

Household Portfolios and Retirement Saving over the Life Cycle

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ABSTRACT

Using account-level data on millions of U.S. middle-class investors over 2006 to 2018, we characterize the share of investable wealth that they hold in the stock market over their working lives. Relative to the 1990s, this share has both risen by 10% and become age-dependent. The Pension Protection Act (PPA)—which allowed target date funds (TDFs) to be default options in retirement plans—played an important role: younger (older) workers starting at a firm after TDFs became the default option post-PPA invested more (less) in stocks, in line with the TDF glidepath. In contrast, contribution rates changed little following the PPA.

CLASSICAL ECONOMIC MODELS RELATE SAVING and portfolio choices to a household's preferences, risk exposures, and economic circumstances. At the same time, financial products and intermediaries also influence these choices, and so, their design or regulation can improve (or worsen) household saving and portfolio allocations, as discussed in Campbell (2016) for example. Perhaps, the most important area in which these design choices can affect households' financial well-being is in retirement saving, because many investors are not financially sophisticated, employers who choose plan features have a fiduciary duty to investors, and regulation plays a large role in plan design. However, while retirement plan features can increase saving or alter

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portfolio choices (e.g., Madrian and Shea (2001), Choi et al. (2004)), much less is known about the size, aggregate importance, or longer-run persistence of these effects (e.g., Choukhmane (2021), Beshears et al. (2022)).

In this paper, we examine how a significant change in retirement plan design in the United States impacted the average saving and portfolio choices of the typical middle-class and upper middle-class investors with some retirement savings. Specifically, we relate the saving rates and portfolios of a sample of millions of investors with trillions in investable wealth to the passage of the Pension Protection Act (PPA) of 2006, the most important change to the U.S. retirement savings landscape over the last three decades. The PPA allowed target date funds (TDFs) to be used as default investment options in employer-sponsored retirement plans. Unlike typical funds, TDFs invest in both stocks and bonds in age-dependent shares that approximate the optimal shares in many models of life-cycle portfolio allocation. A typical TDF maintains 90% of its assets in equity funds until roughly 20 years before retirement date, and then decreases this share as employees age to 40% to 50% in equity at target retirement date. TDFs (and similar funds) grew from managing less than \$8 billion in 2000 to managing almost \$6 trillion in 2021.¹

We document three main findings. First, we show that the share of investable wealth held in equities by retail investors has changed significantly over the past three decades. In our sample covering the periods 2006 to 2018, these investors held over two-thirds of their investable wealth in stocks on average, with this share hump-shaped over their working life—increasing until age 45 to 50, and then declining until retirement. On the one hand, this life-cycle profile of the equity share of investable wealth is broadly consistent with prescriptions of optimizing models, and our analysis provides moments with which to estimate such models.² On the other hand, this profile constitutes a significant change, as households' equity shares were 10 percentage points lower and largely unrelated to age during the 1990s (Ameriks and Zeldes (2004)). We show that this change in allocations has been implemented largely by households through the adoption of TDFs.

Second, we show that these changes in investor behavior were accelerated by the adoption of TDFs as the default option in retirement saving plans following passage of the PPA in 2006. Specifically, we find that younger investors enrolling in a retirement plan just after its default switched to a family of TDFs invest a larger share in the stock market than those enrolling at the same firm just before the change in default, consistent with the age pattern of equity shares in TDFs and lower equity shares in the pre-PPA period. The same comparison for older workers shows that TDFs lead to a lower share invested in stocks, which is again consistent with TDFs causing the share invested in stocks to decline with age. These initial impacts of the TDF default

¹ See Parker, Schoar, and Sun (2023), and Parker and Sun (2023).

² Estimation moments are included in the [supporting information](#) of this paper. We provide averages of equity share and contribution rates by age, year, and birth-year cohort.

decline over time, as more investors adopt TDFs and TDF-like strategies regardless of the default option at initial enrollment.³

Third, in contrast to portfolio allocations, we show that retirement saving rates have a monotone increasing life-cycle pattern that is relatively stable over time and across cohorts, although the cohort born in the 1980s appears to save at slightly higher rates than older cohorts. Saving rates for all cohorts increase steadily with age, almost doubling between age 25 and 65, and are lower on average than those recommended by most prescriptive models of saving and wealth accumulation (e.g., Poterba (2014), Gomes et al. (2018), Duarte et al. (2021)).

In sum, our findings suggest that the regulatory changes and industry developments that led to the rise of TDFs have significantly changed the stock-bond mix of household portfolios such that the life-cycle profile is now closer to that recommended by most prescriptive models of portfolio choice. In contrast, changes in retirement plans that were designed to increase retirement saving seem to have had more limited effects.

These findings are based on our analysis of anonymized account-level data from a large financial services company. The data contain the portfolios, individual trades, and detailed characteristics of millions of investors covering more than a trillion dollars in investable wealth from 2006 to 2018. We focus on a subsample that is reasonably representative of the “typical” American retail investor who has some retirement savings: investors with retirement savings accounts in the middle 80% of the age-adjusted distribution of retirement wealth, who we call *retirement investors (RIs)*. For these investors, we observe their *investable wealth*, which in our definition is the value of stocks, bonds, and investment funds in retirement accounts and nonretirement brokerage accounts and excludes bank accounts, durable goods, and housing. We also observe their (chosen and realized) retirement contribution rates, which capture the vast majority of inflows into their investable wealth.

This sample of U.S. middle- and upper-middle class investors invests 70% of their investable wealth in the stock market on average. Tracking cohorts, the average equity share increases by 7% as people age from 25 to 50 and then falls by the same amount from age 50 to 65, as people reallocate financial wealth into bonds and cash-like securities.

This equity share is higher and more hump-shaped across ages than before the rise of TDFs. Using similar administrative data on retirement savings prior to 2000, Ameriks and Zeldes (2004) reports an average equity share of only 58% and no rebalancing out of equities as people age. Our results also differ from leading survey evidence. The 2016 Survey of Consumer Finances (SCF) shows an average share of only 54% of investable wealth allocated to equities in a comparable sample. Similarly, the SCF shows a reduction in equity shares with age that is only a third as large. We present several pieces of evidence, suggesting that the SCF misestimates equity shares due to underreporting and data processing in the assumptions related to hybrid

³ This effect may be due in part to other plan features such as reenrollment.

funds such as TDFs. That said, our sample comes from only one firm, and the equity shares in our data may be driven in part by the policies of our data provider.⁴ While this question of representativeness is an important caveat, we are able to measure equity share almost without error, which highlights the advantage of administrative data for measuring the financial behaviors of less sophisticated investors who may not fully understand the investment products that they hold.

The behavior we document across 10-year birth cohorts is also consistent with the increased use of TDFs changing portfolio behavior. Across cohorts, each younger cohort—which is more likely to be using TDFs—has higher equity shares than the prior cohort did at the same age. For example, cohorts born after 1970 have higher equity shares *at every (overlapping) age* than the previous, older cohorts. We also find, consistent with greater use of TDFs, that younger cohorts rebalance more as they age than do older cohorts.⁵

Both the increased allocation to equity and the rebalancing into safe assets over the life cycle were accelerated at least in part by the growth of TDFs facilitated by the change in pension law. From a pure time-series perspective, total investment in TDFs took off following the PPA of 2006. The Act allowed the use of TDFs as “Qualified Default Investment Alternatives” (QDIA) in employer-sponsored retirement plans. The contributions of new employees who enroll in a plan and do not make an active choice are invested in the QDIA fund. Prior to the PPA, most QDIAs were money market funds, which do not hold stocks. Following the Act, employers increasingly adopted TDFs as the default option.⁶

We estimate the direct effect of having a TDF as the QDIA by comparing the portfolios of people who enroll in a retirement plan in the two years before the PPA to the portfolios of those at the same employer who enroll in the same plan in the two years after the regulatory change. Because the Act permitted but did not require employers to change the default allocation, we focus on firms that adopted TDFs as the default option in 2007 or 2008. We assume that the change in default option does not lead employers to choose workers with different portfolio preferences, or cause such workers to choose different employers, and thus, we interpret any change in portfolio as caused by the change in default option.

We find that the adoption of a TDF as the QDIA leads younger new enrollees (those aged 25 to 35 when they enroll) to invest 5% more of their financial wealth in the stock market, consistent with TDFs raising equity share for the young. This effect is driven mostly by lower-income workers. For older

⁴ We note that in our data, the plan designs, extent of TDF take-up, and default allocations are all in line with those reported by other large financial services companies. However, the SCF has issues with representativeness stemming from survey participation.

