Journal of Banking and Finance 000 (2016) 1–12

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Made poorer by choice: Worker outcomes in social security vs. private retirement accounts ☆

Javed Ahmed[a], Brad M. Barber[b,*], Terrance Odean[c]

[a] Federal Reserve Board of Governors, 20th & C Streets, NW, Washington, DC 20551, USA
[b] Graduate School of Management, University of California, Davis, CA 95616, USA
[c] Haas School of Business, University of California, Berkeley, CA 94720, USA

ARTICLE INFO

Article history:
Received 12 February 2016
Accepted 4 August 2016
Available online xxx

Keywords:
Social Security
Individual investors
Retirement Saving

ABSTRACT

Can the freedom to choose how retirement funds are invested leave workers worse off? Via simulation, we document that choice in stock v. bond allocation and type of equity investments in private accounts leads to lower utility and greater risk of income shortfalls relative to private accounts without choice. We also compare private account outcomes to currently promised Social Security benefits to demonstrate that a representative worker (an average wage earner) benefits more from private-account alternatives—with or without choice—than do most workers. Thus, representative worker outcome should not be used to assess population-wide benefits of private account alternatives.

1. Introduction

In 2013, 37 million retired workers received an average annual Social Security benefit of about $15,000. Among those over age 65, 26% or more than 9 million retirees rely on Social Security for more than 90% of their income.[1]

Throughout most of Social Security's history, payroll tax inflows have exceeded benefit outflows. In 2010, benefits exceeded payroll taxes, and this funding deficit is expected to worsen in the coming decades absent reform. Many strategies have been proposed in response to Social Security's pending shortfall. These range from increases in the payroll tax and retirement age to privatization of Social Security. In 2001, the President's Commission to Strengthen Social Security proposed three models for Social Security reform which all incorporated voluntary personal accounts. Possible Social Security reform repeatedly emerges during major election cycles, along with recommendations featuring some form of private retirement accounts (PRAs).

In addition to suggesting that PRAs would earn high returns, some proponents argue they benefit workers by allowing them to choose how their retirement savings are invested. This is consistent with standard finance theory, where having more choices can only improve potential investment outcomes. However, to realize this improvement, investors must choose investments wisely. In the context of PRAs, there are two relevant issues. First, as discussed below, there is evidence that many investors do not choose portfolio allocations that maximize their utility. Second, evidence suggests that many investors fail to effectively diversify within their equity portfolios (Barber and Odean, 2000; Calvet et al., 2009; Goetzmann and Kumar, 2008; Gaudeker, 2015). If these tendencies extend to PRAs, outcomes for retirees become more dispersed, and the likelihood of shortfalls relative to currently-promised Social Security benefits increases. Allocation choice and equity choice impart decision risk that materially affects the risk of worker outcomes in a PRA system.

We analyze the effects of decision risk on workers' outcomes under a PRA system. We simulate retirement benefits for a representative cohort of 3655 workers born in the US in 1979. The

☆ We appreciate the comments of On Amir, Alexandre Baptista, Sebastien Betermeier, Hank Bessembinder, Paul Gerrans, Frank de Jong, Matti Keloharju, Alicia Munnell, Arun Muralidhar, Diane Oakley, Jonathan Parker, and seminar participants at the 2015 Gutmann Center Symposium, 2014 AFA Meetings, 2014 EFA Meetings, Arizona State, the Boulder Summer Conference on Consumer Financial Decision Making, the Copenhagen School of Business, the Cleveland Federal Reserve, Drexel, the Federal Reserve Board, Econometric Society, George Washington, Helsinki Finance Summit, the SEC, the University of Innsbruck, the University of South Florida, UT Dallas, and the Western Economic Association. We gratefully acknowledge financial support from the Center for Retirement Research at Boston College and the Sandell Grant Program. The views in this paper are those of the authors and do not necessarily represent the views of the Federal Reserve Board of Governors or its staff.

* Corresponding author.
E-mail addresses: javed.i.ahmed@frb.gov (J. Ahmed), bmbarber@ucdavis.edu (B.M. Barber), odean@haas.berkeley.edu (T. Odean).
URL: http://www.gsm.ucdavis.edu/~bmbarber (B.M. Barber), http://www.odean.org (T. Odean)

[1] Income of the Population 55 or Older, 2010, SSA Publication No. 13-11871, Table 9.B6, p. 309. Among those in the bottom quintile of net worth (including home ownership), the present value of Social Security benefits represents 82% of total wealth (Brady et al. (2013), Figure 16, p.35).

http://dx.doi.org/10.1016/j.jbankfin.2016.08.003
0378-4266/

wages, demographic characteristics, and mortality of our cohort are generated by CORSIM, a dynamic micro-simulation model of the United States population.[2] We compare results from a baseline setting without investment choice to settings in which workers can choose their allocation to stocks and bonds, to equity investments within their stock portfolio, or both.

Two main results emerge from this analysis. First, analyses based on the outcomes of a representative worker are misleading. Several studies of Social Security focus on the welfare of a representative worker (e.g., Auerbach and Kotlikoff (1987), Feldstein and Ranguelova (2001)). Our utility analysis indicates PRAs are much more appealing to the representative worker than to a worker who does not yet know his future income. Second, investment choice decreases worker utility in a PRA system. Over reasonable levels of risk aversion, allowing either allocation or equity choice leaves most workers preferring Social Security. Allowing allocation choice in PRAs increases the probability of an income shortfall relative to Social Security benefits, as some workers will allocate a relatively small amount of their investment portfolio to stocks. Allowing equity choice increases the probability of an income shortfall relative to Social Security benefits, as some workers will fail to effectively diversify.

Though we study outcomes of PRA systems as alternatives to Social Security, our results regarding equity and allocation choice generalize to self-directed retirement accounts intended to provide for the basic living needs in retirement. With greater allocation choice and greater equity choice, more workers are likely to fall short of their minimum goals than if they invest in a balanced portfolio of equity and bond index funds.

2. Institutional background and related literature

2.1. Our Benchmark: the current social security program

Social Security provides guaranteed retirement benefits to those who contribute to the system during their working years. While the majority of Social Security benefits go to retirees, the disabled and family members of beneficiaries also receive benefits. The system is often referred to as a defined-benefit pay-as-you-go (PayGo) system as current taxes are used to pay benefits to current retirees.

Social Security faces a funding shortfall as the result of being set up as an unfunded pay-as-you-go system that delivered about $14 trillion of net transfers (in 2014 present value dollars) to people born before 1937. (See Geanakoplos et al. (1999) for an in depth discussion of the implications of this unfunded liability for returns in a privatized system.) If Social Security were privatized, taxes would need to be levied to pay this liability. In this paper, we ignore Social Securities' projected shortfall as well as the analogous costs of paying this unfunded liability in a transition to a PRA system.

We treat both our Social Security benchmark and the PRA plans as self-funding for the cohort we study. We make Social Security self-funding by setting the Social Security tax rate to 8.8%. In our simulations, the 8.8% tax rate is sufficient to guarantee the aggregate cohort Social Security payout assuming the savings earn the equivalent of US five-year government bond rates.

2.2. Private retirement accounts (PRAs)

Private retirement accounts (PRAs) have been proposed as alternatives to Social Security. These proposals do not address the funding shortfalls discussed above. Instead, they emphasize individual ownership and responsibility and allow individuals to choose how retirement assets are invested.

While many privatization reform plans initially restrict investment choice, restrictions often give way to more choice over time. For example, Australia legislation to adopt a PRA (the Superannuation Guarantee) was passed in 1992. When first introduced, employees had very limited choices available (Fear and Pace, 2009). Over time, the choices available to employees have expanded, an expansion accelerated by the passage of the Superannuation Legislation Amendment (Choice of Fund) Act in 2004. Workers invest through a superannuation fund, often referred to as a super fund. In 2011, there were hundreds of super funds. Each super fund may offer workers a wide variety of investment options (one fund offered 2700). The investment options offered by a super fund have few restrictions and can include mutual funds, individual stocks, hedge funds, private equity, and property trusts (to name a few).

The experience in 401(k) retirement plans in the US is also informative. Brown et al. (2007) document the number of options available to workers has increased over time. In addition, the new options tend to be actively managed equity funds that charge higher fees and earn lower returns. More recently, brokerage windows, which allow investors to direct 401(k) assets to brokerage accounts and purchase individual equities, have become increasingly popular. Aon Hewitt Inc. (2013) reports the percentage of plans that offer brokerage windows has increased from 12% in 2001 to 40% in 2013.

The anticipated benefits of personal accounts include direct ownership (including heritability) and higher expected returns from investing in equities and other securities. Several studies (for example, Diamond and Geanakoplos, 2003; Modigliani et al., 2003) point out the returns and risks from investing in equities could be incorporated into Social Security without adding to the administrative costs of managing many individual personal accounts.

Prior studies simulate outcomes from a PRA system. However, we add more detailed assumptions regarding risks and expected returns faced by workers in their forced savings accounts. For example, the Bush Commission's projections assume that all personal accounts are invested in a 50/50 portfolio of equities and bonds that earn a constant annual real rate of return of 4.6%; a constant return assumption is clearly unrealistic when workers invest in risky assets (particularly stocks).

