future investment returns will not be exactly seven percent each year, and future mortality experience will not follow the mortality table exactly. Thus, future payouts from an assurance fund account would not actually be constant but rather would vary. For equity investments, this payout variability would be significant due to the high volatility associated with equity investments. For more conservative portfolios, payout variability would naturally be smaller. In the next section, we develop a model to simulate more realistically the effects of investment volatility and mortality variability on assurance fund payout volatility.

A More Realistic Illustration

To examine the potential range and volatility of investor payouts, we model a set of assurance funds using Monte Carlo simulations of investment returns and member deaths. Because our goal is to focus on payout volatility, we focus on members that are old enough to be receiving payouts (i.e., retirees).

We simulate an assurance fund pool of 10,000 assurance fund pool members. The size of the membership pool has a direct effect on the volatility of the mortality credits that members will receive. This volatility decreases (increases) as the size of the membership pool increases (decreases), but mortality experience is usually quite close to expectations with a pool that has at least 5,000 members (Sabin and Forman 2016). This is simply the law of large numbers at work in diversifying the idiosyncratic mortality risk of the individuals in the pool. To aid in decomposing the contribution to payout volatility between investment return and mortality experience (as opposed to membership pool size), we hold the pool size steady by assuming that one new member joins each year for every member that died the previous year.

We assume that the assurance fund pool is mature, meaning that it has been operating long enough to have many members who are old enough to be receiving payouts. At the time our simulation begins, some members are about to receive their first payout, while others will have already been receiving payouts for many years. To model this maturity, we randomly assign each member an age, gender, investment portfolio, account balance, and age of death.

Ages are assigned in the range from 65 to 85, inclusive. Investment portfolios are assigned as a choice between equity and bond portfolios. The equity portfolio has an expected return of seven percent and volatility of 17 percent, and the bond portfolio has expected return of three percent and volatility of four percent.[16] For simplicity, we assume no correlation between these portfolios. As a result, an allocation weighted, for example, 50 percent to the equity portfolio and 50 percent to the bond portfolio has an expected return of five percent and volatility of 8.73 percent.[17]

Account balances range from approximately $63,000 to $1,000,000 and are selected according to a log-uniform distribution that results in relatively smaller initial balances for most members.[18] Roughly one-third of initial balances are less than $158,000, and roughly two-thirds are less than $400,000. Only a small fraction of members have balances near $1,000,000.

We note that except for the size of the pool, none of the other parameter values discussed above will have a material effect on our results. This lack of material effects is a feature of actuarially-fair tontine (or pooled annuity) designs: because the design is fair, payouts to any given member are largely unaffected by the ages, genders, investment amounts, and portfolio selections of the other members.

Times of death are modeled using the 2012 IAM mortality table—this time using projection scale G2 (Society of Actuaries 2020) to account for expected mortality improvement.[19] This table is also used to fairly redistribute forfeited account balances in the form of mortality credits from those who die to those who are still alive. The IAM mortality table with projection scale is a generational table, meaning that an individual's probability of death depends not only on age and gender, but also on year of birth. The table projects decreasing probability of death (i.e., a longer life) as the birth year increases.

Payouts are in the form of a life annuity that commences at age 65. We randomly assign a payout trajectory for each member, whether level/uniform or escalating at 2.5 percent per year.[20]

To fairly redistribute forfeitures when members die, we use the ‘nominal-gain method’ of tontine accounting described in Sabin and Forman (2016).[21] We performed 10,000 simulation runs, with each run spanning 56 years, which is long enough to ensure that everyone who is taking payouts at the start of the simulation will have reached the maximum age of mortality (i.e., age 120) by the end of the simulation. In each simulation run, random portfolio returns were generated for each of the 56 years and random years of death were generated for each member.

Payouts and Payout Volatility

Consider two 65-year-old men who each have $100,000 in their assurance fund accounts at the start of the year and who each elect to receive uniform payouts in retirement. Edgar invests in the equity portfolio, and he receives an $8,646 payout at the start of the year.[22] Brian invests in the bond portfolio and receives a $5,970 payout at the start of the year (only about 69 percent of what Edgar receives). This difference is entirely attributable to the assumed annual interest rates used in their respective annuity factor calculations—seven percent for Edgar and three percent for Brian, matching the expected returns on their respective portfolios. As illustrated previously in Table 2, the expected payout in subsequent years for each investor will be the same as the payout in the initial year. These payouts will vary from year to year, but the expected value around which they vary will be uniform through time.

The volatility of assurance fund payouts is primarily a function of two factors—the investment strategy (which affects investment return volatility) and the size of the membership pool (which affects mortality credit volatility). Assuming the membership pool is reasonably large, say at least 1,000 people, payout volatility will depend almost entirely on the investment strategy (Sabin and Forman 2016).

Mortality risk contribution. Recall that while risk pooling effectively diversifies idiosyncratic mortality/longevity risk, it does not eliminate it. Figure 1 illustrates the contribution to payout volatility that derives solely from undiversified idiosyncratic mortality risk. In other words, it illustrates what the range in payout levels would be if a member were to receive exactly the expected rate of return of their selected portfolio each year, with zero portfolio return volatility.[23]

Note that because the tontine is fair by design, the effect of mortality risk on a member's payouts will be the same regardless of which investment is selected: equity, bonds, cash, or any combination of these. For this reason, Figure 1 shows the *normalized* payout each year expressed as a percentage of the initial year payout, which will apply to both Edgar and Brian. In other words, Figure 1 shows the potential percent change in payouts from that results from random variations in mortality rates among the membership from year to year.

[Figure 1 here]

Figure 1 shows these percent-change in payout values at the mean and at the 90th and 10th percentiles. The range of outcomes shown would be even narrower if the membership pool size were larger, because larger pools result in even greater diversification of the idiosyncratic risk.[24]

Notice that the mean of the payout simulations in each year is almost perfectly uniform. This is a feature of the fairness principle and conveys that our model is well behaved. In addition, the deviation about the mean is largely symmetrical and growing with age—it is small and barely noticeable until about age 85 and then grows more noticeably after that. The reason for this is that the mortality credit is a function of the member's probability of death, which increases with age.[25] The range between the 10th and 90th percentile of outcomes is less than one percent at age 80, two percent at age 90, 10 percent at age 100, and 22 percent at age 110.

Note, however, that some of the year-to-year variation will ‘cancel out’ over time, because deaths will be somewhat higher than expected in some years and somewhat lower than expected in other years simply by random chance. The distribution of the cumulative average payout values will therefore be tighter than that of the year-to-year payout values.

Investment risk contribution. Next, we show the effect on payout variability when portfolio returns are also volatile, meaning the complete simulation that includes both sources of payout variability—the mortality credits and the investment returns.

Figure 2 shows the results for Brian with the bond portfolio. Payouts start at $5,970 at age 65 and gradually grow more volatile over time. By age 90, there is a 10 percent chance that his payout that year would be less than $4,547 and a 10 percent chance that it would be more than $7,553.

[Figure 2 here]

Figure 3 shows the even larger volatility for Edgar with his equity portfolio. Payouts start at $8,646 at age 65 and grow more volatile over time. By age 90, there is a 10 percent chance that his payout that year would be less than $2,167 and a 10 percent chance that it would be more than $17,666. In both Figure 2 and Figure 3, we see that the means of the payout simulations are almost perfectly uniform and that the deviation about those means (i.e., the payout volatility) is largely symmetrical. Again, this is expected of a fairly designed tontine.

[Figure 3 here]

The fact that Brian, the bond investor, receives only $5,970 in the first year, whereas Edgar, the equity investor, receives $8,646 might seem like a great reason to invest in equity. Perhaps so, but equity is a much riskier investment and thus there is a tradeoff decision to be made between risk and reward. While Edgar is likely to continue receiving higher payouts than Brian throughout his retirement, there is a chance that he might not, and in the scenario of a severe bear market—which could occur at any time—his payouts could drop significantly below those of Brian. Naturally, those invested in a blended allocation of equity and bonds would receive initial payouts that are between those of an all-equity or all-bond investor, and the volatility of their payouts would likewise be between those of an all-equity or all-bond investor.[26]

To reiterate, the potential for lower payouts is not unique to assurance funds. To keep payouts or withdrawals at high levels in the face of portfolio losses is an exercise fraught with peril. Assurance funds avoid such peril by automatically making the adjustments necessary (whether up or down) to remain fully funded, thereby maximizing payouts without risking ruin.

The Risk of Ruin

For those taking systematic withdrawals from a retirement portfolio, risk is commonly measured as the risk of ruin, referring to the risk that the participant outlives her retirement savings—as happened to the investor in Table 4 above. Assurance funds are designed to have a virtually zero risk of ruin before the maximum age of mortality (age 120 in our model). This is accomplished through strict adherence to the budget constraint, which ensures that the expected present value of the payouts is always equal to the present value of the fund's assets.