⁵ This pattern is similar across terciles of ex-ante income, and while log income differences explain about half of the *level* differences in equity shares across people, the life-cycle pattern of income does not change the life-cycle pattern in equity shares.

⁶ Initially, existing plan participants (existing employees) were unaffected by a change in the default, but over time many plans adopted regular automatic reenrollment, and thus investors would have at least observed the default option if not been defaulted into it.

workers, the adoption of a TDF as the QDIA reduces the share of investable wealth allocated to stocks, which is also consistent with a causal effect of TDFs given the lower share of equity in TDFs as individuals approach their target retirement date. Both of these differences in default allocations decline over the five years following enrollment, as investors who did not enroll when the QDIA was a TDF adopt portfolios more like those who enrolled after the change in default. These investors may have been influenced by observing the default option of their peers or responded to advertising and other financial advice. It therefore appears that the regulatory approval of TDFs and their implied life-cycle glide paths, and their subsequent adoption by retirement plan sponsors and administrators, led to the more widespread adoption of TDFs and TDF-type strategies through channels besides default investment funds.⁷

In the third and last parts of our paper, we show that unlike portfolio allocations, there has been little change in retirement savings rates across cohorts over time. Measuring a person's retirement savings rate as their annual contribution to their retirement saving plan as a share of their income, average retirement saving rates across all birth cohorts average 4.5% at age 25 and 8.5% at age 65.⁸ This pattern does not change much across cohorts, with the exceptions that (i) the youngest cohort, born in the 1980s, saves at a higher rate, and (ii) after controlling for income, younger cohorts increase saving rates just slightly faster than older cohorts as they age.⁹ Finally, comparing people enrolling in plans at the same employer before and after the PPA, which included a number of provisions intended to increase savings, we find that people enrolling after the Act had similar or even lower contribution rates than those enrolling before the Act. Although we are unable to compare these savings rates to those of a similar population in the 1990s, our evidence suggests that contribution rates to retirement saving plans among our RIs have remained relatively stable despite large changes over time in both portfolio holdings and retirement plan design and regulation.

Related Literature. Our paper is most closely related to studies that use administrative data to measure household portfolio allocations over the life cycle, in particular, Ameriks and Zeldes (2004). Using survey data, Poterba and Samwick (2001) documented significant cohort effects in portfolio allocations over the life cycle, and more recently, Gomes and Smirnova (2021) show a hump-shaped pattern in age. Administrative data from Norway show

⁷ Since the introduction of the PPA in 2006 was followed by the 2008 financial crisis, in Section III, we provide a number of robustness checks to rule out the possibility that changes in market conditions are driving our results.

⁸ This measure includes automatic payroll deductions or autoescalation programs, but excludes any rebalancing flows or portfolio appreciation. We also check that our main conclusions are not related to people hitting the legal limit on tax-advantaged contributions in a given year, which occurs for 6% to 9% of our sample.

⁹ There is significant heterogeneity in average contribution rates across income terciles, but this pattern also stays relatively constant across birth cohorts. On average, the bottom tercile of the income distribution has an almost 2% lower contribution rate than the top tercile, but a similar increase with age (from 3.9% at age 25 to 7.3% at age 65, as compared to 5.7% at age 25 to 9.2% at age 65 for the top tercile).

that Norwegian investors have a hump-shaped equity allocation (Fagereng, Gottlieb, and Guiso, 2017). But there are substantial differences in portfolios across countries (see, for example, Guiso, Haliassos, and Jappelli (2003a, 2003b)), and U.S. households have higher levels of stock ownership and stock market participation than most European households (e.g., 49.7% versus 26%, Christelis, Georgarakos, and Haliassos (2013)).

We also contribute to a growing literature on the institutional causes of portfolio behavior. McDonald, Richardson, and Rietz (2019) study changes in fund selection by new participants following changes in default investment funds in retirement plans in 2012. Using Vanguard data, the paper Mitchell and Utkus (2022) looks at the effects of TDFs on existing employees and new entrants under both voluntary choice and automatic enrollment plans, and shows that in voluntary enrollment plans, 28.4% of new entrants adopted a TDF in their 401(k) portfolios, compared to only 10.2% of existing employees, but in plans with automatic enrollment, 79% of new entrants chose a TDF. However, similar to but larger than our findings, TDF investors held substantially more in equity: 81% for TDF investors compared to 63% for those without TDFs. TDFs also improve investment performance due to a reduction in risk-taking in anticipation of lower expected returns (Gomes, Michaelides, and Zhang (2020)).

Our paper further informs models of optimal portfolio choice (see the surveys of Curcuru et al. (2010) and Wachter (2010)). Merton (1969) and Samuelson (1969) provide canonical models in which portfolio allocations are constant over the life cycle and scale invariant. A large body of research derives optimal portfolio choice in more complex models, with the most pertinent example the case in which where investors receive realistic stochastic, nontradable “endowment” income over their working lives, which generally implies that investors should reduce holdings of risky assets over their life cycle (see Viceira (2001), Heaton and Lucas (2000), Campbell and Viceira (2002), Benzoni, Collin-Dufrense, and Goldstein (2007), Gomes, Michaelides, and Zhang (2020), and Storesletten, Telmer, and Yaron (2007)). Other examples include nonstandard utility functions, differences in risk aversion, and differences in beliefs.¹⁰

With respect to the life-cycle pattern of the savings rate, our paper relates to a large prescriptive literature concerned with the optimal amount that households should be saving (e.g., Scholz, Seshadri, and Khitatrakun (2006), Lusardi and Mitchell (2007)), as well as to a large positive literature that estimates models from saving profiles assuming optimal behavior (e.g., Gourinchas and Parker (2002)). When looking at contribution rates, the analysis in Gomes et al. (2018) suggests that more than 75% of U.S. retirement savers display a significant shortfall in contributions relative to an optimal consumption model. Calculations in Poterba, Venti, and Wise (2011) similarly show that households have inadequate financial wealth to support retirement, and for more than 70% of households, social security is their major asset.

¹⁰ For utility functions, see Carroll (2000), Wachter and Yogo (2010), and Meeuwis (2019); for risk aversion, see Ameriks et al. (2015) and Ameriks et al. (2019); and for beliefs, see Meeuwis et al. (2022) and Giglio et al. (2021).

The rest of the paper is organized as follows. In Section I, we describe our data. In Section II, we discuss the equity share of portfolios. In Section III, we analyze the effect of the PPA on portfolio allocations, and in Section IV, we analyze contribution rates. Section V concludes.

I. Data

This section describes the account-level data set and our procedure for creating a subsample that we can match to a well-defined subpopulation of typical American RIs.¹¹

A. Account-Level Data

Our main data set contains anonymized, account-level data on financial holdings from a large U.S. financial institution. For each investor, the data contain information on all of their accounts held at the firm. For these accounts, we observe end-of-month account balances and holdings, and all inflows, outflows, and transfers at a daily frequency. We observe assets at the Committee on Uniform Securities Identification Procedures (CUSIP) level for 87% of wealth. For the remaining 13%, we observe characteristics of the fund that the wealth is invested in. We aggregate accounts at the (deidentified) individual level and track each individual's portfolio. The data cover millions of investors and trillions in financial wealth. Our sample uses information from December 31, 2006 to December 31, 2018. We use the data at an annual frequency. We measure balances and holdings at the end of each calendar year and aggregate contributions over the year to calculate saving rates. When we observe joint accounts for married couples, we allocate the funds to the spouse who has more total individual assets.

We focus on investable wealth, which comprises money market funds, nonmoney market funds, individual stocks and bonds, certificates of deposit, quasi-liquid retirement wealth, and other managed accounts.¹² We classify fund and security holdings into equity, long-term bonds, short-term bonds, and alternative assets (e.g., real estate and precious metals). Multiclass funds, also known as TDFs or hybrid funds, are split between equity and fixed income in proportion to the observed equity share of the fund. Table I provides detailed variable definitions.

In addition to account-level portfolio information, we observe each investor's age, gender, zip code, and marital status (and an (imperfect) link to the partner if they also have accounts at the firm). For a subsample of the data, we also observe an anonymized employer indicator, three-digit NAICS code of the employer's industry, employment tenure, and, for a further subsample,

¹¹ This method is closely related to Meeuwis et al. (2022).