Feldstein and Liebman (2002) consider the distributional aspects of Social Security by considering worker-level outcomes, but do not model variation in market outcomes or risks arising from workers' different investment choices. They conclude that virtually all demographic groups benefit from a shift to PRAs. They assume a constant (i.e., risk-free) annual after cost logarithmic real portfolio return of 5.5% on PRA investments, which is close to the historic returns on a 60/40 stock/bond portfolio. However, they do not model variation in the returns earned on these risky investments across years or across households.

Feldstein and Ranguelova (2001) analyze outcomes of a representative worker who invests in a PRA and conclude the representative worker generally fares well under PRAs. They assume that personal accounts are invested in a 60/40 portfolio of equities and bonds, which earns a stochastic annual real return of 6.5%.[3] The

[2] CORSIM was developed by Steven Caldwell at Cornell University. The model was purchased by the U.S. Social Security Administration, which adapted it for internal use under the name POLISIM. The model was also adapted for use by the Canadian and Swedish governments (see Caldwell, 1996; Caldwell and Morrison, 2000, and http://www.strategicforecasting.com/corsim/index.html).

[3] Feldstein and Ranguelova (2001) assume a mean annual real log return of 5.5% on a 60/40 stock/bond portfolio (with a standard deviation of 12.5%), which corresponds to a mean level real return of approximately $6.5\% = e^{(5.5\% + \frac{(12.5)^2}{2})} - 1$. Our main results differ from theirs because they ignore worker-level outcomes focusing only on a representative worker and, we believe, they overestimate the market risk premium by using historical averages.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

returns earned in personal accounts vary across cohorts, but *not* across individuals within a cohort. Variation in outcomes across cohorts captures the risk that a particular generation of workers will experience a poor investment outcome. Gollier (2008) and Shiller (2006) also study this generational risk. We extend this line of inquiry by allowing for variation in returns across cohorts and, more importantly, allowing variation in investment choice across individuals within a cohort.

Our first departure from prior studies is to consider worker-level outcomes in a setting with stochastic investment returns. Next we allow for allocation choice in an investor's PRA. None of the aforementioned models studies the impact of allocation choice—the mix of stocks and bonds chosen by each individual in their investment portfolio. This is an important dimension of choice that almost certainly has a big impact on expected outcomes for workers. Extant research indicates that the stock-bond allocation decisions of investors are largely idiosyncratic. For example, Shum and Faig (2006) analyze the U.S. Survey of Consumer Finances (SCF) data and conclude that less than 10% of the variation in stock ownership can be explained by 18 variables conjectured to predict variation in stock ownership (e.g., education and age). Consistent with the observation that the stock allocation choices of investors are largely idiosyncratic, the stock allocation choices of investors are heavily influenced by the default options (e.g., Beshears et al., 2008, 2009) and choice framing (Benartzi and Thaler, 2001, 2007). In addition, many investors fail to participate in stock markets or allocate only a small fraction of their financial assets to equities (Campbell, 2006).

Our second innovation is to consider cross-sectional variation in the equity returns of individual workers. Even when investors experience the same market return, their personal investment results will vary. Modeling this cross-sectional variation in performance is important, as some investors will beat the market while others will underperform. There is considerable evidence that individual investors do not manage equity portfolios optimally. Investors fail to diversify their retirement portfolios by, for example, overinvesting in their employer's stock (Poterba, 2003; Benartzi, 2001). Kelly (1995), analyzing data from the SCF, and Goetzmann and Kumar (2008), analyzing data for a large U.S. broker, conclude investors fail to diversify their stock portfolios. Benartzi and Thaler (2001, 2007) argue investors follow naïve diversification strategies in their retirement plans. Calvet et al. (2009) analyze complete portfolios for Swedish households. While the median household holds a well-diversified portfolio, some households hold portfolios that are severely underdiversified. In addition, households with low education and wealth are less likely to participate in the stock market and more likely to invest inefficiently if they do participate. Gaudeker (2015) analyzes the complete portfolios of Dutch investors and finds the underdiversificaiton is more prevalent among investors with low levels of financial literacy who self-manage their investment portfolios. Similarly, Grinblatt et al. (2011, 2012) show that cognitive abilities positively affect both stock market participation and trading performance among Finnish investors. In summary, there are many reasons to expect high cross-sectional variation in investor outcomes under a PRA system, particularly since many workers tasked with managing their retirement portfolios will be new to investing and thus lack investment experience or knowledge.

By modeling outcomes at the individual rather than cohort level, we are also able to identify demographic patterns that emerge when we shift from an insurance-based Social Security program to PRAs. Under the current Social Security scheme, those who earn low wages during their lifetime receive proportionately greater benefits than high-wage earners. Thus, a worker-level analysis allows us to estimate the probability of an income shortfall for different demographic groups, which is clearly important given the progressive nature of Social Security benefits.[4]

Finally, modeling outcomes at the individual rather than cohort level also allows us to compare the outcomes of individual workers to that of a representative worker. Compared to a representative worker, individual workers face greater lifetime income uncertainty, work for fewer years, and have lower (median) incomes. Thus the welfare implications of switching from Social Security to PRAs for a representative worker are not a good measure of how such a switch affects the welfare of most workers.

3. Data and methodology

In our base case, we compare PRA income, where workers without investment choice invest in a 50/50 stock/bond portfolio and purchase a variable annuity in retirement, to currently promised Social Security benefits based on a worker's earnings history. We simulate the experiences for 10,000 generations of workers. Each generation shares the same income profile, but experiences a different market return.

We use simulated data for lifetime earnings of a cohort of 3655 individuals born in 1979, which we obtained from CORSIM. CORSIM provides a detailed micro-simulation of incomes for a representative sample of the US population based on numerous sources (e.g., Survey of Consumer Finances, Panel Study of Income Dynamics, and The US Census). See Caldwell (1996) and Caldwell and Morrison (2000) for details. The CORSIM micro-simulations have been used in studies by Caldwell et al. (1999) and Gokhale and Kotlikoff (1999, 2002). The data include demographic details (e.g., race and gender), annual earnings subject to social security benefits, and year of death.

In the online appendix, we present descriptive statistics on lifetime earnings of the 1979 birth cohort by decade from 1999 through 2069. Mean and median income increase with age until the cohort reaches age 50 and then tails off quickly as workers retire. The mortality profile of the CORSIM cohort is similar to projections from the Social Security Administration.

3.1. Estimating social security benefits

We estimate the currently promised Social Security benefit for each worker in each year during retirement based on the algorithm used to calculate Social Security benefits as described in Board of Trustees (2012) and assuming a retirement age of 67.[5] In the online appendix, we describe these calculations in detail.

3.2. Private retirement account (PRA) income

To calculate PRA income, we assume workers are required to save the equivalent of their Social Security tax in a defined-contribution PRA. In our base case, we assume workers invest their PRAs in portfolios with a 50% allocation to equities and 50% allocation to bonds with annual rebalancing. Simulated returns on 50/50 portfolios average 7.6% per year. In retirement, we assume all workers buy a variable annuity. Thus, mortality risk is pooled, but each worker continues to bear market risk in retirement. We assume any balances in the PRAs of those who die before retirement are transferred to a common pool that continues to earn returns until the cohort retires and is then used to help finance the cohort's variable annuity.

[4] See Samwick, 2009, for a discussion of how progressivity could be incorporated into a PRA system.

[5] The normal Social Security retirement age varies from 65 for those born in 1937 and earlier to 67 for those born in 1960 or later.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

3.2.1. Savings rate

Our simulations assume a savings rate (or, equivalently, Social Security tax) of 8.8%. We arrive at this savings rate by assuming the aggregate savings of a cohort are sufficient to fund its retirement obligations if the cohort savings earned a rate of return equal to that on long-term US government bonds. We believe this is a reasonable assumption, since these obligations are virtually default free and are a close approximation to the type of security that would be used to immunize the liability generated by the cohort's retirement obligations. Specifically, we assume that the real log return on long-term government bonds is 1.79%, the mean real log return on long-term government bonds from 1946–2013. We adjust the assumed real return on long-term government bonds to reflect an assumed inflation rate of 3% (log inflation of 2.96%), yielding a nominal mean log return of 4.75%. Given this return assumption, we calculate the savings rate (or Social Security tax) that would fund the cohort's retirement obligations to be 8.8%.[6]

3.2.2. Portfolio returns without choice

We assume the annual return on a 50/50 stock/bond portfolio is 7.6% per annum. We assume that stocks earn a mean annual level return of 9.5%, bonds earn 5.7%, and the inflation rate is 3%. (Thus the portfolio has a mean level *real* return of 4.6% = 7.6%–3%.) Assuming one-month Treasury Bills earn 50 bps over inflation,[7] we implicitly assume an equity risk premium v. T-Bills of 6.0% = 9.5%–3.5%. In the online appendix, we discuss the reasoning behind these assumptions.