The risk of ruin is principally a function of an investor's age, spending rate, and investment returns. The so-called 'four percent rule' of Bengen (1994) has become a common rule-of-thumb in financial planning as the maximum 'safe' withdrawal rate for new retirees. The idea is that investors are likely to avoid ruin over a 30-year planning horizon when invested in a portfolio consisting of 50 percent equity and 50 percent bonds if they withdraw four percent of the portfolio in the first year of retirement and then adjust that amount for inflation in each subsequent year, which we assume to be 2.5 percent per year.

Figure 4 shows the risk of ruin for a regular investment account using this rule for three different investment portfolios used in our simulation. The portfolios are the equity portfolio, the bond portfolio, and a portfolio weighted 50 percent to equity and 50 percent to bonds. The plot shows the cumulative probability of ruin under each portfolio and compares these ruin probabilities with that of an assurance fund. For example, for a regular account invested 100 percent in bonds, there is a 10 percent chance of running out of money around age 86 and a 50 percent chance of running out of money around age 90.

[*Figure 4 here*]

Using the returns in our model, the three portfolios held in a regular investment account all begin to exhibit a material risk of ruin by age 85 when following the four percent rule. More risky portfolios begin to face the risk of ruin sooner due to their higher volatility but also have the potential to last longer due to their higher expected returns. A regular investment account invested in any of the three portfolios would have at least a 30 percent chance of ruin by age 93.

In contrast, assurance funds have zero chance of ruin before age 120 regardless of how they are invested, and they always make a full payout at age 120 with the remaining money left in the investor's account. Moreover, for *any* of these portfolios held in an assurance fund account, an investor who elects to receive payouts with the 2.5 percent annual growth option will enjoy higher payouts *every year* than an investor would receive by applying the four percent rule and investing in the same portfolio in a regular investment account. The tradeoff, of course, is that the assurance fund does not allow the investor to freely make any additional withdrawals nor leave any bequests at death.

Using Escalating Payouts to Reduce Downside Payout Risk

An examination of Figure 2 shows that even bond portfolios can result in meaningful payout volatility. The risk of falling payouts are concerning to many retirees, especially those who must rely heavily on their DC plan savings to pay for living expenses in retirement.

When the payout growth rate used to compute an investor's payout is set equal to zero (as is the case with a uniform payout), there will be about a 50-50 chance that any future payout will be either above or below the initial payout received in the first year. This downside risk can be mitigated by instead selecting an escalating payout method. Doing so reduces the initial payout, but also reduces the risk that future payouts will fall below the level of prior payouts.

Figure 5 illustrates this by showing the payout on Brian's bond portfolio if he had instead selected his payout to include a 2.5 percent per year growth rate. The plot confirms that the payout does indeed increase by 2.5 percent per year, on average. In addition, the 10th percentile curve reveals that the risk that future payouts will drop below the initial payout is significantly reduced compared to the uniform payout option shown in Figure 2. The initial payout drops from $5,970 in the case of uniform payouts to $4,462 in the case of escalating payouts, but the growing payouts are expected to surpass the uniform payout level by age 77. Notably, even the 4.462 percent initial payout rate for the escalating-payout assurance fund is greater than what an investor could get by applying the four percent rule to a regular investment account, and the assurance fund comes with no risk of ruin before age 120.

[Figure 5 here]

These beneficial effects of using a positive payout growth rate would also hold for assurance funds that use riskier investment portfolios. For example, Figure 6 shows the payout to a 65-year-old male using a portfolio allocated 50 percent to equity and 50 percent to bonds, using a 2.5 percent per year payout growth rate. In this case, the initial annual payout would be $5,655 (5.655 percent), considerably higher than what an investor could get from applying the four percent rule to a regular investment account—and, again, with no risk of ruin before age 120.

[Figure 6 here]

Of course, there is another very good reason that people should want growing payout trajectories—inflation. Accordingly, state-sponsored assurance funds may want to encourage the use of escalating payout options.

Note that using a positive payout growth rate by itself does not materially change the volatility of the payouts. It just shifts the payout distribution to be escalating rather than uniform, which has the welcoming effect of reducing the chance that future payouts will fall below previous payouts.

Managing Volatility

In the previous examples, the annual volatility of the payout stream as measured by the standard deviation of the payouts was 14.8 percent for the equity portfolio and 3.7 percent for the bond portfolio. What can be done for those that desire even less payout volatility?

For one thing, states that offer assurance funds might include a portfolio option that uses cash-flow matching techniques, such as with bond ladders. In addition, plan participants could smooth plan payouts by keeping a portion of their retirement assets in a regular investment account and taking additional withdrawals from that regular investment account as needed to smooth their overall consumption. In this way, the regular investment account would act as a type of reserve mechanism.

Bond ladders. Cash-flow matching techniques, such as with Treasury bond ladders structured to produce a precise set of cash flows when held to maturity, could reduce payout volatility significantly. Although the market value of the bonds will vary as interest rates change over time, their cash flows will be unaffected. Furthermore, these cash flows would automatically adjust with inflation if the ladder was constructed using Treasury Inflation Protected Securities (TIPS).

It might seem a first glance that a laddering strategy would introduce reinvestment risk as the receipt of periodic mortality credits are reinvested into an investor's account. Yet, it turns out that this reinvestment has no effect on the payouts. The reason is that the reinvested mortality credits increase the par value of each bond in the ladder by a factor that depends only on the realized mortality credit yield and not on the current market value of the bonds. Thus, payouts are immunized from interest rate risk (see Fullmer and Sabin 2019b). Such strategies may prove popular among those with a strong preference for payout stability.

Side reserves. The whole idea of an assurance fund is to dispense with reserves in order to reduce costs, avoid counter-party risk, and maximize payouts. There is no reason, however, that an investor could not hold some assets in a regular investment account to dip into as needed or otherwise use for bequest motives. In fact, we expect that most assurance fund investors would do this. An assurance fund combined with a regular investment account provides both a source of assured lifetime income and a flexible asset reserve that can be used to smooth consumption in years that the assurance fund payouts fall and to fund unexpected spending needs from time to time.

Systematic Mortality Risk

Our model incorporated idiosyncratic mortality risk, but not systematic mortality risk, which cannot be diversified away. This fact is highly significant to a DB plan sponsor or insurance company with liabilities that cover many persons. However, it is less significant to an individual person. To put it in perspective, an unexpected improvement in longevity might add a year or two or three to life expectancy over the course of a person's retirement years. This will matter to the person only if she is fortunate enough to live into the right-hand tail of her age cohort. But even if she does, the effect of the systematic component is quite small compared to the idiosyncratic component. Absent any pooling, idiosyncratic longevity risk is remarkably high given that the remaining lifespan of a new retiree may be 10, 20, 30, 40 years or more. Thus, there is great benefit in cheaply diversifying this large idiosyncratic uncertainty away, and relatively little benefit in paying the more expensive cost to transfer the residual systematic risk to an insurer.

That said, the issue of systematic mortality risk is important, and we do not mean to marginalize it. Unexpected macro improvements (or declines) in longevity would surely result in a downward (or upward) force on assurance fund payouts, and it is the members who bear this risk. An analytical discussion of systematic mortality risk is presented in Sabin and Forman (2016) and illustrated in the form of individual accounts (as would be the case of assurance funds) in Fullmer and Sabin (2019a). An interesting, and indeed useful, characteristic of assurance funds is that unexpected changes in macro longevity would be handled gradually and gracefully. The budget constraint forces the assurance fund to lower (or raise) payouts continually in response to actual member deaths from year to year. Should the membership systematically die more quickly or slowly than expected, payout changes would begin immediately to reflect that change. Thus, payout changes due to systematic mortality risk will typically be small and gradual rather than large and lumpy.

An exception lies in the case of sharp spikes in mortality rates that can occur, for example, in a time of pandemic such as the outbreak discovered in December 2019 of severe acute respiratory syndrome coronavirus (SARS-CoV-2). If a pandemic were to cause the mortality rate within an assurance pool to increase unexpectedly, the mortality credits distributed to the surviving members would increase. As a result, payouts would also increase relative to what they would have been absent the pandemic. Essentially, a pandemic causes mortality credits—and thus payouts—to be pulled forward from future periods to the present. This unexpected 'payout bump' would likely be followed by a gradual payout dip in later years because those who died during the pandemic would, of course, not die later when they otherwise would have. If, however, the higher mortality rates caused by the pandemic were more permanent (i.e., resulted in a permanent reduction in life expectancies), the fund's mortality tables would be adjusted accordingly, and payout rates would remain at the higher level. A cure for cancer, on the other hand, would have the opposite effects (i.e., increasing life expectancies and reducing annual payouts).