¹² Excluded categories of financial wealth are checking and savings accounts, saving bonds, cash value of life insurance, and other financial assets.

Table I
Definitions of Key Variables

Variable	Definition
Investable wealth	The dollar value of the following assets, measured at the end of each calendar year and summed across retirement funds, individual brokerage accounts, and accounts managed by a financial advisor: money market mutual funds, nonmoney market funds (including mutual funds and ETFs), individual stocks and bonds, certificate of deposits, and trusts. The measure excludes bank accounts (checking and saving), savings bonds, cash value of life insurance, durable goods, and housing.
Retirement wealth	The dollar value of all wealth in retirement saving accounts of all types, measured at the end of each calendar year. This includes 401K and 403B plans, IRAs, and other Thrift plans. It excludes defined benefit plans and social security.
Nonretirement wealth	The dollar value of all investable wealth that is not retirement wealth, measured at the end of each calendar year. It includes individual stocks, bonds, money market mutual funds, and nonmoney market funds (including mutual funds and ETFs), certificates of deposit, and trusts that are not held in retirement accounts.
Labor income	The dollar value of gross labor/wage income (pretax) earned by the head of household, annualized by scaling up part-year incomes to a full-year equivalent. In the SCF, the sum of wages from the head of household's first and second jobs and self-employment income. Both measures exclude rental income, dividends, royalties, and any income that is not payment for labor. When included in regressions, we normalize income by taking the log deviation of labor income from the RI sample average in the same year.
Retirement Share of Wealth	Total retirement wealth divided by total investable wealth at the end of each calendar year.
Target Date Funds (TDFs)	Mutual funds that maintain a given portfolio share of assets invested in different asset classes, where the shares change with the number of years until "target date," the expected retirement date of the investor, sometimes referred to as "hybrid," "combination," "auto-rebalancing," or "mixed" funds.
TDF Share of Investable Wealth	Total dollar value of TDFs in the portfolio divided by total investable wealth at the end of each calendar year.
Employment Tenure	The number of years that an employee has been working for their current employer, available for a subset of our sample for which labor income is available.
Equity share of retirement wealth	The percentage share of the retirement wealth at the end of each calendar year that is invested in equities and equity-like securities such as individual stocks, equity mutual funds, and the equity component of blended funds (TDFs and auto-rebalancing funds).
Equity share of investable wealth	The percentage share of investable wealth at the end of the calendar year that is invested in equities and equity-like securities such as individual stocks, equity mutual funds, and the equity component of blended funds (TDFs and auto-rebalancing funds).
Equity share of nonretirement wealth	The percentage share of nonretirement wealth at the end of the calendar year that is invested in equities and equity-like securities such as individual stocks, equity mutual funds, and the equity component of blended funds (TDFs and auto-rebalancing funds).

(Continued)

Table I—Continued

Variable	Definition
Long-term bonds (fixed income)	Bond funds, long-term government and corporate bonds, and the portion of funds that invest across asset classes (TDFs and auto-rebalancing funds) that is not allocated to equity.
Short-term bonds (cash-like securities)	Money market mutual funds, short-term Treasury bonds, and CDs.
Market betas	Using all available return data from 2006 to 2018, we estimate betas from monthly regressions of excess asset returns on excess market returns. We require at least 24 monthly return observations. We set the market beta of short-term bonds to zero. We use the estimated beta on a corresponding ETF as a proxy for individual betas on agency bonds (ticker: AGZ), municipal bonds (MUB), TIPS (TIP), gold (IAU), silver (SLV), and platinum (PPLT). For mixed-asset funds, we account for time variation in betas due to a changing equity share of the portfolio (especially for life cycle funds) by assuming that the fund market beta is affine in the fund equity share with a fund-specific intercept and a common slope. We estimate the common slope in a pooled regression that includes all mixed-asset funds in an investor's portfolio.
Reported contribution rate	The elected retirement saving rate as a fraction of labor income in employment-based accounts, reported at a monthly frequency. We use the value reported in January for our annual data. This is available only for the subset of the sample for which labor income is observed. The measure excludes employer contributions.
Realized contribution rate	The sum of all flows into retirement accounts in a given year, as a fraction of annual realized labor income. This is calculated only for the subset of the sample for which labor income is observed. The measure excludes employer contributions.

gross annual wage income. We annualize all income observations by scaling up partial-year incomes to a full-year equivalent.

B. Retirement Investor Subsample

While these data provide a detailed view of portfolio allocations for a large number of U.S. investors, there are two potential limitations of our data. First, while we observe a significant share of U.S. investors, this is obviously not a randomly selected sample. In particular, most of the wealth that we observe is held in retirement saving accounts and few investors have very high net worth (as we document below). We would like to understand the relationship between our sample and a similar subsample of the U.S. population. The second potential limitation is that we do not necessarily observe all of an individual's investable wealth because we do not observe wealth held at other institutions.¹³

¹³ The only concern is missing investable wealth. In both our data and the SCF, we exclude wealth in savings and checking accounts, as well as net housing wealth, defined benefit pension plans, etc.

To both minimize and evaluate the importance of these two concerns, we construct a subsample of people who are well represented in our data and that we can confirm are broadly similar to the same subsample in the U.S. population. Our firm's data mainly include typical working Americans with retirement saving during their working lives. This allows us to define a sample of RIs that we can compare to a similarly defined sample in the SCF.

First, we restrict our RI sample to investors between 25 and 65 years of age. We exclude the youngest members of the sample because they typically have very low levels of investable wealth. By selecting 65 as the upper bound, we avoid the issue of significant attrition among older investors from our data. Our analysis therefore focuses on working-age investors and hence mostly on investors with labor income. Second, we drop investors with extremely high or low levels of retirement wealth, where retirement wealth consists of all investable wealth in retirement saving accounts of all types (excluding defined benefit plans and Social Security). We drop low-wealth investors because they may simply have wealth at other institutions, and we drop high-wealth individuals because they are underrepresented in our data. We construct our sample based on retirement wealth rather than total investable wealth because our data have incomplete coverage of nonretirement wealth (as we discuss below).

To construct our sample of RIs, we use data from the 2016 SCF to identify a consistent sample of households based on retirement wealth. We treat couples in the SCF as two individuals. The SCF data allow us to measure retirement wealth, wage income, and age at the individual level, but nonretirement wealth is measured only at the household level, an issue that we address in the following subsection. Focusing on individuals aged 25 to 85 with some retirement wealth, we run quantile regressions of the log of individuals' retirement wealth (comparable to the measures in our institution's data) on a third-order polynomial in age. We then drop individuals with retirement wealth below the estimated 10th percentile or above the 90th percentile by age.¹⁴

Individual RIs make up 28% of the population of U.S. households and 38% of the population of households aged 25 to 65 according to the (representative) SCF. They hold 33% (39%) of all household investable (retirement) wealth and 52% (54%) of investable (retirement) wealth among households aged 25 to 65. Approximately 33% of both retirement wealth and investable wealth is held by the top 10%. Approximately 30% of retirement wealth and investable wealth is held by those aged 66 to 85.

In our data, RIs – individuals between ages 25 and 65 and in the middle 80% of the distribution of retirement wealth at each age – make up 73% of accounts that we observe and hold 75% of all retirement wealth. Our sample of RIs contains millions of individual investors and well more than a trillion dollars in investable wealth.

¹⁴ For age 30, in the SCF data, the lower bound is \$1,328 and the upper bound is \$66,370. For age 60, the lower bound is \$6,774 and the upper bound is \$744,000. See Internet Appendix Figure IA.3. The Internet Appendix is available in the online version of this article on *The Journal of Finance* website.

C. Descriptive Statistics and Comparison to SCF

The top panel of Table II shows summary statistics for our sample of RIs in 2016.¹⁵ In our sample, the average age is 45, and the average (median) wage income is \$101,384 (\$74,230). About 55% of the sample is male and 70% of individuals are married. The average portfolio beta is 0.75, and nearly half of investable wealth, on average, is allocated to TDFs. The average retirement wealth is \$96,000. The bottom panel of Table II reports analogous statistics for the population of U.S. RIs as estimated from the 2016 SCF. The average age is 47, the average (median) wage income is lower at \$66,459 (\$50,000), about half of investors are male, and a slightly higher 78% of investors are married.¹⁶ In terms of wealth, the average investor in the SCF RI sample lives in a household with approximately \$273,000 of investable wealth and has \$98,000 in retirement wealth themselves (bottom panel of Table II), comparable to the average in our sample.¹⁷

Figure 1 shows that the distribution of retirement wealth in our RI sample lines up well with that of individual respondents measured by the SCF. The SCF implies a somewhat higher mass of high-wealth individuals, but overall the distributions are similar, suggesting that we are missing little retirement wealth at other financial institutions. Because RIs in our sample typically have most or all of their investable wealth in retirement accounts, we conclude that our sample of RIs provides a good overview of how the investable wealth of typical U.S. retail investors is allocated.