3.2.3. Portfolio returns with choice

(a) Stock-Bond Allocation Choice

Most individually controlled retirement account plans (e.g., 401(k)s, Keoghs, IRAs) as well as the alternative PRA proposals in the 2001 Report of the President's Commission allow investors to choose their stock-bond allocation. To assess the impact of allocation choice on outcomes, we consider simulations with and without allocation choice. In our baseline simulations, we assume all investors choose a 50/50 stock/bond allocation. In our allocation choice simulations, we model variation in choice using the observed stock allocation in retirement accounts.[8]

To estimate the variation in stock allocation in retirement accounts, we use the 2010 Survey of Consumer Finance (SCF) dataset. For each household in the dataset, we sum investments in IRAs, Keoghs, and 401k plans. For those households with a positive balance in at least one of these retirement accounts, we calculate the percentage of the account allocated to stock. Since we are focused on allocations during workers savings years, we restrict the analysis to households under the age of 68. For households with positive balances in retirement accounts and a head of household under the age of 68, the average (median) balance in these retirement accounts is $145,000 ($38,000), and the average (median) household allocates 48% (46%) of the account investments to stock. To reduce the complexity of our simulations, we do not model allocations to stock as a declining function of age, but note the cross-sectional variation in allocation choices is much greater than the variation in average allocation by age group.[9]

About 12% of households have no allocation to stocks and about 14% of households allocate 100% of their investments to stock.[10] In our simulations that allow allocation choice, for each worker we sample from a uniform distribution from 0 to 100, round to the nearest integer, and identify the stock allocation for the corresponding percentile from the SCF. This stock allocation is then used as the stock-bond allocation for the worker during all of his saving years.

We model the allocation choice in this way for two reasons. First, we do not know workers risk preferences so we implicitly assume the risk appetites are randomly assigned. Second, investors' allocation choices in defined contribution retirement accounts (e.g., contribution rates, asset allocation decisions, and investment in own company stock) are influenced by plan default options (e.g., Beshears et al., 2008, 2009) and choice framing (Benartzi and Thaler, 2001, 2007). This suggests that at least some investors' observed choices are not determined based on solving a portfolio optimization problem. Alternatively, we could model allocation choice as a function of demographic characteristics. For example, stock market participation tends to be lower for the less wealthy, so we might assume that low-income workers are more likely to spurn equity investment in their retirement accounts. However, lower income workers may also be more likely to choose default options, which could result in higher equity investments and less active trading.

Stock and bond allocation decisions reported in the SCF are made by households who anticipate receiving Social Security benefits – a low-risk cost-of-living protected annuity. If households are currently optimizing their asset allocation, then in the absence of Social Security they will reduce their allocation to stocks and increase their allocation to bonds (or annuities). As we document later, a lower equity allocation tends to increase the probability of an income shortfall; thus, lower equity allocations for any reason would further increase the probability of an income shortfalls.

(b) Stock Investment Choice

When investors have choices other than index funds, individual investment outcomes will vary from market returns. To calibrate the extent of this variation, we use realized returns in tax-deferred retirement accounts at a large discount broker in the US over the period 1991 to 1996. The dataset contains records for 78,000 households, but we limit our analysis to households' stock and equity mutual fund investments in tax-deferred retirement accounts for which we have complete positions during a calendar year (so we can reliably estimate the annual return earned in a household's tax-deferred account).[11] (See Barber and Odean (2000) for a complete description of these data.) For the average household, the tax-deferred account represents 79% of their total equity investments at the broker and 36% of the tax-deferred account is held in mutual funds with the remainder in individual stocks. For each household, we calculate the monthly portfolio return by matching month-end positions to Center for Research in Security Prices (CRSP) data on stock and equity mutual fund returns. From these monthly returns, we calculate an annual return for each household. These annual returns are used to calibrate the variation in annual

[6] The assumed savings rate (or Social Security tax) of 8.8% is 71% of the current OASDI tax rate of 12.4%. Our simulation of a solvent Social Security system requires lower taxes than the current 12.4% for two reasons. First, the current tax rate is required to partially fund the large embedded liability in the PayGO system that results from the transfer to retirees born prior to 1937. Second, the 12.4% tax rate funds both old age supplements (OAS) and disability income (DI). Our simulations only consider OAS payments, which represent about 2/3rds of total Social Security payouts.

[7] From 1926 to 2013, the annual level return on T-bills was 3.54% and CPI was 3.04%.

[8] Binsbergen et al. (2013), Bovenberg et al. (2014), Berkelaar et al. (2004), and Dahlquist et al. (2013) explore optimal portfolio choice in defined contribution pensions.

[9] The average equity allocation ranges from 43% for those in their 60s to 52% for those in their 20s. The mean and median household allocation to equity in tax-deferred retirement accounts were close to 50% in the 2004 and 2007 SCF datasets.

[10] Social Security is a large part of the retirement portfolio for many of these households and is effectively a fixed income investment converted to an annuity upon retirement. Thus the SCF Survey underestimates how conservatively total household retirement savings (including Social Security) are actually invested.

[11] Though we estimate equity return variation in actual retirement accounts, many of these accounts (e.g., IRAs) will not have default options. We would expect less variation in equity returns in a PRA system with well-diversified equity defaults.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

returns across households. In the online appendix, we present descriptive statistics on the returns earned by these households.

To model the cross-sectional variation in returns, we assume the cross-sectional distribution of household log returns is normally distributed with a standard deviation equal to 24% (i.e., the annual standard deviation of the household log returns). Thus, household log returns exhibit two sources of variation: time-series variation in equity market returns (17.4% from Section 2.2.2 above) and cross-sectional variation in household returns (24%). We assume these two sources of variation are normally distributed and independent. Thus, combining variation in equity market returns and the cross-sectional variation in household returns, the time-series standard deviation of the household log return is $29.6\% = \sqrt{.174^2 + .240^2}$.

In our choice-based simulations, we assume all investors invest in a 50/50 stock bond portfolio with annual rebalancing and bond returns do not vary across investors. However, each investor earns a different return on his or her stock portfolio, though investors collectively earn the simulated market return. To simulate this cross-sectional variation, we proceed in two steps. First, in each simulated year we draw a market return for equity, which is common for all investors. Second, we add idiosyncratic volatility to each investor's annual stock market return. Some investors beat the market, while others underperform.[12]

We assume the variation in outcomes across households is random within and across years. We do so for modeling simplicity, but this likely underestimates the effect of equity choice on the variation in outcomes that would be observed in a PRA system since a household that is undiversified in one year is likely to remain undiversified in subsequent years.

3.2.4. The variable annuity

We assume cohort members begin work at the beginning of their 21st year and retire at the end of their 67th year. The aggregate value of the cohorts' PRAs at retirement is used to finance a variable annuity for the cohort. We use the mortality tables implied in CORSIM data, but assume all cohort members alive at age 99 die at age 100. We present an example of the cohort annuity calculation in the online appendix.

4. Results

We estimate the percentage of the population that prefers Social Security to PRAs (with different levels of choice) based on a lifetime utility calculation, where we vary the level of relative risk aversion used in the calculation. Specifically, we calculate lifetime utility, *E[u],* for each worker assuming a constant relative risk aversion (CRRA) utility function, *u(Ct)*:

$$u(C_t) = \frac{{C_t}^{1-\gamma} - 1}{1-\gamma} \tag{2}$$

$$E[u] = E\left[\sum_{t=68}^{100} \beta^{t-68} u(C_t)\right] \tag{3}$$

where γ is the worker's relative risk aversion parameter, and β is his time discount factor. We assume a discount factor $\beta = 0.96$. In the Social Security regime, C_t is the promised Social Security benefit; the expected utility under Social Security is equal to the utility of the promised Social Security benefits. In the PRA regime, C_t is the income from a variable annuity that is purchased at retirement using accumulated savings and investment returns during working years. For each worker, the expected utility under the PRA regime is equal to his average utility across the 10,000 simulations. At different levels of relative risk-aversion (γ), we count the number of workers who prefer Social Security to PRAs.

We next calculate the probability that a worker's PRA income is less than her Social Security benefit, which we refer to as an income shortfall, at the ages of 68, 78, and 88. We measure the probability of income shortfalls in two ways. First, we calculate the probability of an income shortfall across all workers and all simulations. We refer to this metric as worker outcomes. Second, we report the percentage of workers who experience income shortfalls in more than 25% of simulations. While the 25% cutoff is somewhat arbitrary, this measure emphasizes the safety-net nature of Social Security for many workers and the asymmetrical effect on utility of losses versus gains relative to promised payments. This metric measures the percentage of workers with a risk of more than one quarter of being worse off with a PRA. We refer to this metric as percent-at-risk. Both of these measures focus on the downside risk of PRAs relative to Social Security, which we believe appropriate given its social insurance objective.