People who prefer not to accept any amount of longevity risk could, of course, transfer that risk to an insurance company by purchasing a commercial life annuity rather than an assurance fund, although that risk transfer would naturally come at a cost. Because annuity providers bear systematic longevity risk, they are required to ensure their solvency by pricing in a suitable risk premium (NAIC 2013). Since assurance funds offer no such risk transfer or guarantee, no such risk premiums are charged. As a result, purchasers of commercial annuities sacrifice some amount of yield as the price for transferring the systematic component of longevity risk to the insurance company (Warshawsky 2012; Fullmer and Sabin 2019a). Assurance fund members instead keep that yield for themselves.

Conclusion

Assurance funds can enhance defined contribution plans by providing retirees with universal access to pension-like lifetime income. This income would not be fixed, and it would not be guaranteed; rather, it would be variable and nonguaranteed. But by adhering to a strict budget constraint, these plans and the income that they provide would always be fully funded and, therefore, fully sustainable.

Assurance funds are relatively simple. They payout out what they can—no more and no less—using simple, transparent formulas in a highly efficient way. Organized as either tontines or pooled annuities, payouts would be significantly higher, on average, than retirees could obtain from regular retirement savings accounts or comparable commercial life annuities. Moreover, if assurance fund accounts were offered along with regular investment accounts, together they would provide investors a sensible way to mitigate longevity risk, preserve liquidity, smooth consumption, and bequeath assets upon death.

State retirement savings programs could partner with various private-sector investment and record-keeping companies to add assurance funds to their investment platforms as a way to transform their programs from simple retirement savings plans into true lifetime pension plans. Costs could be quite low, and, since assurance funds make no guarantees, the sponsors would bear no fiduciary due diligence risks associated with selecting a guarantor. Assurance funds may also be of interest outside the US as an efficient, low-cost way to provide access to assured lifetime retirement income, perhaps especially in countries where a well-established insurance market does not currently exist.

References

AARP Public Policy Institute (2020). 'State Retirement Savings Resource Center.' Washington, DC: *AARP Public Policy Institute*. https://www.aarp.org/ppi/state-retirement-plans.html.

American Academy of Actuaries (2015). 'Risky Business: Living Longer Without Income for Life: Information for Current and Future Retirees.' *Issue Brief*, Washington, DC: American Academy of Actuaries. http://actuary.org/files/Retiree_PreRetirees_IB_102215.pdf.

Aubry, J-P, C.V. Crawford, and K. Wandrei (2018). 'Stability in Overall Pension Plan Funding Masks a Growing Divide.' *State and Local Pension Plans Issue in Brief 62*, Chestnut Hill, MA: Boston College Center for Retirement Research.

Bengen, W.P. (1994). 'Determining Withdrawal Rates Using Historical Data.' *Journal of Financial Planning*, 7(4): 14–24.

Benartzi, S., A. Previtero, and R.H. Thaler (2011). 'Annuitization Puzzles.' *Journal of Economic Perspectives,* 25(4): 143−164.

Board of Governors of the Federal Reserve System (2020). *Financial Accounts of the United States: Flow of Funds, Balance Sheets, and Integrated Macroeconomic Accounts: First Quarter 2020*, Washington, DC: Board of Governors of the Federal Reserve System.

Cooper, R.W. (1972). *An Historical Analysis of the Tontine Principle,* Philadelphia: Huebner Foundation/University of Pennsylvania.

Copeland, C. (2014). 'Employment-Based Retirement Plan Participation: Geographic Differences and Trends, 2013.' *EBRI Issue Brief 405*, Washington, DC: Employee Benefit Research Institute.

Croce, B. (2019). 'Auto portability program gets thumbs up by regulators.' *Pensions & Investments.* July 31: https://www.pionline.com/regulation/auto-portability-program-gets-thumbs-regulators.

Donnelly, C. (2015). ‘Actuarial Fairness and Solidarity in Pooled Annuity Funds.’ *ASTIN Bulletin*, 45(1): 49–74.

Donnelly, C., M. Guillén, and J.P. Nielsen (2014). ‘Bringing cost transparency to the life annuity market.’ *Insurance: Mathematics and Economics*, 56: 14−27.

Forman, J.B. (2020). ‘Fully Funded Pensions.’ 103(4) *Marquette Law Review*, 103(4): 1205−1312.

Forman, J.B. and G.D. Mackenzie (2013). ‘Optimal Rules for Defined Contribution Plans: What Can We Learn from the US and Australian Pension Systems?’ *Tax Lawyer,* 66(3): 613−651.

Forman, J.B. and M.J. Sabin (2015). ‘Tontine Pensions.’ *University of Pennsylvania Law Review*, 163(33): 755−831.

Forman, J.B. and M.J. Sabin (2016). ‘Survivor Funds.’ *Pace Law Review*, 37(1): 204−291.

Fullmer, R.K. (2019). ‘Tontines: A Practitioner’s Guide to Mortality-Pooled Investments.’ *CFA Institute Research Foundation Brief*. Charlottesville, VA: CFA Institute Research Foundation. https://www.cfainstitute.org/-/media/documents/article/rf-brief/fullmer-tontines-rf-brief.ashx.

Fullmer, R.K. and M.J. Sabin (2019a). ‘Individual Tontine Accounts.’ *Journal of Accounting and Finance*, 19(8): https://doi.org/10.33423/jaf.v19i8.2615.

Fullmer, R.K. and M. J. Sabin (2019b). ‘Tontine Bond Ladders.’ https://dx.doi.org/10.2139/ssrn.3373251.

Gale, W. and D. John (2018). ‘State-sponsored Retirement Savings Plans: New Approaches to Boost Retirement Plan Coverage.’ In O.S. Mitchell, R.L. Clark, and R. Maurer, eds., *How Persistent Low Returns Will Shape Saving and Retirement*. Oxford, UK: Oxford University

Press, pp. 173−193.

Goldsticker, R. (2007). ‘A Mutual Fund to Yield Annuity-Like Benefits.’ *Financial Analysts Journal,* 63(1): 63–67.

Holden, S. and D. Schrass (2019). ‘The Role of IRAs in US Households’ Saving for Retirement, 2019.’ *ICI Research Perspective*, 25(10): 1−40. Washington, DC: Investment Company Institute.

Internal Revenue Service (2019). *2020 Limitations Adjusted as Provided in Section 415(d), etc.* Notice 2019-59. Washington, DC: Internal Revenue Service.

Lusardi, A. and O.S. Mitchell (2014). ‘The Economic Importance of Financial Literacy: Theory and Evidence.’ *Journal of Economic Literature*, 52(1): 5–44.

Mackenzie, G.A. (2010). *The Decline of the Traditional Pension: A Comparative Study of Threats to Retirement Security*, New York, NY: Cambridge University Press.

Maurer, R., O.S. Mitchell, R. Rogalla, and V. Kartashov (2013a). ‘Lifecycle Portfolio Choice With Systematic Longevity Risk and Variable Investment-Linked Deferred Annuities.’ *Journal of Risk & Insurance*, 80(3): 649–676.

Maurer, R., R. Rogalla, and I. Siegelin (2013b). ‘Participating Payout Life Annuities: Lessons from Germany.’ *ASTIN Bulletin*, 43(2): 159–187.

Milevsky, M.A. (2015). *King William's Tontine: Why the Retirement Annuity of the Future Should Resemble its Past*, New York, NY: Cambridge University Press.

Milevsky, M.A. and T.S. Salisbury (2015). ‘Optimal Retirement Income Tontines.’ *Insurance: Mathematics and Economics*, 64: 91–105.

Milevsky, M.A. and T.S. Salisbury (2016). ‘Equitable retirement income tontines: Mixing cohorts without discriminating.’ *ASTIN Bulletin*, 46(3): 571−604.

Milevsky, M., T.S. Salisbury, G. Gonzalez, H. Jankowski (2018). ‘Annuities Versus Tontines in the 21st Century: A Canadian Case Study.’ *Society of Actuaries.* https://www.soa.org/globalassets/assets/Files/resources/research-report/2018/annuities-vs-tontines.pdf.

NAIC (National Association of Insurance Commissioners) (2013). ‘NAIC Model Rule (Regulation) for Recognizing a New Annuity Mortality Table for Use in Determining Reserve Liabilities for Annuities.’ National Association of Insurance Commissioners. http://www.naic.org/store/free/MDL-821.pdf.

Newfield, P. (2014). ‘The Tontine: An Improvement on the Conventional Annuity?’ *Journal of Retirement,* 1(3): 37–48.

Oklahoma 529 College Savings Plan (2019). ‘Invest Today for a Brighter Future.’ *State of Oklahoma*. https://www.ok4saving.org/documents/ok_enrollment.pdf.