However, Table II also shows that the RIs in our data have significantly less nonretirement wealth than RIs in the SCF. Figure 2, Panel A, shows the total investable wealth distribution for individuals in our sample compared to households in the SCF (as in Table II) and confirms that we miss non-retirement wealth for wealthier individuals/households relative to the SCF. This raises the question of whether our sample has less nonretirement wealth because we miss wealth held at other institutions or because our data measure *individual* wealth, in which case we miss some household-level wealth for partnered investors.

In fact, the primary reason that our sample has less investable wealth is because the SCF measures household wealth rather than individual wealth, rather than because we do not observe wealth held at other institutions. In our data, the sample of married households for which we observe both spouses has on average 50% more investable wealth. Figure 2, Panel B, shows that the distributions of total household investable wealth are much more similar for this married subset of our sample and the sample of married investors

¹⁵ See Internet Appendix Table IA.I for the entire sample period, and Internet Appendix Figure IA.4 for the distribution of labor income.

¹⁶ Because of low heads of households are assigned in the SCF, about 78% of respondents are male in the SCF. When including partners, the sample is evenly split between males and females.

¹⁷ The statistics in Table II are for our retirement sample of middle-class Americans with retirement wealth. They are not representative of the assets under management for a typical firm, since we exclude high-net-worth households whose wealth is held mostly outside of retirement accounts.

Table II
Characteristics of Sample of Retirement Investors in 2016

This table presents summary statistics on demographics, wealth, and portfolio allocations for our retirement investor (RI) sample in 2016 and a comparable sample of the 2016 Survey of Consumer Finance (SCF). Detailed definitions for retirement wealth and investable wealth are provided in Table I. The reported contribution rate is the percentage of income that an individual designates to be allocated into their retirement account at the beginning of each calendar year. The realized contribution rate is the percentage of an individual's annual income that has been invested into a retirement account over the previous year, calculated at the end of each calendar year. Market betas are obtained by regressing monthly fund or security excess returns on the value-weighted CRSP market excess return over the period 2007 to 2017 with at least 24 observations. Income is the labor income of the respondent in 2015. The sample is not representative of the assets under management of our financial service firm, since by design we drop the highest and lowest income groups.

Retirement Investors				
	Summary Statistics			Percentage of RI Sample with Observed Data
	Mean	Median	SD	
Age (Years)	45.38	46	11.28	100%
Female	0.46	0	0.50	94.0%
Married	0.72	1	0.45	89.5%
Labor Income (\$)	101,384	74,230	195,060	41.0%
Investable Wealth (\$)	116,938	38,394	367,156	100%
Retirement Wealth (\$)	95,654	35,451	155,237	100%
Retirement Share of Wealth (%)	96.3	100	13.9	100%
Portfolio Beta	0.75	0.84	0.32	86.9%
TDF Share of Invest. Wealth (%)	47.9	37.3	44.7	99.6%
Employment Tenure (Years)	10.50	7.94	9.17	60.0%
Reported Contribution Rate (%)	8.1	6.0	7.3	53.2%
Realized Contribution Rate (%)	6.4	5.5	5.3	47.1%

Retirement Investors—Survey of Consumer Finance				
	Summary Statistics			Number of Observations
	Mean	Median	SD	
Age	46.78	47	10.63	3,130
Female	0.50	0	0.50	3,130
Married	0.78	1	0.39	3,130
Labor Income (Individual, \$)	66,459	50,000	1,129,486	3,130
Labor Income (Household, \$)	101,349	77,000	1,445,913	1,889
Investable Wealth (Household, \$)	273,282	72,000	17,019,097	1,889
Retirement Wealth (Household, \$)	193,568	76,830	659,727	1,889
Retirement Wealth (Individual, \$)	97,658	41,500	155,503	3,130
Retirement Share of Investable Wealth (Individual, %)	65.32	76.19	38.43	3,130
Retirement Share of Investable Wealth (Household, %)	87.81	100.00	31.33	1,889

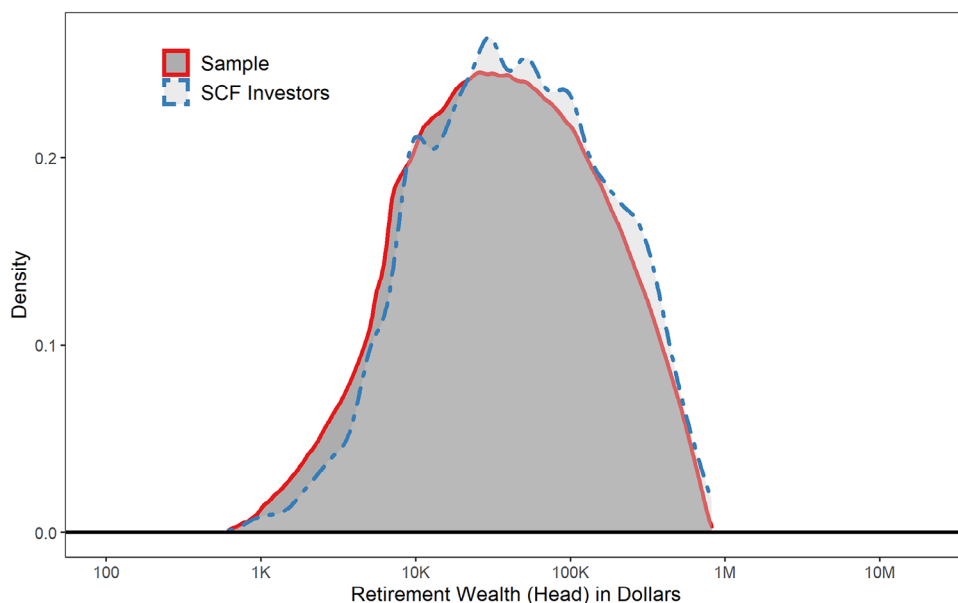


Figure 1. Individual retirement wealth distribution in firm data and the SCF in 2016. This figure plots the distribution of retirement wealth in the sample of retirement investors (RIs) in 2016 versus the distribution of retirement wealth for RIs in the SCF in 2016. Retirement wealth is defined as any wealth in retirement saving accounts of all types (excluding defined benefit plans and Social Security). (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/jofi.13473))

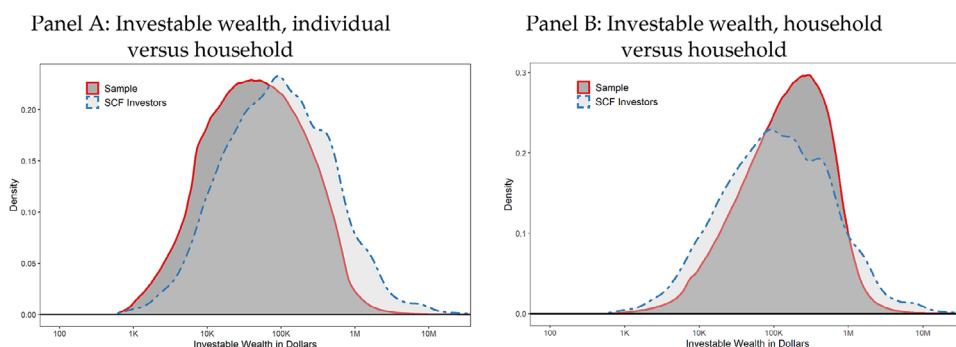


Figure 2. Investable wealth distribution in firm data and the SCF in 2016. This figure plots the distribution of investable wealth of retirement investors (RIs) versus the distribution of investable wealth for RIs in the SCF in 2016. Panel A shows individual investable wealth in our sample versus household investable wealth in the SCF. Panel B shows household investable wealth in our sample for the subset of households in which we observe both spouses versus household wealth in the SCF for the subsample of investors who are married. Investable wealth is defined as money market funds, nonmoney market funds, individual stocks and bonds, certificates of deposit, quasi-liquid retirement wealth, and other managed accounts. (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/jofi.13473))