4.1. Expected utility

To consider whether the potential upside associated with private retirement accounts with varying degrees of choice is sufficient to compensate for downside risk, we analyze the percentage of the population that prefers Social Security to different PRAs given each member of the population has CRRA utility with a specified level of relative risk aversion (γ). To estimate how risk averse people are, economists analyze a wide variety of data including investment returns, options pricing, insurance choices, insurance deductibles, peer-to-peer lending, and survey responses; estimates of CRRA risk aversion levels vary from less than 1 to more than 50.[13]

To the extent possible, risk aversion should be measured in the context of the choices being considered. Since Social Security benefits provide income in retirement, the most relevant consideration is the distribution of retirement-income-based risk aversion in the population. Barsky et al. (1997) elicit relative risk aversion parameters by asking subjects a series of questions about their willingness to take a risky new job and find that 65% of subjects make choices consistent with an income-based risk aversion parameter greater than 3.76 (i.e., reject the new job with a 50–50 chance of doubling income or cutting it by 20%). Hanna et al. (2001) estimate a median risk aversion parameter of 5.65 when these questions are modified to ask about a pension in retirement. Because the estimates from these studies map closely into the setting we analyze, we calculate results for relative risk aversion parameters of 3.8 and 5.65[14]; to illustrate the sensitivity of the analysis to risk aversion

[12] The choice-based simulations assume the same annual level return on stocks (9.5%) as the no-choice simulations. To do so, we draw a log market return from a normal distribution with a mean of 4.7% and a standard deviation of 17.4%. Idiosyncratic volatility is added by drawing from a normal distribution with mean zero and standard deviation of 24.0%. The two draws are added to yield the household's log equity return for the year, which is normally distributed with a mean of 4.7% and a standard deviation of 29.6%. Thus, we preserve the assumed level return on equity (9.5%) by shaving the log return on equity from 7.6% to 4.7%: $9.5\% = \exp(.076 + .5^*.174^2) - 1 = \exp(.047 + .5^*.296^2) - 1$.

[13] E.g., Friedman (1973), Friend and Blume (1975), Hansen and Singleton (1982), Mehra and Prescott (1985), Szpiro (1986), Campbell (1996), Ait-Sahalia and Lo (2000), Bliss and Panigirtzoglou (2004), Sydnor (2010), Chiappori and Paiella (2011), and Paravisini et al. (2013). Rabin (2000) shows that within an expected utility framework typical choices for small and moderate stakes gambles imply absurdly high levels of risk aversion for gambles over large stakes. Rabin and Thaler (2001) write "… the correct conclusion for economists to draw, both from thought experiments and actual data, is that people do not display a consistent coefficient of relative risk aversion…"

[14] Since 1992, the Survey of Consumer Finances asks the question "Which of the statements on this page comes closest to the amount of financial risk that you are willing to take when you save or make investments?" Between 1992 and 2001, the percentage of people choosing "Not willing to take any financial risks," ranged from 38.7 to 49.8 (Yao et al. (2004)).

Table 1
Percentage of population preferring Social Security to Private Retirement Accounts at different levels of relative risk aversion (γ).
This table presents the percentage of the population that prefers Social Security to Private Retirement Accounts at relative risk aversion parameters (γ) of 2.0, 3.8, and 5.65. We assume workers have utility over consumption, $u(C_t)$, with constant relative risk aversion:
$u(C_t) = \frac{C_t^{1-\gamma}-1}{1-\gamma}$
and calculate expected lifetime utility ($E[u]$) assuming a discount rate $\beta = 0.96$:
$E[u] = E\left[\sum_{t=68}^{100} \beta^{t-68} u(C_t)\right]$
Expected lifetime utility under Social Security is based on the promised benefits; expected lifetime utility under the PRA system is the average utility across simulations.

		No Investment Choice	With Investment Choice
	γ	Panel A: All Workers	
50/50 Stock/Bond Allocation	2.00	20.3	38.3
	3.80	36.9	79.7
	5.65	60.5	97.6
Stock/Bond Allocation Choice	2.00	30.6	55.2
	3.80	50.8	98.2
	5.65	79.1	100.0

Panel B: By Quintile of Lifetime Earnings

		Quintile of Lifetime Earnings					Quintile of Lifetime Earnings				
		1 (Lo)	2	3	4	5 (Hi)	1 (Lo)	2	3	4	5 (Hi)
50/50 Stock/Bond Allocation	2.00	77.6	24.0	0.2	0.0	0.0	100.0	85.2	6.6	0.0	0.0
	3.80	100.0	80.1	4.6	0.0	0.0	100.0	100.0	99.6	81.9	17.0
	5.65	100.0	99.6	79.5	23.3	0.0	100.0	100.0	100.0	100.0	87.9
Stock/Bond Allocation Choice	2.00	99.3	43.3	3.8	3.4	3.6	100.0	99.6	62.3	14.0	0.0
	3.80	100.0	98.6	46.8	5.2	3.6	100.0	100.0	100.0	100.0	91.3
	5.65	100.0	100.0	98.9	78.7	18.0	100.0	100.0	100.0	100.0	100.0

assumptions we also include results for a relative risk aversion parameter of 2.0.

The results of this analysis are in Table 1, where we report the percentage of the population that prefers Social Security to PRAs across 10,000 simulations. We present four sets of results, where we alternatively consider outcomes with/without allocation choice and with/without stock investment choice. In each panel of this table and those that follow, we present results in the following matrix format:

No Stock Investment Choice 50/50 Stock/Bond Allocation	With Stock Investment Choice 50/50 Stock/Bond Allocation
No Stock Investment Choice Stock/Bond Allocation Choice	With Stock Investment Choice Stock/Bond Allocation Choice

In Panel A, we present results for all workers. Assuming each member of the population has a relative risk aversion of 2.0, 20.3% of workers prefer Social Security to PRAs without choice but a much larger percentage (55.2%) prefer Social Security to PRAs with both equity and allocation choice (with most of the action coming from equity choice). When we use a relative risk aversion parameter of 3.8, 36.9% prefer Social Security without choice to a PRA, but nearly everyone (98.2%) prefers Social Security to a PRA with both equity and allocation choice. Finally, assuming a risk aversion parameter of 5.65, 60.5% prefer Social Security to a PRA without choice and everyone (100.0%) prefers Social Security to a PRA with both equity and allocation choice. In Panel B, we present results partitioned by lifetime earnings quintiles. Without choice, lower income households have a stronger preference for Social Security because of the progressive nature of Social Security benefits. However, for each income quintile, choice materially increases the proportion of the population favoring Social Security over PRAs.

Equity choice reduces utility because some investors fail to effectively diversify. Allocation choice reduces utility because some investors make allocation choices inconsistent with their risk aversion over retirement income.

In a model of utility-maximizing agents, relaxing a constraint will not make people worse off. We estimate variation in stock-bond allocation from the 2010 Survey of Consumer Finance and the variation in investment outcomes from tax-deferred retirement accounts at a large U.S. discount brokerage. We then assume that all workers in our simulation have the same level of risk-aversion (for three levels of risk-aversion) but make heterogeneous choices. Thus we are assuming that, given choice, people do not optimally maximize their expected utility. An alternative view would be that the variation in asset allocation documented in the Survey of Consumer Finances and the variation in investment choices at the large U.S. brokerage are rational responses to variations in personal beliefs and risk aversion and that, in practice, people always hold the portfolios that maximize their personal expected utility.[15] A great deal of empirical evidence suggests otherwise. For asset allocation, mutual funds selection, and stock trades, people make choices that are materially influenced by irrelevant information and that unnecessarily reduce their investment returns. For example, Benartzi and Thaler (2001) find that equity-bond asset allocation in 401(k) plans tends to match the proportion of equity and bond funds offered in each plan. They find no compelling economic reasons for workers' allocation choices to depend upon the proportions of equity and bond funds offered in their plan. In an experiment with substantial incentives, Laibson, Choi, and Madrian (2010) find that people choose S&P 500 index funds with higher historical performance and higher fees over S&P 500 index funds with lower historical performance and lower fees, even though the optimal choice is the low fee funds. Finally, several studies document that stock trading by individual investors lowers average net returns (e.g., Barber and Odean, 2000; Barber et al., 2009).

One objection to Social Security when compared to a PRA system with allocation choice, is that workers are forced to invest in

[15] Even if some workers did maximize their expected utility with very risky PRA portfolios, their risk-taking could impose undesirable externalities. Some workers who lost their PRA savings through risky investments would either go hungry and homeless in retirement or become burdens on society.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

Table 2
Risk aversion parameter (γ) that leaves the worker at birth and average worker indifferent between Social Security and PRAs.
The table presents the risk aversion parameter (γ) that equates the utility from Social Security benefits to the expected utility across PRA outcomes. Panel A presents results for a worker at birth that has an equal probability of earning the lifetime income of each member of his cohort. Panel A presents results for the worker who earns the average wage of his cohort in each year. We assume workers have utility over consumption, $u(C_t)$, with constant relative risk aversion:
$u(C_t) = \frac{C_t^{1-\gamma}-1}{1-\gamma}$
and calculate expected lifetime utility ($E[u]$) assuming a discount rate $\beta = 0.96$:
$E[u] = E\left[\sum_{t=68}^{100} \beta^{t-68} u(C_t)\right]$
For the average worker (Panel A), expected lifetime utility under Social Security is based on the promised benefits; expected lifetime utility under the PRA system is the average utility across simulations. For the worker at birth (Panel B), expected lifetime utility under Social Security is the average utility of Social Security benefits across workers; expected lifetime utility under PRA system is the average utility across workers and simulations.