OregonSaves (2020). ‘Work hard. Save easy.’ *OregonSaves*. https://www.oregonsaves.com/.

OECD (Organization for Economic Cooperation and Development) (2012). *OECD Pensions Outlook 2012*, Paris, France: OECD.

OECD (2015). ‘Pension Policy Notes and Reviews: Colombia.’ Paris, France: OECD: *Pension Policy Notes and Reviews.* https://www.oecd.org/pensions/policy-notes-and-reviews.htm.

OECD (2019a). ‘Country Profiles of Pensions Systems: Chile.’ Paris, France: OECD: *Pensions at a Glance.* https://www.oecd.org/publications/oecd-pensions-at-a-glance-19991363.htm.

OECD (2019b). *Pensions at a Glance 2019*. Paris, France: OECD.

Pension Rights Center (2020). ‘State-based retirement plans for the private sector. Washington, DC: *Pension Rights Center*. http://www.pensionrights.org/issues/legislation/state-based-retirement-plans-private-sector.

Piggott, J., E.A. Valdez, and B. Detzel (2005). ‘The Simple Analytics of a Pooled Annuity Fund.’ *Journal of Risk and Insurance*, 72(3): 497–520.

Qiao, C. and M. Sherris (2013). ‘Managing Systematic Mortality Risk With Group Self-Pooling and Annuitization Schemes.’ *Journal of Risk and Insurance*, 80(4): 949−974.

Retirement Clearinghouse (2020). ‘Auto Portability - Increasing Retirement Security for Americans.’ Charlotte, NC: *Retirement Clearinghouse*. https://rch1.com/auto-portability.

Sabin, M.J. (2010). ‘Fair Tontine Annuity.’ http://ssrn.com/abstract=1579932

Sabin, M.J. and J.B. Forman (2016). ‘The Analytics of a Single-Period Tontine.’ https://ssrn.com/abstract=2874160.

Society of Actuaries (2020). ‘2012 Individual Annuity Reserving Report & Table.’ Schaumburg, IL: *Society of Actuaries*. https://www.soa.org/resources/experience-studies/2011/2012-ind-annuity-reserving-rpt/.

Staff of the Joint Committee on Taxation (2016). *Present Law and Background Relating To Tax-Favored Retirement Saving And Certain Related Legislative Proposals*. JCX-3-16. Washington, DC: Joint Committee on Taxation.

Staff of the Joint Committee on Taxation (2019). *Present Law and Background Relating to Challenges in the Retirement System*. JCX-20-19. Washington, DC: Joint Committee on Taxation.

Stites, S. (2019). ‘Thousands of Oregon workers now saving for retirement under new program.’ *Salem Reporter*. December 1: https://www.salemreporter.com/posts/1562/thousands-of-oregon-workers-now-saving-for-retirement-under-new-program.

US Department of Labor, Bureau of Labor Statistics (2019). *National Compensation Survey: Employee Benefits in the United States—March 2019*. Bulletin 2791 Washington, DC: US

Department of Labor.

US Department of Labor, Employee Benefits Security Administration (2013). *Target Date Retirement Funds - Tips for ERISA Plan Fiduciaries*. Washington, DC: US Department of Labor.

VanDerhei, J. (2019). ‘What if OregonSaves Went National: A Look at the Impact on Retirement Income Adequacy.’ *EBRI Issue Brief* 494. Washington, DC: Employee Benefit Research Institute.

Waring, M.B. and L.B. Siegel (2018). ‘What Investment Risk Means to You: Strategic Asset Allocation, the Budget Constraint, and the Volatility of Spending During Retirement.’ *The Journal of Retirement*, 6(2): 7−26.

Warshawsky, M.J. (2012). *Retirement Income: Risks and Strategies*. Cambridge, MA: MIT Press.

Wilkenson, L. (2018). ‘What is CDC and how might it work in the UK?’ *Research Report*. London, UK: Pensions Policy Institute.

Yaari, M.E. (1965). ‘Uncertain Lifetime, Life Insurance and the Theory of the Consumer.’ *The Review of Economic Studies*, 32(2): 137−150.

Zelinsky, E.A. (2004). *The Origins of the Ownership Society: How the Defined Contribution Paradigm Changed America*, New York, NY: Oxford University Press.

Endnotes

[1] Tontines are named after Lorenzo de Tonti, the 17th-century Italian who is credited with the idea (Milevsky 2015). Group self-annuitization (Piggott et al. 2005; Qiao and Sherris 2013) is a similar concept that could be used. Participating variable index-linked annuities (Maurer, et al. 2013a; Maurer, et al. 2013b) could also be used—provided that the participation applies fully on both the upside and the downside. This would exclude 'one-way' participating annuities that offer upside participation with downside protection.

[2] See Waring and Siegel (2018) for a discussion on the budget constraint as it relates to retirement spending. The budget constraint differentiates assurance funds from so-called 'collective defined contribution' (CDC) plans which may permit intergenerational wealth redistribution that can result in significant underfunding and unsustainability risks that we wish to avoid (see, e.g., Wilkenson 2018).

[3] By this we mean efficient economically for individual retirement consumers; see the lifecycle model in Yaari (1965), for example.

[4] We use the terms 'member' and 'investor' somewhat interchangeably when referring to those that invest in an assurance fund. In general, we use the term investor when referring to concepts that apply generally to any investor, and we use the term member when referring to concepts that apply to risk pooling, risk sharing, forfeitures, and other concepts that do not apply to regular investment accounts.

[5] We use the term 'mutual fund' generically to include similar offerings such as collective investment trusts. Assurance funds might likewise be organized as either funds or trusts.

[6] See, for example, Warshawsky (2012) who notes that commercial life annuities typically provide benefits that are worth just 88 percent of what an actuarially fair annuity would provide. A

comparison of expected assurance fund performance relative to fixed annuities is significantly more nuanced. The same rational—that assurance funds dispense with the risk costs required of commercial life annuities—still applies, but we note that a theoretical comparison using historical fixed annuity prices in Canada by Milevsky et al. (2018) was not so clear-cut. That study found that the comparison results depended significantly on the assumptions used.

[7] Similar arrangements go by other names, including participating annuities and group-self annuitization schemes (Piggott et al. 2005; Qiao and Sherris 2013; Maurer, et al. 2013a; Maurer, et al. 2013b).

[8] Moreover, these accounts could be used to automatically combine each worker's past pensions into a single account, which could help to reduce leakage and preserve retirement savings for retirement purposes (Croce 2019; Retirement Clearinghouse 2020).

[9] Self-employed workers would also be allowed to participate in these state-sponsored pensions, if they desired. For that matter, it might make sense to allow anyone who can legally open or own an IRA to participate.

[10] States might even automatically default a portion of each worker's contributions into an assurance fund but allow the worker to opt out. We view this approach as unlikely in the United States, where a default into any type of irrevocable, annuity-like option would certainly be controversial. On the other hand, in countries where government-mandated actions are more commonplace, it could be appropriate to automatically default a portion of each worker's contributions into an assurance fund (either with, or without, an opt-out).

[11] We illustrate yearly mortality rates and payout amounts here for brevity, but the same principle applies when using monthly rates and payouts. Also, we are not advocating that assurance funds should take gender into account but only noting that they could. For more discussion of gender

issues in annuities and pensions, see Forman and Sabin (2015).

[12] The monthly rate of return R_m is computed as $1.07^{(1/12)} - 1$. The monthly investment return is calculated as the beginning of period balance multiplied by R_m plus the current month's contribution multiplied by $(1 + R_m)^{1/2} - 1$.

[13] These mortality credits are calculated by taking the beginning of period balance and adding the monthly investment return, then multiplying this sum by the mortality credit yield.

[14] The formula for the annuity factor at age x is $\ddot{a}_x = 1 + \sum_{t=1}^{\infty} v^t \, {}_t p_x$, where ${}_t p_x$ is the probability of surviving to age $x + t$ given that the member is alive at age x, and $v = 1/(1 + i)$ is the discount factor, with i the assumed interest rate (e.g., 7 percent). The value of ${}_t p_x$ is calculated from the mortality table. The IAM mortality table used here has a terminal age of 120, meaning there is zero probability of surviving to ages greater than 120, and so the sum in the formula has a finite number of terms. In practice, an assurance fund provider could extend the table to even more advanced ages to accommodate the possibility of even longer lives.

[15] At least until the maximum age of the mortality table, which is 120 in this case.

[16] We assume that the returns on both portfolios are random and normally distributed. The reason is that we are not trying to model specific equity or bond portfolios, but rather depict portfolios with higher/lower returns and higher/lower return volatility. In a later section, we briefly discuss the potential of other investment strategies with different return characteristics.