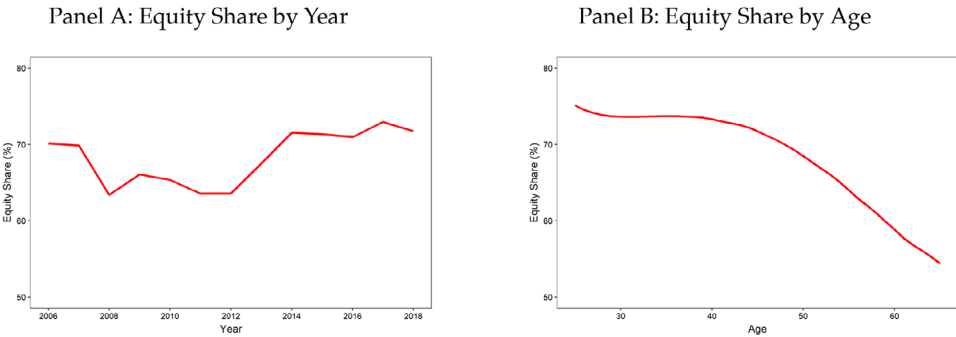


Figure 3. Portfolio equity share by year and age. This figure shows the portfolio equity share in our sample. Panel A shows the equity share for the entire sample, averaged by year. Panel B shows the equity share averaged by age. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. The sample comprises our full set of retirement investors (RI). (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/jofi.13473))

in the SCF. For couples, our data match the SCF more closely, although our sample has a slightly higher median and mean wealth than the SCF. This rough similarity holds both for married couples and separately for single individuals (see Internet Appendix Tables [IA.II](#) and [IA.III](#)). We conclude that the difference in the distribution of wealth between our RI sample and that of the SCF is driven primarily (but not solely) by the unit of observation – an individual investor as opposed to households.

Table [II](#) also summarizes the retirement saving behavior of our sample. The average RI has a contribution rate of 8.1% of their income. However, because many people choose high rates that exceed the legal maximum contribution limit, the average ex-post rate is 6.4% of income. The SCF does not measure or allow us to infer portfolio betas, employment tenure, or retirement plan contribution rates.

II. The Equity Shares of Portfolios

A. The Average Equity Share

Our first main result is that in our RI sample, middle-class American investors hold a large share of their portfolios in equity. The average equity share of investable wealth is 71.0% in 2016 (Table [III](#)) and the median is 77.3%. For retirement wealth, the average is 71.1% and the median is 77.7%. Figure [3](#), Panel A, plots the average equity share by year. While it is higher when the stock market has done well and lower when the stock market has done poorly, the average equity share is reasonably stable over time.¹⁸

¹⁸ Internet Appendix Table [IA.IV](#) shows the comparison of the 2016 SCF with our full sample from 2006 to 2018. The magnitudes change slightly, but the arguments that follow continue to hold.

Table III
Average Share of Equity in Portfolios among Retirement Investors

This table presents the share of equity in the portfolio allocations for various samples of our retirement investors (RIs) sample in 2016 and the comparable RI sample of the 2016 Survey of Consumer Finance (SCF). Panel A shows equity shares of total investable wealth at the individual level in our sample and the household level in the SCF. Panel B shows equity shares of retirement wealth at the individual level in both data sets. Panel C shows equity shares of nonretirement wealth at the individual level in our sample and the household level in the SCF. The results in Panel C are conditional on owning some nonretirement wealth, which is approximately 40% of the SCF RI sample and 16% of our RI sample. The first two columns show the means for the full sample of RIs in each data set. The last two columns show the means for the subsample of the RI sample that has some of their retirement assets in a target date fund (TDF). Investable wealth is defined as money market funds, nonmoney market funds, and individual stocks and bonds. Retirement wealth is defined as any wealth in retirement saving accounts of all types (excluding defined benefit plans and Social Security): Certificates of deposit, quasi-liquid retirement wealth, and other managed accounts. The equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets.

	All Retirement Investors		Retirement Investors with Hybrid Fund (e.g., TDF) in Retirement Account	
	Main Sample (Individuals)	SCF (Households)	Main Sample (Individuals)	SCF (Households)
Panel A: All Investable Wealth				
All RIs	71.0	54.5	76.6	46.9
Age 25 to 34	77.6	59.1	84.8	49.6
Age 35 to 44	76.0	55.9	82.2	47.9
Age 45 to 54	71.2	53.8	74.7	45.5
Age 55 to 65	60.5	51.2	61.2	45.4
Respondents		54.3		47.0
Partners		54.8		46.9
Panel B: Retirement Wealth				
All RIs	71.1	51.7	76.7	42.1
Age 25 to 34	77.7	56.2	85.0	44.2
Age 35 to 44	76.2	54.1	82.4	43.5
Age 45 to 54	71.4	50.5	74.8	40.2
Age 55 to 65	60.6	48.0	61.2	41.2
Respondents		52.1		43.3
Partners		50.8		39.8
Panel C: Nonretirement Wealth				
All RIs	51.1	73.4	53.2	73.2
Age 25 to 34	52.0	87.5	53.0	86.9
Age 35 to 44	53.5	68.9	55.5	68.3
Age 45 to 54	51.1	74.5	52.9	73.6
Age 55 to 65	48.8	69.6	50.8	69.6
Respondents		73.9		74.4
Partners		72.7		71.2

Table III shows that the equity shares calculated for RIs in the 2016 SCF are substantially lower, at 54.5% of household investable wealth and 52% of individual retirement wealth.¹⁹

We hypothesize that the difference in the equity shares across the two samples arises in part because our administrative data allow us to measure investors' portfolio allocations precisely. Specifically, the SCF data are based on survey responses in which people might underreport the share of their wealth invested in equity if they underestimate how aggressively TDFs allocate money into equities, especially when they are far from target retirement date. The main alternative hypotheses are that our sample underrepresents investors with low equity shares or that the part of individuals' investable wealth that we do not observe (because it is held at other financial institutions) has a lower equity share. Five pieces of evidence point in the direction of people underreporting equity allocations of TDFs in the SCF.

First, the respondents in the SCF who have some of their retirement assets in "mixed" funds report having lower-than-average equity shares, as shown by comparing columns (2) and (4) of Table III.²⁰ In the SCF, the subset of RIs who report having some assets in a mixed fund report an equity share of only 47%, versus 54% for all RIs in the SCF. We observe the exact opposite in our data: the subset of investors with TDFs has a somewhat higher equity share (77% versus 71%), consistent with the underreporting of the equity share by SCF respondents.

Second, SCF respondents also appear to underreport the decline in equity shares with age, which is again correlated with TDF ownership. Households in the SCF report little rebalancing out of equity as they approach retirement relative to investors in our data. Further, what decline there is occurs primarily among those investors not holding TDFs. Those holding TDFs report quite flat equity shares despite the significant automatic rebalancing with age by TDFs. As a result, the difference between equity shares in our data and the SCF is highest for young investors who hold some TDFs. These are the patterns that one would anticipate if misreporting were due to a lack of understanding about how much TDFs allocate to equity for younger investors.

Third, the difference between equity shares of investors holding TDFs and investors who do not occurs primarily in retirement wealth, where the vast majority of TDFs are held, and not in nonretirement accounts. Panel B of Table III shows that RIs in the SCF reported equity shares that are about 9%

¹⁹ These numbers are somewhat lower than commonly reported in the SCF because we are calculating the average equity share rather than taking the ratio of averages. Because equity shares increase with wealth, equity shares calculated as aggregate equity over aggregate wealth are larger (e.g., Bricker et al. (2016)).

²⁰ The SCF phrases this question as "How is it invested? Is it all in stocks, all in interest-earning assets, is it split between these, or something else?" and then offers a variety of choices. We infer that the participant has some wealth in a TDF if they report having a mixed allocation of assets or if they have assets in a mutual fund or exchange-traded fund. Thus, just as survey responses may misreport equity share, they may also mischaracterize investments as hybrid funds.

lower when they hold assets in a mixed fund, while RIs in our sample report an equity share that is approximately 5% higher when they hold assets in a TDF.