	No Stock Investment Choice	With Stock Investment Choice
	Panel A: Worker at Birth	
50/50 Stock/Bond Allocation	1.78	1.47
Stock/Bond Allocation Choice	1.60	1.32
	Panel B: Worker who Earns Average Wage	
50/50 Stock/Bond Allocation	5.65	3.09
Stock/Bond Allocation Choice	4.73	2.38

a low risk, low return asset, i.e., Social Security, regardless of their risk preferences. As discussed in Geanakoplos et al. (1998), this constraint is only binding on workers without investable savings outside of Social Security.

4.2. Utility of the representative worker and worker at birth

In our expected utility calculations, investment returns are uncertain but income paths are fixed. Thus we calculate expected utility of consumption in retirement from the perspective of a person who has not yet started working but knows exactly what his or her lifetime labor income will be. However, at the beginning of one's working life, lifetime income is uncertain and this uncertainty affects expected utility. Social Security provides a hedge with respect to lifetime earnings by providing proportionately higher retirement payments to those whose ex-post earned income is lowest.

To incorporate income uncertainty into our expected utility estimates, we calculate expected utility from the perspective of a worker who has not yet entered the workforce and has complete uncertainty about his or her future income (a worker at birth). We assume that with equal probability the worker will realize the income of any of her cohort members and then we simulate 10,000 investment return paths. We then calculate the level of risk aversion for which this worker is indifferent between the distribution of retirement incomes he will receive with Social Security (which depend only upon his income path) and the distribution of PRA annuity payments (which depend upon his income path and investment returns). Following Feldstein and Ranguelova (2001), we also calculate the level of risk aversion for which a representative worker, who earns the average income of his cohort each year, is indifferent between promised Social Security retirement payments and the distribution of PRA annuity payments.

The results of this analysis are presented in Table 2. The worker at birth (Panel A) with equal likelihood of earning any of his cohort's lifetime earnings is indifferent between Social Security and a PRA without choice for a risk-aversion parameter of 1.78 while the representative worker who earns his cohort's mean income each year is indifferent between Social Security and a PRA without choice for a risk-aversion parameter of 5.65. To put this in perspective, the worker at birth with a risk-aversion parameter of 5.65 would be willing to accept reductions in Social Security payments up to 61% before preferring PRAs to Social Security. Clearly the representative worker benefits much more from a switch to a PRA than do most workers and his preferences and welfare are not representative of his cohort.

Why is the representative worker happier with a PRA than a worker at birth? First, the representative worker does not face income uncertainty. Second, his annual income is above his cohort's median annual income (though below the income cap on Social Security taxes). Thus he does not benefit from the progressivity of Social Security benefits. And, third, unlike most workers, he earns income for 47 years. Only the top 35 of these years contribute to his AIME and Social Security benefits, but all 47 years contribute to his PRA savings. This increases the appeal to him of PRAs. In lifetime income, representative worker is much wealthier than most of his peers. Measured in nominal dollars, the representative worker's lifetime income is nearly double that of the median worker, $3757,423 versus $2000,641.[16]

In our analysis, PRA savings are automatically invested in annuities. Thus, workers who die early in retirement reap lower total retirement income from both Social Security and the PRA system and conditional mortality does not affect our analysis. If savings were not annuitized but held in private accounts after retirement, workers who died early in retirement might derive additional benefit from the PRA system through bequests. However, without annuitizing PRA savings, the payouts from PRAs would be lower and all workers would face considerable longevity risk.

Our analysis is at the individual level. To the extent that higher income individuals are likely to live longer or be married to non-working spouses, we underestimate the relative benefits of Social Security to the higher income quintiles (see Liebman, 2002 and Brown et al., 2009). Doing so does not affect our results on choice; choice reduces welfare for all income groups. However, if we underestimate the relative benefits of Social Security to higher-income workers, we may overestimate the level of risk aversion for which the representative worker is indifferent between Social Security and a PRA-based system. We do not, however, intend our estimates of risk aversion to be precise calibrations. Indeed, it is unlikely that most people have constant relative risk aversion utility. Our goal in presenting results for a representative worker is to illustrate that as long as Social Security provides a better average return on savings to lower income workers, the welfare of the representative worker will not be representative of the welfare of his cohort.

[16] Social Security provides a better return on savings for the lowest income workers. However, a number of features of Social Security prevent it from consistently redistributing wealth from higher-income to lower-income workers.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

Table 3
Retirement outcomes for Private Retirement Accounts vs. Social Security.
The table simulates outcomes for 10,000 generations of workers who save 8.8% of their income during working years and invest the proceeds in a 50/50 stock/bond portfolio. Each generation includes over 3000 representative worker income profiles; income profiles are static across simulations. The log returns on stocks and bonds are drawn from a bivariate normal distribution with means of 7.6% and 5.1%, standard deviations of 17.4 and 9.7%, and a correlation of 25%. When households are allowed choice in their stock investments, we increase the standard deviation of the stock return at the household level to 29.6% while retaining the same aggregate level return on stocks.
Worker Outcomes represent the percentage of outcomes across simulations where the worker has lower retirement income from PRA than promised Social Security benefit. Percent at Risk represents the percentage of workers where retirement income across PRA simulations is lower than promised Social Security benefit in more than 25% of simulations.

All Workers

	Age	No Stock Investment Choice	With Stock Investment Choice
		Panel A: Worker Outcomes (% PRA < SS Benefit)	
50/50	68	17.9	30.6
Stock/Bond	78	23.2	34.4
Allocation	88	26.6	36.7
Stock/Bond	68	22.8	34.9
Allocation	78	27.8	38.8
Choice	88	30.8	41.0
		Panel B: Percent at Risk (% of workers for whom PRA < SS Benefit in > 25% of simulations)	
50/50	68	29.7	52.1
Stock/Bond	78	36.3	66.1
Allocation	88	42.2	74.6
Stock/Bond	68	36.0	61.3
Allocation	78	44.1	75.8
Choice	88	52.4	81.9

Outcomes for workers sorted into quintiles based upon earnings through age 65.

		No Stock Investment Choice across Lifetime Earnings Quintiles					Stock Investment Choice across Lifetime Earnings Quintiles				
	Age	1 (Lo)	2	3	4	5 (Hi)	1 (Lo)	2	3	4	5 (Hi)
					Panel C: Worker Outcomes (% PRA < Social Security Benefit)						
50/50 Stock/Bond Allocation	68	44.5	26.9	10.7	5.5	1.8	56.0	41.8	26.1	18.8	10.4
	78	48.6	33.3	17.3	11.3	5.4	58.0	45.2	30.6	23.5	14.8
	88	49.2	35.8	21.2	15.3	8.5	58.0	46.2	32.9	26.2	17.4
Stock/Bond Allocation Choice	68	51.4	34.1	16.0	9.1	3.4	62.5	47.5	29.9	21.7	12.8
	78	53.9	39.1	22.4	15.4	8.0	63.6	50.5	34.9	27.2	17.7
	88	53.8	40.7	25.9	19.2	11.3	63.0	51.1	37.1	30.0	20.6
					Panel D: Percent at Risk (% of workers for whom PRA < SS Benefit in > 25% of simulations)						
50/50 Stock/Bond Allocation	68	97.5	50.1	0.9	0.0	0.0	100.0	100.0	58.4	2.1	0.0
	78	100.0	76.3	5.9	0.0	0.0	100.0	100.0	95.0	33.0	0.0
	88	100.0	90.6	12.4	0.8	0.0	100.0	100.0	99.1	66.8	0.0
Stock/Bond Allocation Choice	68	100.0	76.9	3.0	0.0	0.0	100.0	100.0	86.6	20.0	0.0
	78	100.0	98.9	20.6	0.5	0.0	100.0	100.0	100.0	74.5	2.5
	88	100.0	100.0	51.1	4.2	0.0	100.0	100.0	100.0	92.9	10.5

Simulations sorted into quintiles based upon the market returns earned during savings years.

		No Investment Choice across Simulation Return Quintiles					With Investment Choice across Simulation Return Quintiles				
	Age	1 (Lo)	2	3	4	5 (Hi)	1 (Lo)	2	3	4	5 (Hi)
		5.2%	6.7%	7.6%	8.5%	10.0%	5.2%	6.7%	7.6%	8.5%	10.0%
					Panel E: Worker Outcomes (% PRA < Social Security Benefit)						
50/50 Stock/Bond Allocation	68	49.6	23.2	11.1	4.3	1.1	58.2	39.2	28.2	18.8	8.6
	78	54.0	31.2	18.2	9.1	3.4	60.3	43.7	32.7	23.0	12.5
	88	55.5	36.0	22.9	12.8	5.9	60.9	46.2	35.5	25.5	15.5
Stock/Bond Allocation Choice	68	52.5	28.7	17.6	10.4	4.9	60.6	43.4	33.3	24.1	12.9
	78	56.1	35.6	23.7	15.0	8.3	62.7	47.9	37.7	28.3	17.4
	88	57.2	39.6	27.7	18.3	11.2	63.2	50.1	40.4	30.7	20.6
					Panel F: Percent at Risk (% of workers for whom PRA < SS Benefit in > 25% of simulations)						
50/50 Stock/Bond Allocation	68	69.2	33.9	18.6	5.0	1.0	93.6	68.0	44.3	31.0	6.7
	78	84.3	46.0	26.9	14.3	2.0	98.7	80.7	57.1	36.6	14.6
	88	92.3	58.4	35.7	20.1	3.5	100.0	86.9	66.7	41.6	20.2
Stock/Bond Allocation Choice	68	76.9	40.2	27.6	14.9	2.2	94.6	74.1	52.6	36.6	17.6
	78	88.2	56.3	36.7	21.5	5.6	99.9	86.3	69.9	45.0	24.8
	88	94.7	70.6	44.0	26.2	11.2	100.0	93.0	78.5	52.9	31.3

4.3. Income shortfalls

4.3.1. All workers

Income shortfalls across all workers are presented in Table 3 Panels A and B. Without stock investment or allocation choice (top left, Panel A), the probability of an income shortfall ranges from 17.9% at age 68 to 26.6% at age 88. Solely allowing allocation choice while restricting stock investment choice (bottom left, Panel A) increases the probability of an income shortfall with a range of 22.8% at age 68 to 30.8% at age 88. Solely allowing stock

investment choice while restricting allocation choice (top right, Panel A), has a larger impact on the probability of an income shortfall, with a range of 30.6% at age 68 to 36.7% at age 88. Allowing both allocation and stock investment choice (bottom right, Panel A) yields a further increase in the probability of an income shortfall to 41.0% at age 88.