[17] The expected return on a blended portfolio is $w_e r_e + w_b r_b$, where w_e is the weight in the equity portfolio, r_e is the expected return of the equity portfolio, w_b is the weight in the bond portfolio, and r_b is the expected return of the bond portfolio. Because we assume no correlation between portfolios, the volatility is simply $({w_e}^2{\sigma_e}^2 + {w_b}^2{\sigma_b}^2)^{1/2}$, where σ_e is the volatility of the equity portfolio and σ_b is the volatility of the bond portfolio.

[18] Specifically, balances are assigned by the formula $10^{(1.2U+4.8)}$, where U is a uniform random number in the range of zero to one.

[19] With respect to mortality improvement projection, the first year of the simulation is assumed to be 2020 and the last year of the simulation is 2075.

[20] For level/uniform payouts, the assumed annual interest rate is seven percent for the equity portfolio and three percent for the bond portfolio. For escalating payouts, the assumed annual interest rate is $(1 + r) / (1 + g) - 1 = (1 + 0.07) / (1 + 0.025) - 1 \approx 4.39$ percent for the equity portfolio and $(1 + r) / (1 + g) - 1 = (1 + 0.03) / (1 + 0.025) - 1 \approx 0.49$ percent for the bond portfolio. The assumed annual interest rate for blended portfolios are computed similarly using the expected rate of return on the blended portfolio (refer to endnote 17) in the numerator of this calculation.

[21] As explained in Sabin and Forman (2016), the nominal-gain method is not strictly fair in an actuarial sense, at least not exactly. The analysis is complicated, but for our purposes the bottom line is that its bias is negligible in an assurance fund pool of the size described here (i.e., with 10,000 members). For all practical purposes, we can use the nominal-gain method and regard it as fair. We choose this method for its advantages of simplicity, transparency, and the fact that members will perceive it as being fair.

[22] Note that Edgar's age 65 payout rate of 8.646 percent of the portfolio value in the first year is less than the 8.990 percent payout rate at the same age given in Table 2 (0.08990 = \$36,264 / \$403,372). The reason is that Table 2 illustrated a simple example that assumed no mortality improvement, whereas our simulation model does assume mortality improvement.

[23] At its simplest, imagine a fund that takes investor money and simply holds it, with zero return and zero volatility (in this case, a 65-year-old male investing \$100,000 and selecting the uniform payout option would receive \$4,183 in the first year and expect to continue receiving that amount

every year thereafter).

[24] For an analytical discussion of this effect, see Sabin and Forman (2016).

[25] The expected mortality credit yield at age x is $q_x / (1 - q_x)$, where q_x is the death probability at age x. Since q_x increases with age, so too does the expected mortality credit yield. This amplifies the effect of random mortality deviations on the actual mortality credit yield, resulting in increasing deviation of the percentile curves at higher ages.

[26] Recall that Figures 2 and 3 (as well as Figures 1, 5, and 6) show the range in payouts from year-to-year, and in any particular simulation the payouts both rise and fall over the course of the payout years. These ups and downs 'average out' over time such that the range of the *average* payout received by a member over time will be narrower than the yearly values.

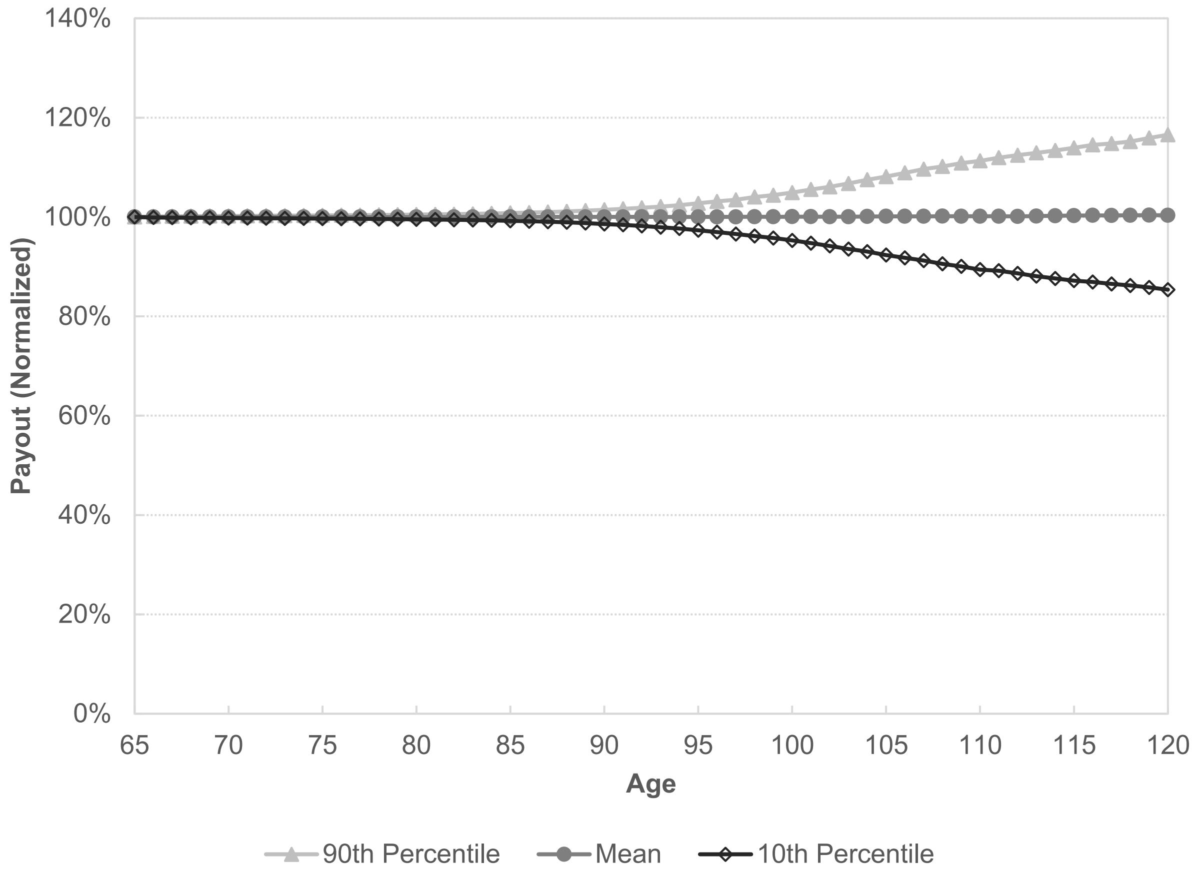

Figure 1. Range of yearly payouts by age (male) due to mortality credit volatility only

Source: Authors' calculations.

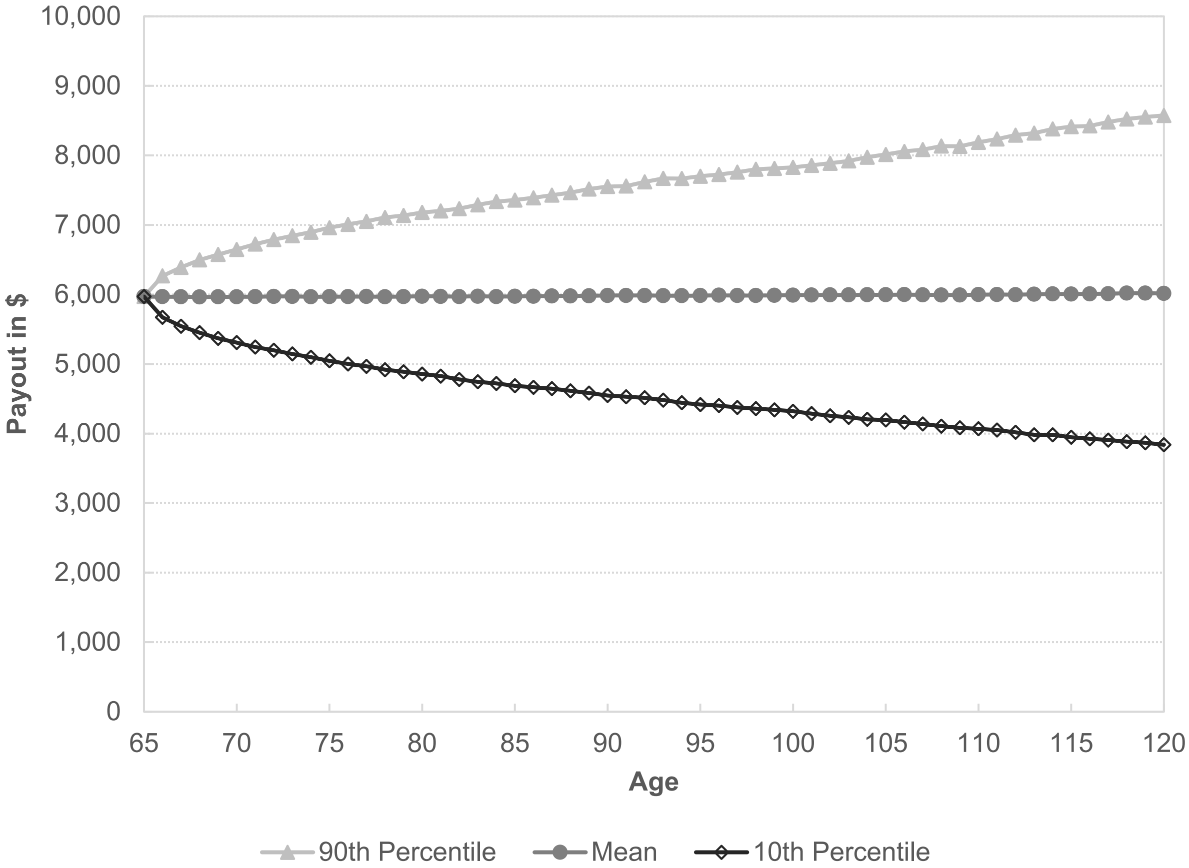

Figure 2. Range of yearly payouts by age (male) due to both mortality credit and investment volatility (bond portfolio with no payout growth rate)

Source: Authors' calculations.