Fourth, it is notable that outside of retirement wealth, our investors hold significantly lower shares of their wealth in equity, compared to their holdings in retirement accounts or compared to what SCF households report in nonretirement accounts. Consider the argument that our sample overstates equity shares because we omit nonretirement wealth that the SCF measures. This is possible because of the distribution of wealth in our sample, as we note above.²¹ But nonretirement assets in the SCF (Panel C of Table III) have an equity share of 73%, which is higher than in our sample (and is higher than in SCF retirement accounts).²² Because this part of wealth has a high equity share in the SCF, if we were able to add such wealth to our data, presumably, it would further raise, not lower, the average equity share in our data.

Finally, we compare the time series of the SCF, starting in 2007, with our sample in the same years and find that the discrepancy worsens over time. While there is already a large difference between the average equity share reported in the SCF and our sample in 2007, the gap grows steadily until 2016, as does the gap between those with and without TDFs in their portfolios (see Internet Appendix Figures IA.5 and IA.6). These changes are consistent with the rise of TDFs in our sample, displayed in Figure 4, and with their general rise across the United States (e.g., see Parker, Schoar, and Sun, 2023).

In addition, we confirm that the TDF design and recommended portfolio allocations of our data provider are in line with the other large providers in the United States. Various subsample analyses, described in the Internet Appendix, show that neither the unit of observation nor household composition appears to be responsible for the higher average equity shares in our data.

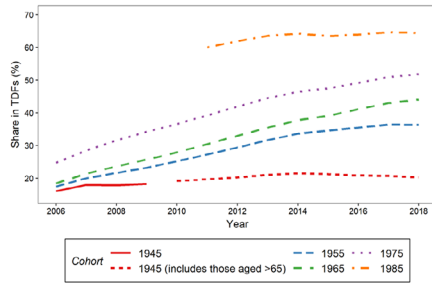
While we believe that this evidence supports the view that equity shares in the SCF are underreported relative to our administrative data, we cannot completely rule out that some of the difference in measured equity shares may come from idiosyncrasies of our sample or from wealth held at institutions other than the one we observe. In particular, our sample has a higher share of one's portfolio invested in stocks than the SCF sample even before the rise of TDFs. While this suggests mismeasurement in one data set or the other, it is unlikely to be driven by TDFs.

We conclude that while the two samples have some differences, the typical RI—a middle- or upper-middle class investor—holds significantly more of their investable wealth in the stock market than what appears to be the case in the SCF. We next turn to our analysis of the changes in the life-cycle dynamics of portfolio holdings over time.

²¹ The SCF reports a somewhat larger amount of wealth held in nonretirement accounts, 13% versus 4% (See Figures 1 and 2, Panel A and Table II).

²² This includes equity held in trusts and mutual funds or stocks held outside of retirement accounts as a fraction of all trusts, mutual funds, stocks, bonds, and certificates of deposit held outside of retirement.

Panel A: TDF Share by Birth Cohort and Year



Panel B: TDF Share by Birth Cohort and Age

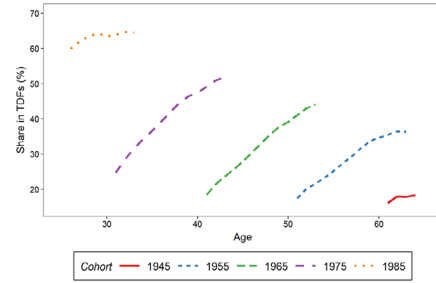


Figure 4. Target date fund share by birth cohort. This figure shows the share of portfolios invested in target date funds (TDFs) averaged by birth-year cohorts. Panel A shows the averages by year over our sample period. We include only those years during which each member of the cohort is 25 to 65 years old, unless otherwise indicated. Panel B shows the averages by age, where age is the median age of the cohort. TDFs are mutual funds that maintain a given portfolio share of assets invested in different asset classes, where the shares change with the number of years until the “target date,” the expected retirement date of the investor. A cohort is defined as having been born in the three-year period centered around the year indicated. The sample comprises our full set of retirement investors (RI). (Color figure can be viewed at wileyonlinelibrary.com)

B. Equity Shares across Ages

B.1. The Cross Section of Equity Shares by Investor Age

We first establish more directly that, in the cross section, averaging across people and years in our sample, the age profile of equity shares is declining in age, as shown in Figure 3, Panel B. We check that this is not due to differences in income across ages by regressing equity share on indicator variables for age groups using the specification

$$y_{it} = \beta_1' \text{Age}_{it} + \beta_2 \text{Inc}_{it} + \epsilon_{it}, \quad (1)$$

where y_{it} is portfolio equity share, Age_{it} is a vector of three-year age-group indicators, and Inc_{it} is the log deviation of the individual’s income each year from the sample mean income, which is included only in some specifications.

The solid (red) line in Figure 5 plots the coefficients from the regression in (1) without the income control, which largely replicates Figure 3, Panel B. The equity shares are approximately 74% for ages 25 to 27 and are lower at higher ages, reaching approximately 55% at ages 64 to 65.²³ The rate of decline across ages is much steeper for at older ages, decreasing by 2% to 3% per year after age 50.

Adding the income control reduces the sample size and raises the average equity share slightly, but the pattern of equity shares across ages remains largely the same, as shown in Figure 5. The short-dashed (yellow-green) line

²³ Internet Appendix Table IA.VIII reports the regression coefficients, also referenced in the next paragraph.

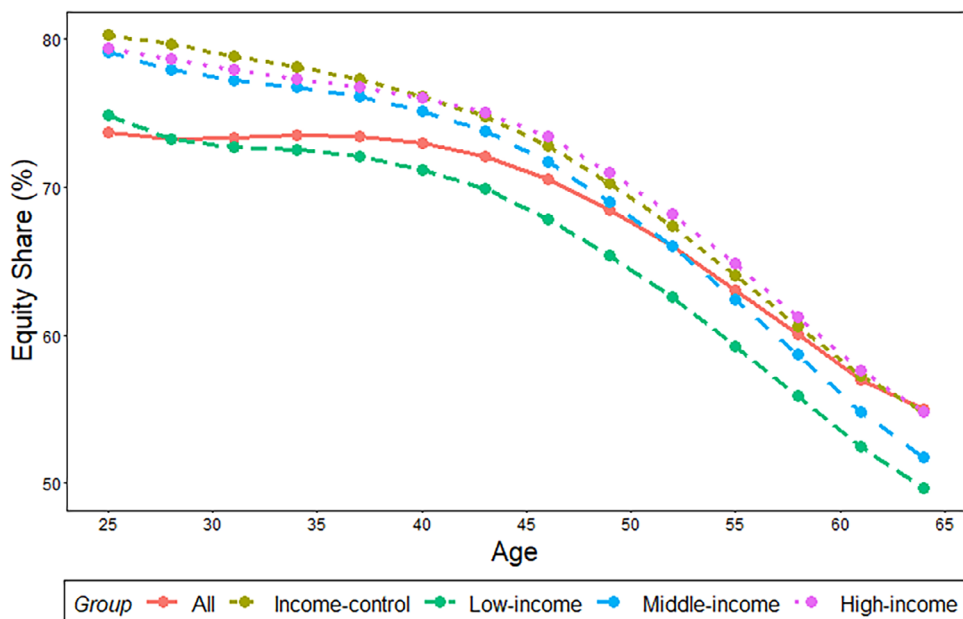


Figure 5. Regression coefficients from cross-sectional regressions of equity share on age, full sample, and by income terciles. This figure plots the regression coefficients of annual individual portfolio equity shares on a set of demographic controls. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. The baseline specification, “All,” shows the coefficients for the regression of equity share on age-group dummies. We then add a control for the log of income in the current year, measured as the individual’s log deviation from the average income in the RI sample. The other lines show results of the baseline specification for the first (lowest) through third tercile of initial income. Initial income is based on the income observed in the first (or second, if the first is not available) year that we observe the individual. The sample comprises our full set of retirement investors (RIs) from 2006 to 2018. (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/terms-and-conditions))

plots the average equity share at the mean income and shows that the portfolio share of equity declines across ages slightly more before age 50, but still declines much more significantly after age 50. The effect of income is based primarily on the correlation of income and equity share within age groups rather than on average across age groups. People with higher income tend to have higher equity shares: a two-standard-deviation change in income is associated with a nearly 8% higher equity share (and in the regression, income explains roughly as much variation in portfolio shares as age groups). Investors in the bottom third of the distribution of starting income have about a 5% lower share of their investable wealth in the stock market, but the decrease with age is similar in magnitude for each third of the distribution of initial income.²⁴

²⁴ Initial income is based on the first (or second, if first is not available) year in which the individual enters our sample. The first tercile of initial income covers those with income below \$46,000 per year. The second covers those with income between \$46,000 and 75,000. The third tercile com-

Finally, it is important to note that this cross-age pattern does not appear to be driven by the passive appreciation of equity holdings for investors over time. The cross-sectional results are similar using price-constant equity shares, which measure inflows and outflows to each asset class, and ignore any change in price (see Internet Appendix Table [IA.IX](#)). The results also hold when we use the ex-ante designated equity share of dollar contributions (Internet Appendix Table [IA.X](#)).