One problem with our income shortfall metric is that it does not distinguish between small and serious shortfalls: 45% of workers experiencing an income shortfall of less than 5% relative to Social Security might not greatly affect welfare. However, income shortfalls are not only common, but also material. Conditional on observing an income shortfall, a worker's expected retirement income at age 88 is 67% of the promised Social Security benefit at age 88 in the no choice scenario and 55% of the promised Social Security benefit with both allocation and equity choice.

In Panel B, we present percent-at-risk. These results indicate a substantial percentage of the worker population has greater than a 25% probability of an income shortfall and the percent-at-risk increases dramatically with investment choice. Without allocation or stock investment choice, the percent-at-risk is 29.7% at age 68 and 42.2% at age 88. With allocation choice, the percent-at-risk is 36.0% at age 68 and 52.4% at age 88. With both allocation choice and equity choice, the percent-at-risk is 61.3% at age 68 and 81.9% at age 88.

Three common patterns emerge in these simulations. First, the probability of an income shortfall increases with age. The erosion of the performance of the PRA with age can be traced to the observation that the median payout from the variable annuity grows less than the mean payout in retirement years. In the online appendix, we provide an example illustrating this result.

Second, the probability of an income shortfall increases with equity choice. Some workers will fail to diversify completely, which will increase the volatility of their outcomes. Increased volatility of investment outcomes does not affect the average return earned by workers. In each period, workers in aggregate earn the same return, regardless of choice. However, choice induces more volatility and skewness in worker outcomes over time, which causes the median worker outcome to drop and thus increases the probability of an income shortfall under the PRA scheme.

Third, allocation choice also increases the probability of an income shortfall. The main reason for the increased shortfall risk when we allow allocation choice is that many workers make relatively small allocations to stock. Over the long periods for which we simulate returns, stocks usually outperform bonds. Thus, in our simulations PRAs outperform Social Security more often when they invest in substantial equity positions. However, as discussed in Section 4, our assumption that annual logged equity returns are normally distributed likely underestimates the likelihood of poor equity performance over long periods.

4.3.2. Results by income

These results indicate that investors in PRAs have increasing probability of income shortfalls relative to their promised Social Security benefit with increasing choice. In this section, we document that while the probability of an income shortfall varies dramatically across income groups—a result which can be traced to the progressive nature of Social Security benefits—choice adversely affects outcomes for all income groups

To investigate this issue, we partition workers into quintiles based on indexed lifetime earnings to age 67. In Table 3 Panel C, we present worker outcomes for each income quintile. With no allocation or stock investment choice, there are dramatic differences in outcomes by income quintile due largely to the progressive nature of Social Security benefits. The probability of an income shortfall for a worker from the lowest income quintile ranges from 44.5% at age 68 to 49.2% at age 88, while the same probability for a worker from the highest income quintile ranges from 1.8% at age 68 to 8.5% at age 88. Consistent with our earlier findings, for all income groups, both allocation choice and equity choice increase the probability of a shortfall.

In Table 3 Panel D, we present the percent-at-risk and the distributional effects of PRA accounts are even starker. Without allocation or stock investment choice, *no one* in the top income quintile has a greater than a 25% probability of experiencing a PRA income less than their promised Social Security benefit. With equity choice, the percent-at-risk among the top-quintile wage earners ranges from 0% at age 68 to 10.5% at age 88. In contrast, the entire population of the low-income wage earners (the bottom 20% of lifetime indexed earnings, discussed above) has greater than a 25% probability of an income shortfall in retirement (regardless of the choice scenario). With allocation choice, nearly all workers in the bottom two income quintiles have greater than a 25% risk of an income shortfall. With stock investment choice, all workers in the bottom three quintiles face this risk at age 88. Again, choice adversely affects outcomes for all income groups.

4.3.3. Results by market outcomes

To investigate how market outcomes affect generational outcomes, we partition simulations into quintiles based on the market return earned during the cohort's savings years. The results of this analysis are presented in Table 3 Panels E and F.

Not surprisingly, market risk plays a huge role in the attractiveness of PRAs. The mean level return on the 50/50 stock/bond portfolio in the bottom quintile of generational outcomes is 5.2% – a mere 2.2% over inflation. The probability of an income shortfall in these bottom-quintile market outcomes is quite high, ranging from 49.6% at age 68 to 55.5% at age 88 across all workers. The percent-at-risk is also high; over 90% of workers have greater than a 25% probability of an income shortfall at age 88 during bottom-quintile market outcomes. Choice continues to increase the probability of an income shortfall during these poor market conditions.

In strong (top quintile) market conditions, the portfolio earns a return of 10.0%. Without choice, workers have a low probability of an income shortfall (ranging from 1.1% at age 68 to 5.9% at age 88). Allocation choice increases these probabilities (ranging from 4.9% at age 68 to 11.2% at age 88), while equity choice increases them dramatically (ranging from 8.6% at age 68 to 15.5% at age 68) and the combination of allocation and equity choice even more (12.9% at age 68 and 20.6% at age 88). Thus, even in strong market conditions, about 1/5th of the worker population experiences income shortfalls at age 88 with allocation and equity choice. Similarly, the percent-at-risk in these high return outcomes is very low (ranging from 1.0% at age 68 to 3.5% at age 88). However, with allocation choice, the percent-at-risk increases (ranging from 2.2% at age 68 to 11.2% at age 88). Equity choice increases this risk, ranging from 6.7% at age 68 to 20.2% at age 88. With both equity and allocation choice, this risk increases to 17.6% at age 68 and 31.3% at age 88. These results indicate a sizable fraction of workers – almost 1/3rd at age 88 – face greater than a 25% risk of an income shortfall even in the best market conditions when both allocation and equity choice are allowed.

5. Discussion

Our simulations compare the outcomes from PRAs with various levels of choice to promised Social Security benefits. Simulating Social Security outcomes provides a benchmark against which to compare levels of choice in PRA systems and allows us to demonstrate the shortcoming of using a representative worker to capture the utility of all workers.

As a direct comparison of PRA systems to Social Security, our simulations are illustrative, not definitive. There are many dimen-

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

sions of Social Security and PRAs that we do not attempt to model. We compare Social Security and PRAs as self-funded retirement plans for a single cohort. We thus ignore the differences in intergenerational risk sharing under Social Security and a PRA. Our Social Security simulation assumes risk free real log return equal to the real log return on five-year government bonds during the post-war period (1946–2013); current government bond returns are lower than this and low returns may persist for several years. We do not consider Social Security's liabilities resulting from net transfers to people born before 1937, how these liabilities would be paid in the transition to a PRA system, or the political uncertainty resulting from these liabilities.[17]

Feldstein (1997, p.22) argues one advantage of a PRA type system is the increased availability of capital for private investment, which he argues could drive down the return on capital by 20% (from the historic average of 9% to 7.2%); Geanakoplos, Mitchell, and Zeldes (1999, p. 127) make a similar point. Lower returns on capital are the equivalent of lower expected returns for investors. Lower expected returns would make PRAs less attractive to workers, but the increased investment could generate positive externalities. We do not consider either the effect of lower returns or additional investment in our simulations. Nor do we consider the possible equilibrium effect on returns of requiring that retirement savings be rebalanced annually to a fixed asset allocation.

We estimate the volatility of equity choice from the cross-section of equity returns in tax-deferred accounts held by individual investors at a large discount brokerage firm from 1991–1996. For several reasons, this level of volatility is likely to be an upper bound on what one might anticipate in private retirement accounts. First, the investors at the discount brokerage self-selected to manage their own investments and may underdiversify to a greater extent than other investors. Second, the introduction of Exchange Traded Funds (ETFs) has provided an additional channel for investors to invest in well-diversified funds. However, not all ETFs are well diversified, some even take levered short positions; thus ETFs could both reduce and increase the volatility of investor returns. Third, it is possible that individual investors have grown more sophisticated since 1996. Fourth, a PRA system is likely to provide well-diversified default options that will influence the choices of many investors.