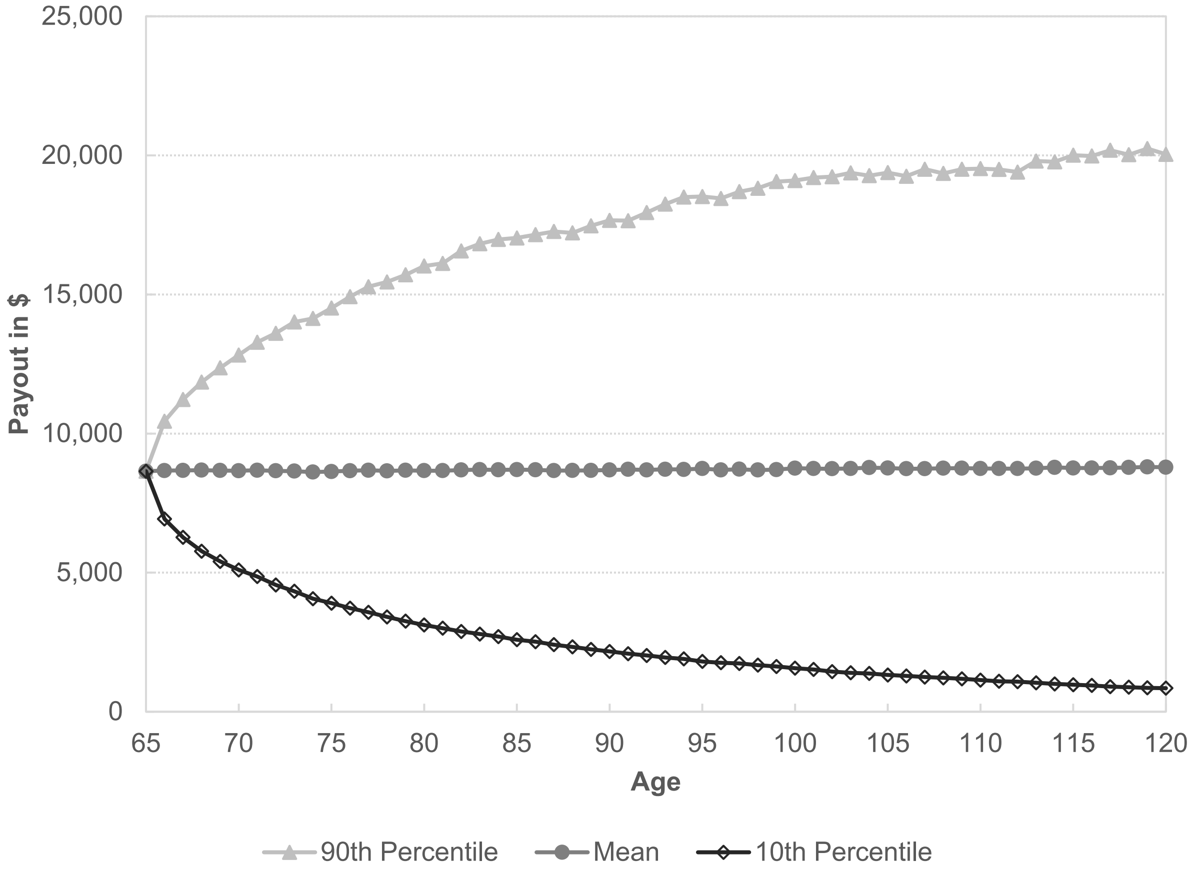

Figure 3. Range of yearly payouts by age (male) due to both mortality credit and investment volatility (equity portfolio with no payout growth rate)

Source: Authors' calculations.

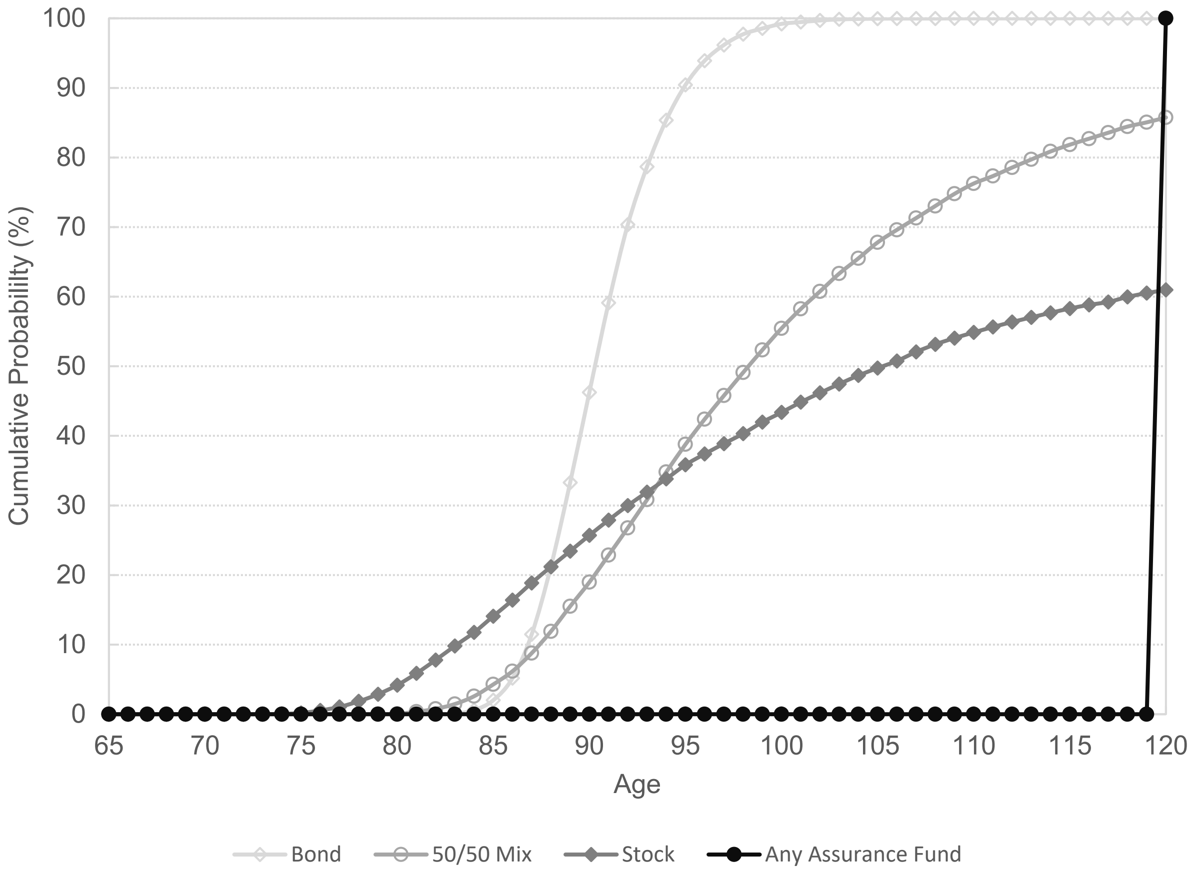

Figure 4. Cumulative probability of ruin for regular investment accounts under the four percent rule, compared to assurance fund accounts

Source: Authors' calculations.