B.2. The Hump-Shaped Life-Cycle Profile of Investor Equity Shares

Next, tracking the same investors over time, we find that equity shares rise at young ages, in contrast to the cross-sectional pattern just shown, and are hump-shaped over an individual's working life.

Figure 6 plots the coefficients from regressions analogous to the specification in equation (1) but including person fixed effects, and thus measure the average change in equity share across investors at each age as they age (normalized to the average equity share).²⁵ The baseline specification shows that young people tend to increase the equity share of their portfolios, but as they approach retirement they reduce their equity exposure. In particular, people increase their equity share by approximately 7% from age 25 to 50, and then they decrease this share by about the same amount from age 50 to 65. Changes in income do not drive this result. The same pattern holds when controlling for income, with a slightly higher magnitude (10% instead of 7%).²⁶

This hump-shaped pattern over the life cycle holds across income groups. The remaining lines in Figure 6 show results for different levels of initial income. Each group increases its equity share by 5% to 7% from age 25 to 50, and then decreases it as they age. We observe more aggressive rebalancing away from equity in the higher income groups, with the richest individuals decreasing their equity share by about 7% relative to their position at age 25 to 27. Those in the lowest income group decrease their equity share by only about 2%. Of course, those with higher income also start out with higher equity shares and thus have more room to decrease them.

Due to the challenge of fully disentangling age, time, and cohort effects, we next perform two robustness checks to verify the hump-shaped pattern. We first find that the hump-shaped pattern continues to hold if we model time effects as a linear function of the excess return of the S&P500 (relative to the risk-free interest rate) in the 10 years leading up to each observation, using this a proxy for time effects, similar to Malmendier and Nagel (2011) (see Internet Appendix Table [IA.XIII](#)).

prises those with initial income greater than roughly \$75,000 per year. Internet Appendix Table [IA.XI](#) shows the results with standard errors clustered at the employer, rather than individual, level. The statistical significance is unchanged.

²⁵ Internet Appendix Table [IA.XII](#) shows the corresponding regression results.

²⁶ The coefficient on income measuring the effect of changes in income is also smaller than the coefficient on the level of income in Internet Appendix Table [IA.VIII](#) measured in the cross section, an effect examined in detail in Meeuwis (2019).

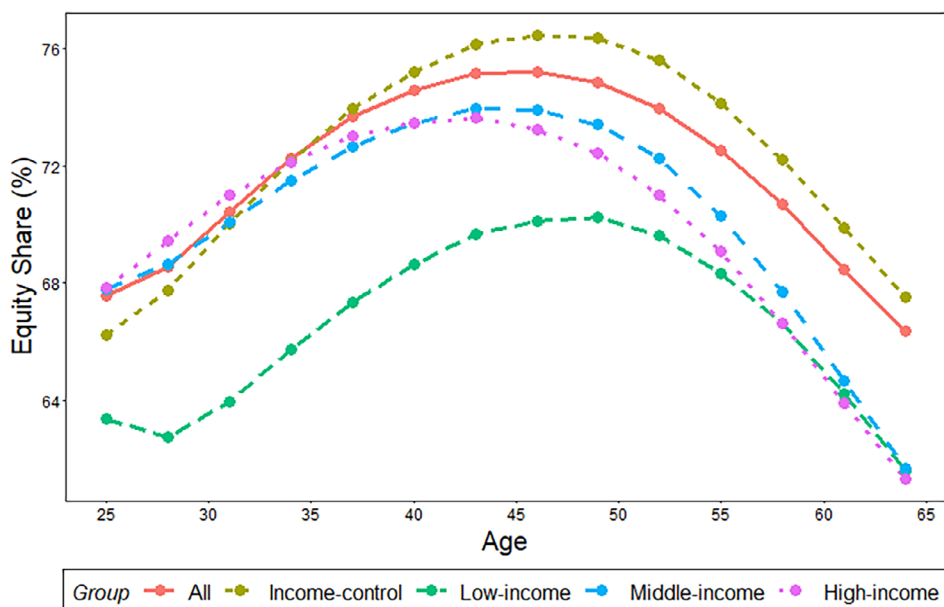
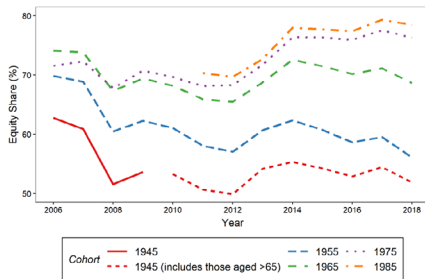


Figure 6. Regression coefficients from within-person regressions of equity share on age, full sample, and by income terciles. This figure plots the regression coefficients of annual individual portfolio equity shares on a set of demographic controls. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. The baseline specification, “All,” shows the coefficients for the regression of equity share on age-group dummies. We then add a control for the log of income in the current year, measured as the individual’s log deviation from the average income in the RI sample. The other lines show results of the baseline specification for the first (lowest) through third tercile of initial income. Initial income is based on the income observed in the first (or second, if the first is not available) year that we observe the individual. All regressions include person fixed effects. The age-group coefficients are normalized by adding the average fixed effect back to the estimated coefficients. The excluded age group is those aged 64 to 65. The sample comprises our full set of retirement investors (RIs) from 2006 to 2018. (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com))

Second, we reconstruct the age effects and again find a hump-shaped pattern using the method of McKenzie (2006). Under this approach, the equity share is differenced across age and time within a cohort to eliminate cohort effects. These first differences are then differenced over time to eliminate time effects and recover the age profile between adjacent ages. This method gives a discrete approximation and point identification of the second partial derivative. First derivatives and level effects can then be recovered by assuming a normalization of some constant slope between two ages. We select a slope of zero between age 25 and 26, a minor normalization given that observed equity shares are relatively flat early in life (see Figure 3, Panel B). We find that the second derivatives and recovered level effects are consistent with a hump-shaped pattern over the life cycle. We describe this approach in more detail and report the results in Internet Appendix Section II).

Panel A: Equity Share by Birth Cohort and Year



Panel B: Equity Share by Birth Cohort and Age



Figure 7. Portfolio equity share by birth cohort. This figure shows the portfolio equity share averaged by birth-year cohorts. Panel A shows the averages by year over our sample period. We include only years during which each member of the cohort is aged 25 to 65 years old, unless otherwise indicated. Panel B shows the averages by age, where age is the median age of the cohort. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. A cohort is defined as having been born in the three-year period centered around the year indicated. The sample comprises our full set of retirement investors (RIs). (Color figure can be viewed at wileyonlinelibrary.com)

B.3. The Life-Cycle Profiles of Equity Shares of Different Cohorts

In our next set of analysis, we document that, across cohorts, equity shares have both risen for younger cohorts and become more hump-shaped in general, consistent with the increased use of TDFs raising the equity share of young investors and decreasing equity shares of older investors. We focus on cohorts of people born in 10-year periods, which gives us five cohorts, starting with those born between 1943 and 1952 and ending with those born between 1983 and 1992. Looking across ages and across cohorts reveals three patterns.

First, over time, Figure 7, Panel A, shows that the three cohorts born more recently (those born around 1965, 1975, and 1985) have slightly higher equity shares than those born around 1945 and 1955 in the early 2000s, with 15% to 20% higher equity shares by 2018. The oldest cohort starts with roughly 10% less of their portfolio allocated to equity and ends the sample with 15% to 25% less in equity than the youngest three cohorts.

Second, and more importantly, every cohort has a higher equity share at every age than all of the older cohorts did at the same age (with a one-year exception for the second-oldest cohort). This result can be seen at the ages for which cohorts overlap in Figure 7, Panel B, which plots equity share by median age for different cohorts.²⁷ More precisely (based on Internet Appendix Table IA.XV), at any age there is a monotone increase in average equity share before around age 40.