In many ways, the outcomes we present underestimate the potential income shortfalls and the distributional effects of PRAs. In the PRA scheme we model, we have prohibited bequests, forced purchase of variable annuities, assumed investors who self-manage their accounts do not pay high fees or sacrifice expected returns, and assumed all investors have the same ability to pick stocks and mutual funds. Furthermore, our distributional assumptions likely underestimate the probability of dramatically poor equity returns. We discuss each of these factors in turn.

We have pooled bequests and ignored variation in outcomes during retirement years. Our implementation of PRAs assumes that any remaining balance in the PRA when a worker dies is used to fund payouts for living cohort members. If workers were allowed to bequest the remainder of their PRA, payouts from PRAs would be reduced and the probability of an income shortfall would increase. If workers were not forced to buy a variable annuity in their retirement years, many would continue to self-manage their accounts. Few U.S. households currently buy annuities, an observation referred to as the "annuity puzzle." (Inkman et al., 2011 present recent evidence on the annuity puzzle.) The continued self-management of PRAs would further increase the volatility of outcomes across workers and increase the probability of income shortfalls.

We do not charge a performance penalty to workers who self-manage their portfolios. There is considerable evidence that individual investors underperform appropriate benchmarks when managing their own investment portfolios (Barber and Odean, 2000; Barber and Odean, 2001; Grinblatt and Keloharju, 2001; Barber et al., 2009). Furthermore, the average mutual fund charges expenses far greater than the 40 bps assumption used in our simulations. Khorana et al. (2009) document asset-weighted average bond and stock expense ratios in the US are 0.78% and 1.11%, respectively. Including load fees amortized over a five-year holding period, total shareholder costs for bond and stock funds are 1.05% and 1.53%, respectively. Attaching a performance penalty or higher fees to self-managed investment accounts would further erode the performance of PRAs and increase the probability of an income shortfall.

We do not consider predictable variation in performance across investors. In our simulations, we assume all investors earn the same expected return. However, there is strong evidence that investment outcomes predictably vary across investors (see Barber and Odean 2011 for a review). For example, the wealthy tend to earn stronger returns than the poor (Barber and Odean, 2000; Andersen and Nielsen, 2015), the better-educated perform better than the less-well educated (Andersen and Nielsen, 2015), and the young do better than the old (Korniotis and Kumar, 2011). High IQ investors earn stronger returns than low IQ investors (Grinblatt et al., 2011) and also pay lower fees on their mutual funds (Grinblatt, Ikäheimo, Kelaharju, and Knupfer, 2012). Thus, the combined evidence provides strong support for the possibility that young, wealthy, better educated, and smart investors will earn stronger returns than others. Adding this cross-sectional variation in expected returns would increase the differences in outcomes for low- and high-income workers.

We do not model the well-documented relation between stock market participation and wealth (Campbell, 2006). In our simulations that allow allocation choice, we find that a low allocation to stocks results in a lower expected return on a worker's investment portfolio and a much higher probability of an income shortfall. If low-income wage earners are less likely to allocate their investment portfolio to stocks, the probability of a shortfall for low-income workers will be higher than the estimates we obtain.

Finally, our simulations underestimate the probability of bad market outcomes. In our simulations, we assume that equity index returns follow a lognormal distribution, which implies logged returns are normally distributed. However, empirically observed logged returns are negatively skewed.[18] Thus our simulation underestimates the likelihood of large negative equity returns. As discussed above, we estimate the mean and standard deviation of logged returns from 1946–2008 historical returns, reducing the mean by 2 percentage points in response to recent academic estimates of the equity risk premium. We assume that the returns earned in sequential years are independent and thereby ignore the possibility that a crisis in financial markets may feed back into the real economy thereby affecting subsequent market returns. Thus we underestimate, perhaps severely, the probability that equity markets will underperform over long periods. To illustrate this point, imagine that at the beginning of 1990 one had estimated the mean annual logged return and variance of the Japanese stock market from 1947 through 1989.[19] Forecasting the distribution of returns from 1990 through 2012, one would have estimated that

[17] Luttmer and Samwick (2012) estimate that on average individuals would be willing to forego 4–6 percent of the benefits they are supposed to get under current law to remove policy uncertainty.

[18] Over the 1946–2034 sample period, the skewness coefficient of the annual logged return on the S&P 500 is −0.90 ($p < .01$).

[19] For this analysis, we use the Global Financial Data Japan Nikko Securities Composite Total Market Return Index.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

the realized 22-year logged return of −0.44 had a probability of less than 1.5 in 10 million (0.000000147). Had one reduced the assumed mean logged return by 2 percentage points – as we do the historical mean logged return in our simulations – one would have estimated the realized 22-year logged return had a probability of 0.00000116. This example highlights the dangers of forecasting from historical returns. While one in a million events do occur, biased econometric models are more common. Our simulations underestimate the likelihood of poor market performance over long horizons.

6. Conclusion

We simulate retirement outcomes for a representative sample of U.S. workers in private retirement account (PRA) systems with varying degrees of choice and compare these to expected payoffs from the current U.S. Social Security system. When workers are required to invest PRA savings in a stock and bond index fund, we document that across all simulations 17.9% of age 68 retirees and 26.6% of age 88 retirees have PRA payouts that fall below their currently promised Social Security benefit. With allocation choice, the risk of lower income increases to 22.8% at age 68 and 30.8% at age 88; with equity choice, it grows to 30.6% at age 68 and 36.7% at age 88; with both allocation and equity choice, it grows to 34.9% at age 68 and 41.0% at age 88.

Our analysis of the utility over retirement income indicates that choice reduces the potential upside associated with PRA outcomes even at modest levels of risk aversion. For example, at a risk aversion level of 3.8, 36.9% of workers prefer Social Security to PRAs with no allocation or equity choice, but virtually all workers (98.2%) prefer Social Security to PRAs with allocation and equity choice.

A representative worker who earns the average wage of his cohort during each year of his life has a stronger preference for PRAs – with or without choice – than does a worker chosen randomly at birth. PRAs are more appealing to the representative worker because he faces no lifetime income uncertainty, he earns much more than the median income of his cohort, and he works for 47 years (while Social Security benefits are based on the top 35 years of indexed earnings). In short, the welfare of the representative worker is not representative of most workers' welfare.

Our simulations focus on choice in PRAs as an alternative to Social Security. However, our central message applies more broadly to self-directed retirement plans, including 401(k) plans. Offering workers more investment choice is likely to reduce the standard of living in retirement for many of them.

Most models in economics presume that agents are better off with more choice or with a larger opportunity set. However, this is only true for investors if they are equipped with the knowledge, skill, and discipline to select optimal investment portfolios. If investors fail to diversify, underperform benchmarks, pay high fees, or refrain from participating in stock markets, choice will not necessarily lead to better outcomes. Indeed, many investors will be made poorer by choice.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jbankfin.2016.08.003.