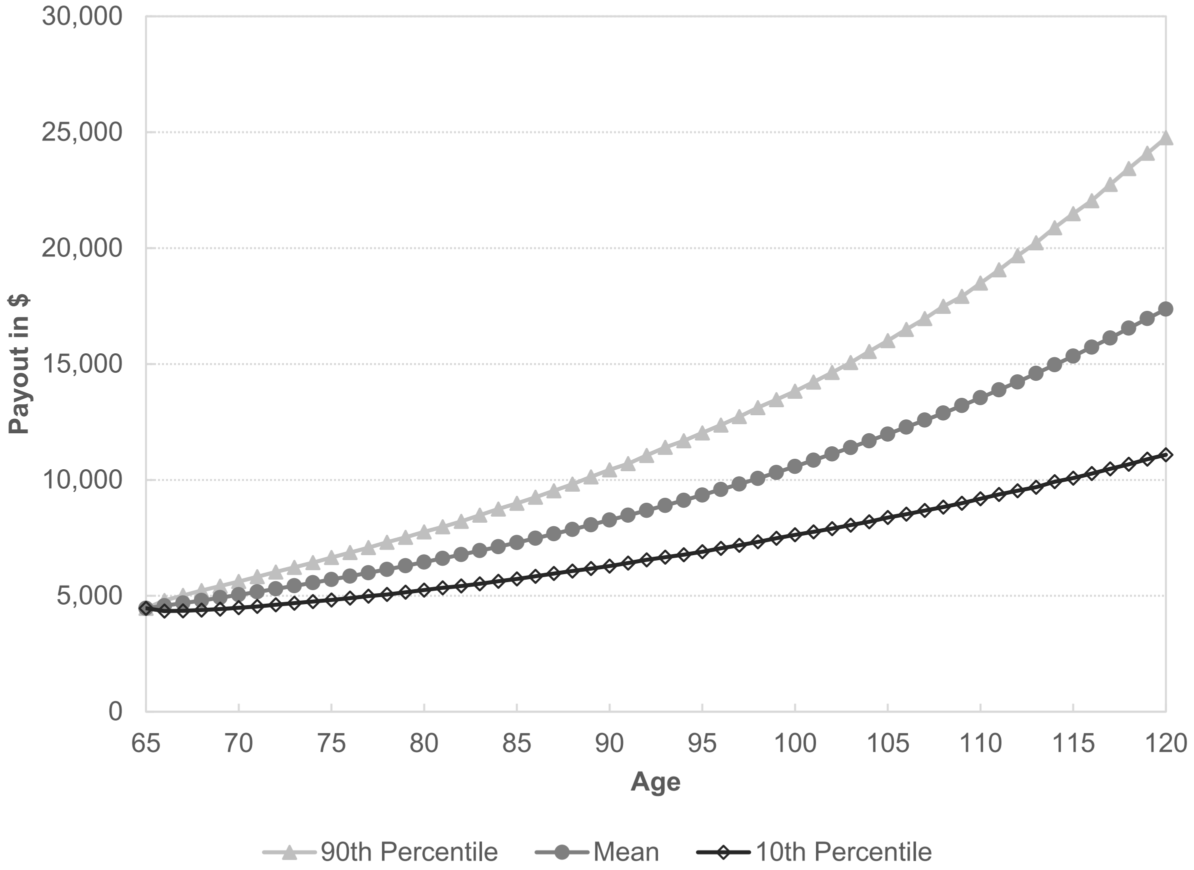

Figure 5. Range of yearly payouts by age (male) due to both mortality credit and investment volatility (bond portfolio with a 2.5 percent per year payout growth rate)

Source: Authors' calculations.

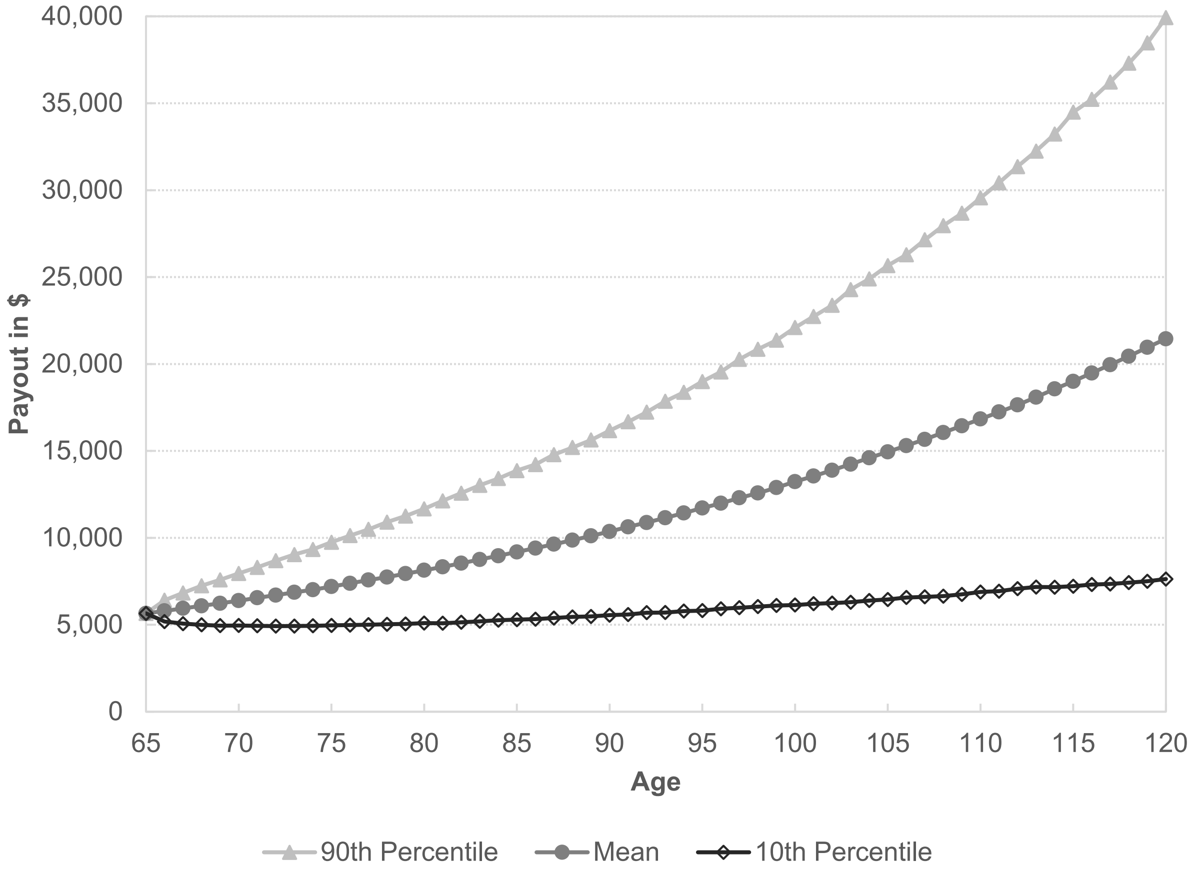

Figure 6: Range of yearly payouts by age (male) due to both mortality credit and investment volatility (50/50 equity/bond allocation with a 2.5 percent per year payout growth rate)

Source: Authors' calculations.

Table 1. Account balances before retirement

		Regular Investment Account			Assurance Fund Account			
Age	Salary	Contribution	Investment Return	Ending Balance	Contribution	Investment Return	Mortality Credit	Ending Balance
35	$50,000	$2,500	$86	$2,586	$2,500	$86	$2	$2,588
36	52,000	2,600	270	5,457	2,600	271	4	5,463
37	54,080	2,704	475	8,635	2,704	475	7	8,649
38	56,243	2,812	701	12,149	2,812	702	10	12,174
39	58,493	2,925	951	16,025	2,925	953	14	16,066
40	60,833	3,042	1,226	20,293	3,042	1,229	19	20,356
41	63,266	3,163	1,529	24,985	3,163	1,534	26	25,079
42	65,797	3,290	1,862	30,137	3,290	1,869	34	30,271
43	68,428	3,421	2,227	35,786	3,421	2,237	43	35,972
44	71,166	3,558	2,627	41,972	3,558	2,640	54	42,224
45	74,012	3,701	3,065	48,738	3,701	3,083	66	49,074
46	76,973	3,849	3,544	56,130	3,849	3,568	83	56,573
47	80,052	4,003	4,067	64,200	4,003	4,098	105	64,778
48	83,254	4,163	4,637	73,000	4,163	4,678	133	73,752
49	86,584	4,329	5,259	82,588	4,329	5,312	170	83,563
50	90,047	4,502	5,936	93,026	4,502	6,004	215	94,285
51	93,649	4,682	6,673	104,382	4,682	6,761	271	105,999
52	97,395	4,870	7,474	116,726	4,870	7,588	336	118,793
53	101,291	5,065	8,345	130,135	5,065	8,490	410	132,757
54	105,342	5,267	9,291	144,693	5,267	9,474	495	147,993
55	109,556	5,478	10,317	160,488	5,478	10,548	595	164,614
56	113,938	5,697	11,430	177,615	5,697	11,719	717	182,747
57	118,496	5,925	12,637	196,177	5,925	12,996	865	202,533
58	123,236	6,162	13,944	216,283	6,162	14,389	1,049	224,133
59	128,165	6,408	15,360	238,051	6,408	15,910	1,275	247,726
60	133,292	6,665	16,893	261,609	6,665	17,570	1,549	273,510
61	138,623	6,931	18,551	287,091	6,931	19,384	1,882	301,707
62	144,168	7,208	20,344	314,644	7,208	21,367	2,279	332,562
63	149,935	7,497	22,283	344,424	7,497	23,537	2,751	366,347
64	155,933	7,797	24,378	376,598	7,797	25,913	3,316	403,372
		$140,212	$236,386		$140,212	$244,385	$18,775	

Note: For simplicity, this exhibit uses mortality rates without mortality improvements.