References

Ait-Sahalia, Y., Lo, A., 2000. Nonparametric risk management and implied risk aversion. Journal of Econometrics 94, 9–51.
Andersen, S. and H. J. Nielsen, 2015, *Ansvar for Borgeres økonomiske Incompetence*. Working paper.
Aon Hewitt Inc., 2013, *2013 Trends & Experience in Defined Contribution Plans: Paving the Road to Retirement*. Aon Hewitt Inc.
Auerbach, A.J., Kotlikoff, L.J., 1987. Dynamic Fiscal Policy. Cambridge University Press, New York, N.Y.
Barber, B., Odean, T., 2000. Trading is hazardous to your wealth: The common stock investment performance of individual investors. Journal of Finance 55, 773–806.
Barber, B., Odean, T., 2001. Boys will be Boys: gender, overconfidence, and common stock investment. Quarterly Journal of Economics 116, 261–292.
Barber, B., Odean, T., 2011. The behavior of individual investors. In: Constatinides, G., Harris, M., Stulz, R. (Eds.), Handbook of Economics of Finance 2, 2013, pp. 447–466.
Barber, B., Lee, Y.-T., Liu, Y.-J., Odean, T., 2009. Just how much do individual investors lose by trading? Review of Financial Studies 22, 609–632.
Barsky, R.B., Thomas Juster, F., Kimball, M.S., Shapiro, M.D., 1997. Preference parameters and behavioral heterogeneity: an experimental approach in the health and retirement study. The Quarterly Journal of Economics 112, 537–579.
Benartzi, S., 2001. Excessive extrapolation and the allocation of 401(k) accounts to company stock. Journal of Finance 56, 1747–1764.
Benartzi, S., Thaler, R., 2001. Naive Diversification strategies in defined contribution savings plans. American Economic Review 91, 79–98.
Benartzi, S., Thaler, R., 2007. Heuristics and biases in retirement savings behavior. Journal of Economic Perspectives 21, 81–104.
Berkelaar, A.B., Kouwenberg, R., Post, T., 2004. Portfolio choice under loss aversion. The Review of Economics and Statistics 86, 973–987.
Beshears, J., Choi, J.J., Laibson, D., Madrian, B.C., 2008. How are preferences revealed? Journal of Public Economics 92, 1787–1794.
Beshears, J., Choi, J.J., Laibson, D., Madrian, B.C., 2009. The importance of default options for retirement savings outcomes: evidence from the United States. In: Brown, J., Liebman, J., Wise, D. (Eds.), Social Security Policy in a Changing Environment. University of Chicago Press, pp. 167–195.
Binsbergen, Van J., Broeders, D., de Jong, M., Koijen, R., 2013, *Collective Pension Schemes and Individual Choice*, Nespar Papers.
Bliss, R.R., Panigirtzoglou, N., 2004. Option-implied risk aversion estimates. Journal of Finance 59, 407–446.
Board of Trustees, 2012. 2012 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds. U.S. Government Printing Office.
Bovenberg, L., Mehlkopf, R., Nijman, T., 2014, *The Promise of Defined-Ambition Plans: Lessons for the United States*, Nespar Papers.
Brady, P., Burham, K., Holden, S., 2012. The Success of the U.S. Retirement System (December). Investment Company Institute, Washington, DC.
Brown, J., Coronado, J.L., Fullerton, D., 2009, *Is Social Security Part of the Social Safety Net?* CESifo working paper.
Brown, J., Liang, N., Weisbenner, S., 2007. Individual account investment options and portfolio choice: Behavioral lessons from 401(k) Plans. Journal of Public Economics 91, 1992–2013.
Caldwell, S., 1996. Health, wealth, pensions and life paths: The CORSIM dynamic microsimulation model. In: Harding, A. (Ed.), Microsimulation and Public Policy. Elsevier, Amsterdam.
Caldwell, S., Febreault, M., Gantman, A., Gokhale, J., Johnson, T., 1999. Social security's treatment of postwar Americans. In: Poterba, J. (Ed.), Tax Policy and the Economy, 13, pp. 109–148.
Caldwell, S., Morrison, R., 2000. Validation of longitudinal dynamic microsimulation models: experience with CORSIM and DYNACAN. In: Mitton, L., Sutherland, H., Weeks, M. (Eds.), Microsimulation Modeling for Policy Analysis: Challenges and Innovations. Cambridge University Press, Cambridge, pp. 200–225.
Calvet, L., Campbell, J., Sodini, P., 2009. Fight or flight? Portfolio rebalancing by individual investors. Quarterly Journal of Economics 124, 301–348.
Campbell, J., 1996, *Consumption and the Stock Market: Interpreting International Experience*, NBER working paper.
Campbell, J., 2006. Household finance. Journal of Finance 61, 1553–1604.
Chiappori, P.-A., Paiella, M., 2011. Relative Risk aversion is constant: Evidence from panel data. Journal of the European Economic Association 9, 1021–1052.
Dahlquist, M., Setty, O., Vestman, R., 2013. On the Design of a Default Pension Fund. The Pinhas Sapir Center for Development.
Diamond, P., Geanakoplos, J., 2003. Social security investment in equities. The American Economic Review 93, 1047–1074.
Fear, J., Pace, G., 2009. Australia's 'Choice of Fund' legislation: success or failure? Rotman International Journal of Pension Management 2, 26–34.
Feldstein, M., 1997, *Transition to a Fully-Funded Pension System: Five Economic Issues*. NBER Working Paper 6149.
Feldstein, M., Ranguelova, E., 2001. Individual risk in an investment-based social security system. The American Economic Review 91, 1116–1125.
Feldstein, M., Liebman, J., 2002. The Distributional Effects of an Investment-Based Social Security System. In: Feldstein, M., Liebman, J. (Eds.), The Distributional Aspects of Social Security and Social Security Reform. University of Chicago Press, Chicago, pp. 263–326.
Friedman, B., 1973. Risk Aversion and the consumer Choice for Health Insurance. Review of Economics and Statistics 56, 209–214.
Friend, I., Blume, M., 1975. The demand for risky assets. American Economic Review 65, 900–922.
Gaudeker, H.-M.V., 2015. How does household portfolio diversification vary with financial literacy and financial advice? Journal of Finance 70, 489–507.
Geanakoplos, J., Mitchell, O.S., Zeldes, S.P., 1998. Would a privatized social security system really pay a higher rate of return? In: Arnold, R.Douglas, Graetz, Michael J., Munnell, Alicia H. (Eds.), Framing the Social Security Debate: Values, Politics, and Economics. National Academy of Social Insurance, pp. 137–157.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003

Geanakoplos, J., Mitchell, O.S., Zeldes, S.P., 1999. Social security money's worth. In: Mitchell, O., Myers, R., Young, H. (Eds.), Prospects for Social Security Reform. The Pension Research Council of the Wharton School of the University of Pennsylvania, pp. 79–151.
Goetzmann, W., Kumar, A., 2008. Equity Portfolio Diversification. Review of Finance 12, 433–463.
Gokhale, J., Kotlikoff, L., 1999, *Social security's treatment of postwar Americans: how bad can it get?*, NBER Working Paper W7362.
Gokhale, J., Kotlikoff, L., 2002. The impact of social security and other factors on the distribution of wealth. In: Feldstein, M., Liebman, J. (Eds.), The Distributional Aspects of Social Security and Social Security Reform. University of Chicago Press, Chicago, pp. 85–114.
Gollier, C., 2008. Intergenerational Risk-sharing and Risk-taking of a Pension Fund. Journal of Public Economics 92, 1463–1485.
Grinblatt, M., Keloharju, M., 2001. What makes investors trade? Journal of Finance 56, 589–616.
Grinblatt, M., Keloharju, M., Linnainmaa, J., 2011. IQ and Stock Market Participation. Journal of Finance 66, 2121–2164.
Grinblatt, M., Ikäheimo, S., Keloharju, M., Linnainmaa, J., 2012. IQ, trading behavior, and performance. Journal of Financial Economics 104, 339–362.
Hanna, S.D., Gutter, M.S., Fan, J.X., 2001. A measure of risk tolerance based on economic theory. Financial Counseling and Planning 12, 53–60.
Hansen, L.P., Singleton, K., 1982. Generalized instrumental variables estimation of nonlinear rational expectations models. Econometrica 50, 1269–1286.
Inkman, J., Lope, P., Michaelides, A., 2011. How deep is the annuity market participation puzzle? Review of Financial Studies 24, 279–319.
Kelly, M., 1995. All their eggs in one basket: Portfolio diversification of U.S. households. Journal of Economic Behavior and Organization 27, 87–96.
Khorana, A., Servaes, H., Tufano, P., 2009. Mutual fund fees around the World. Review of Financial Studies 22, 1279–1310.
Korniotis, G., Kumar, A., 2011. Do Older Investors make better investment decisions? Review of Economics and Statistics 93, 244–265.
Liebman, J.B., 2002. Redistribution in the current U.S. social security system. In: Feldstein, M., Liebman, J. (Eds.), The Distributional Aspects of Social Security and Social Security Reform. University of Chicago Press, Chicago, pp. 11–48.
Luttmer, E.F.P., Samwick, A.A., 2012, *The Welfare Cost of Perceived Policy Uncertainty: Evidence from Social Security*. Working paper.
Mehra, R., Prescott, E., 1985. The equity premium: A puzzle. Journal of Monetary Economics 15, 145–161.
Modigliani, F., Ceprini, M., Muralidhar, A., 2003, *A Proposal for Social Security*, MIT Sloan Management Review.
Paravisini, D., Rappoport, V., Ravina, E., 2013, *Risk Aversion and Wealth: Evidence from Person-To-Person Lending Portfolios*, Working paper.
Poterba, J., 2003. Lessons from Enron: Employer Stock and 401(k) plans. American Economic Review 93, 398–404.
President's Commission to Strengthen Social Security, Strengthening Social Security and Creating Personal Wealth for all Americans, 2001.
Rabin, M., 2000. Risk aversion and expected-utility theory: A Calibration theorem. Econometrica 68, 1281–1292.
Rabin, M., Thaler, R., 2001. Anomalies: risk aversion. The Journal of Economic Perspectives 15, 219–232.
Samwick, A.A., 2009. Changing progressivity as a means of risk protection in investment-based social security. In: Brown, Jeffrey, Liebman, Jeffrey, Wise, David A. (Eds.), Social Security Policy in a Changing Environment. University of Chicago Press, Chicago, pp. 299–327.
Shum, P., Faig, M., 2006. What explains household stock holdings? Journal of Banking and Finance 30, 2579–2597.
Shiller, R., 2006. Life-cycle personal accounts proposal for social security: An evaluation of President Bush's proposal. Journal of Policy Modeling 28, 427–444.
Szpiro, G.G., 1986. Measuring risk aversion: An alternative approach. Review of Economics and Statistics 68, 156–159.
Sydnor, J., 2010. (Over)insuring modest risks. American Economic Journal: Applied Economics 2 (4), 177–199.
Yao, R., Hanna, S.D., Lindamood, Suzanne, 2004. Changes in financial risk tolerance. Financial Services Review 12, 249–266.

Please cite this article as: J. Ahmed et al., Made poorer by choice: Worker outcomes in social security vs. private retirement accounts☆, Journal of Banking and Finance (2016), http://dx.doi.org/10.1016/j.jbankfin.2016.08.003