Source: Authors' calculations.

Table 2. Assurance fund account balance after retirement (uniform payout option)

Age	Beginning Balance	Payout	Investment Return	Mortality Credit	Ending Balance
65	$403,372	$36,264	$25,698	$3,570	$396,376
66	396,376	36,264	25,208	3,694	389,014
67	389,014	36,264	24,693	3,845	381,288
68	381,288	36,264	24,152	4,026	373,201
69	373,201	36,264	23,586	4,240	364,763
70	364,763	36,264	22,995	4,492	355,987
71	355,987	36,264	22,381	4,786	346,890
72	346,890	36,264	21,744	5,128	337,498
73	337,498	36,264	21,086	5,519	327,839
74	327,839	36,264	20,410	5,956	317,941
75	317,941	36,264	19,717	6,435	307,830
76	307,830	36,264	19,010	6,952	297,528
77	297,528	36,264	18,288	7,508	287,060
78	287,060	36,264	17,556	8,102	276,454
79	276,454	36,264	16,813	8,732	265,734
80	265,734	36,264	16,063	9,414	254,948
81	254,948	36,264	15,308	10,183	244,174
82	244,174	36,264	14,554	10,961	233,425
83	233,425	36,264	13,801	11,739	222,702
84	222,702	36,264	13,051	12,541	212,030
85	212,030	36,264	12,304	13,399	201,468
86	201,468	36,264	11,564	14,336	191,104
87	191,104	36,264	10,839	15,356	181,034
88	181,034	36,264	10,134	16,448	171,352
89	171,352	36,264	9,456	17,588	162,132
90	162,132	36,264	8,811	18,751	153,431
91	153,431	36,264	8,202	19,868	145,236
92	145,236	36,264	7,628	20,966	137,567
93	137,567	36,264	7,091	22,056	130,450
94	130,450	36,264	6,593	23,163	123,942
95	123,942	36,264	6,137	24,317	118,132
96	118,132	36,264	5,731	24,599	112,198
97	112,198	36,264	5,315	25,463	106,713
98	106,713	36,264	4,931	26,257	101,637
99	101,637	36,264	4,576	26,963	96,912
100	96,912	36,264	4,245	27,607	92,501
101	92,501	36,264	3,937	28,789	88,963
102	88,963	36,264	3,689	29,594	85,982
103	85,982	36,264	3,480	30,530	83,728
104	83,728	36,264	3,322	31,764	82,551
105	82,551	36,264	3,240	33,018	82,544
106	82,544	36,264	3,240	33,013	82,533
107	82,533	36,264	3,239	33,005	82,514

108	82,514	36,264	3,237	32,991	82,479
109	82,479	36,264	3,235	32,966	82,416
110	82,416	36,264	3,231	32,922	82,305
111	82,305	36,264	3,223	32,842	82,106
112	82,106	36,264	3,209	32,701	81,751
113	81,751	36,264	3,184	32,448	81,119
114	81,119	36,264	3,140	31,997	79,992
115	79,992	36,264	3,061	31,192	77,981
116	77,981	36,264	2,920	29,758	74,396
117	74,396	36,264	2,669	27,201	68,002
118	68,002	36,264	2,222	22,640	56,599
119	56,599	36,264	1,423	14,506	36,264
120	36,264	36,264	0	0	0
		$2,030,783	$578,571	$1,048,840	

Note: For simplicity, this exhibit uses mortality rates without mortality improvements.

Source: Authors’ calculations.

Table 3. Assurance fund account balance after retirement (2.5 percent per year escalating)

Age	Beginning Balance	Payout	Investment Return	Mortality Credit	Ending Balance
65	$403,372	$29,195	$26,192	$3,639	$404,008
66	404,008	29,925	26,186	3,838	404,107
67	404,107	30,673	26,140	4,071	403,644
68	403,644	31,440	26,054	4,343	402,601
69	402,601	32,226	25,926	4,661	400,963
70	400,963	33,032	25,755	5,031	398,717
71	398,717	33,858	25,540	5,462	395,862
72	395,862	34,704	25,281	5,963	392,402
73	392,402	35,572	24,978	6,537	388,346
74	388,346	36,461	24,632	7,188	383,705
75	383,705	37,372	24,243	7,912	378,488
76	378,488	38,307	23,813	8,709	372,703
77	372,703	39,264	23,341	9,582	366,361
78	366,361	40,246	22,828	10,535	359,478
79	359,478	41,252	22,276	11,568	352,070
80	352,070	42,283	21,685	12,710	344,181
81	344,181	43,341	21,059	14,008	335,908
82	335,908	44,424	20,404	15,367	327,255
83	327,255	45,535	19,720	16,774	318,214
84	318,214	46,673	19,008	18,266	308,815
85	308,815	47,840	18,268	19,894	299,138
86	299,138	49,036	17,507	21,703	289,311
87	289,311	50,262	16,733	23,707	279,490
88	279,490	51,518	15,958	25,900	269,830
89	269,830	52,806	15,192	28,257	260,472
90	260,472	54,126	14,444	30,741	251,531
91	251,531	55,480	13,724	33,245	243,020
92	243,020	56,867	13,031	35,816	235,000
93	235,000	58,288	12,370	38,475	227,556
94	227,556	59,745	11,747	41,268	220,826
95	220,826	61,239	11,171	44,260	215,018
96	215,018	62,770	10,657	45,746	208,652
97	208,652	64,339	10,102	48,392	202,806
98	202,806	65,948	9,580	51,009	197,447
99	197,447	67,596	9,090	53,556	192,497
100	192,497	69,286	8,625	56,085	187,920
101	187,920	71,019	8,183	59,845	184,930
102	184,930	72,794	7,850	62,973	182,958
103	182,958	74,614	7,584	66,531	182,459
104	182,459	76,479	7,419	70,924	184,322
105	184,322	78,391	7,415	75,564	188,911
106	188,911	80,351	7,599	77,439	193,598
107	193,598	82,360	7,787	79,350	198,375

108	198,375	84,419	7,977	81,289	203,222
109	203,222	86,529	8,168	83,241	208,102
110	208,102	88,692	8,359	85,179	212,947
111	212,947	90,910	8,543	87,053	217,632
112	217,632	93,182	8,711	88,774	221,936
113	221,936	95,512	8,850	90,182	225,455
114	225,455	97,900	8,929	90,989	227,474
115	227,474	100,347	8,899	90,683	226,709
116	226,709	102,856	8,670	88,348	220,871
117	220,871	105,427	8,081	82,349	205,873
118	205,873	108,063	6,847	69,771	174,429
119	174,429	110,765	4,456	45,414	113,534
120	113,534	113,534	0	0	0
		$3,487,075	$833,586	$2,250,117	

Note: For simplicity, this exhibit uses mortality rates without mortality improvements.

Source: Authors’ calculations.

Table 4. Payout comparison to a regular investment account (uniform payout option)

Age	Beginning Balance	Payout	Investment Return	Ending Balance
65	$403,372	$36,264	$25,698	$392,806
66	392,806	36,264	24,958	381,500
67	381,500	36,264	24,166	369,402
68	369,402	36,264	23,320	356,458
69	356,458	36,264	22,414	342,607
70	342,607	36,264	21,444	327,787
71	327,787	36,264	20,407	311,930
72	311,930	36,264	19,297	294,963
73	294,963	36,264	18,109	276,808
74	276,808	36,264	16,838	257,382
75	257,382	36,264	15,478	236,596
76	236,596	36,264	14,023	214,355
77	214,355	36,264	12,466	190,558
78	190,558	36,264	10,801	165,094
79	165,094	36,264	9,018	137,848
80	137,848	36,264	7,111	108,695
81	108,695	36,264	5,070	77,501
82	77,501	36,264	2,887	44,124
83	44,124	36,264	550	8,410
84	8,410	8,410	0	0
		$697,426	$294,054	

Source: Authors' calculations.