²⁷ Internet Appendix Figure IA.7, Panel B shows that both this pattern and that in Figure 7, Panel A, are also true for portfolio betas. In other words, more recent cohorts have higher-beta portfolios than older cohorts at the same age, and portfolio betas within-cohort are relatively stable over time.

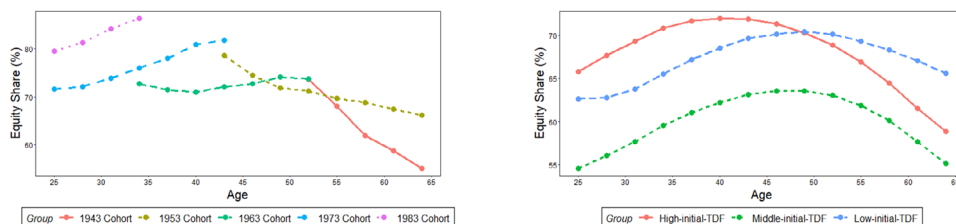


Figure 8. Regression coefficients from within-person regressions of equity share on age, by cohort, and TDF share. This figure plots the regression coefficients of annual individual portfolio equity shares on a set of demographic controls. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. The left panel shows the results including age-group controls and a control for log income, broken out by birth cohort group. A cohort is defined as having been born in the 10-year period beginning with the year indicated. The right panel shows the results for different groups based on the initial share of their portfolio that is invested in target date funds (TDFs). All regressions include person fixed effects. The age-group coefficients are normalized by adding the average fixed effect back to the estimated coefficients. The excluded age group is those aged 64 to 65. The sample comprises our full set of retirement investors (RIs) from 2006 to 2018. (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/jofi.13473))

The left panel of Figure 8 plots our main regression coefficients (with the control for log-income) and individual effects, on subsamples of different birth-year cohorts.²⁸ These regressions control for income and are plotted for the average income of all RIs, which (artificially) raises the equity shares of the youngest and oldest cohorts but allows us to measure how equity shares increase within-cohort as they age, controlling for income.

As without the controls, the older cohorts allocate away from equity sooner and more quickly than younger cohorts. From age 55 to 65, the 1943 cohort decreases its equity share (relative to their own shares at age 52 to 54) by 19%. Meanwhile, those in the 1953 cohort decreased their equity share (again, relative to their own shares at age 52 to 54) by only about 5%. Similarly, large differences appear when comparing the 1953 cohort to the 1963 cohort. Those born between 1953 and 1962 decrease their equity shares by about 8% from age 43 to 52, while those born between 1963 and 1972 actually increase their equity share by nearly 2% over the same age range.²⁹

Third, among the youngest cohorts, those born more recently increase their equity shares more quickly in their earliest years of investing, by approximately 1% more from age 25 to 36 than those born 10 years earlier.

What has driven these changes in portfolio behavior? The greater investment in the stock market by the young and the decline over the latter half of an individual's working life are both consistent with increased adoption of

²⁸ Internet Appendix Table IA.XVI shows the corresponding regression results.

²⁹ Put differently, comparing the trend for the 1953 cohort from age 43 to 57, we see that those born from 1953 to 1962 decrease equity shares at about 2% to 4% per year. In contrast, the 1963 cohort, at the same age, holds their equity share almost constant until they reach age 52, when they start to decrease it by only 1% to 2% per year.

TDFs. As shown in Figure 4, younger cohorts are much more heavily invested in TDFs.

The right panel of Figure 8 shows evidence consistent with these changes across cohorts being driven by the rise of TDFs. Investors who begin with a high allocation of their portfolio to TDFs (75% to 100%) start with higher initial equity shares and exhibit much stronger rebalancing behavior than those who start life with less invested in TDFs. In contrast, those with initially low allocations to TDFs (0% to 25%) have a hump-shaped but flatter equity profile, starting with approximately 62% equity, increasing it to 70% by midlife, and lowering it only modestly to 66% by age 65.

Before turning in Section III to more direct evidence on the role of TDFs in individuals' life-cycle pattern of stock market investment, we compare these investment patterns to those of similar investors in the 1990s.

C. Relation to Portfolios during the 1990s

In this subsection, we present a final piece of direct evidence that portfolio behavior has changed over time by comparing the life-cycle portfolio holdings in our data covering 2006 to 2018 to portfolio holdings in very similar administrative data from the 1990s. Specifically, we replicate the central analysis of Ameriks and Zeldes (2004), which is based on administrative data from a large financial institution, where both the type of data and institution are quite similar to ours. Figure 12 in Ameriks and Zeldes (2004) focuses on a sample of households that own equity and shows that investors held less of their wealth in stocks and did not reduce their equity shares with age.

Figure 9 replicates Figure 12 from Ameriks and Zeldes (2004) and visually summarizes three main points. First, the top panel of Figure 9 shows that equity shares in more recent years are high and decline with age across investors, with a steeper slope after age 55. In contrast, in earlier data, equity shares decrease with age from age 25 to 35 and are roughly the same for all ages after 35 (Ameriks and Zeldes (2004), Figure 12, top panel).

Second, the middle panel of Figure 9 shows that as cohorts age, equity shares are roughly independent of age during the first half of an individual's working life and then decrease with age during the second half of their working life. In contrast, the middle panel of Figure 12 in Ameriks and Zeldes (2004) shows that each cohort's equity share was *upward sloping* in age in the 1990s.

Third, in the last panel of Figure 9, the solid red line shows that equity shares are hump-shaped in age after controlling for differences across cohorts. The analogous figure in Ameriks and Zeldes (2004) shows a linear upward-sloping line. Controlling for differences across years, the dashed blue line shows that equity shares are decreasing, more rapidly later in life, as in a TDF glide path. The analogous figure in Ameriks and Zeldes (2004) shows a flat line.

Finally, to confirm that we are documenting a real change in behavior rather than something specific to administrative data sets or these two firms, we replicate the Ameriks and Zeldes (2004) analysis of portfolios in the SCF. We compare Figure 9 in Ameriks and Zeldes (2004), which is based on SCF data

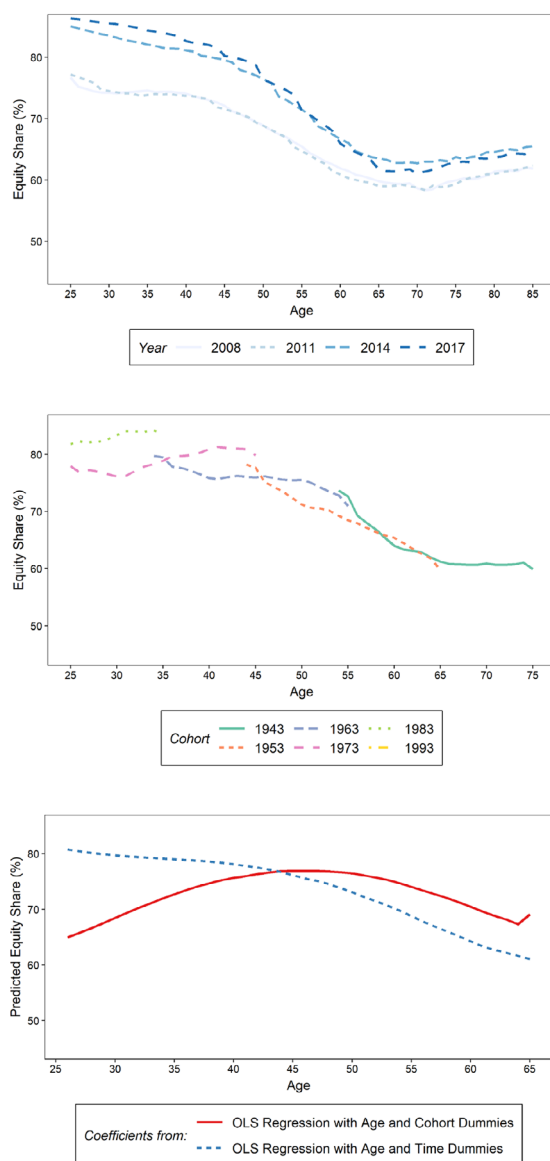


Figure 9. Equity share among equity owners. This figure replicates the results shown in Figure 12 of Ameriks and Zeldes (2004). The top panel shows the observed equity share by age in four different years of our sample. The middle panel shows the observed equity share by age in each cohort in our sample. A cohort is defined as having been born in the 10-year period beginning with the year indicated. The bottom panel shows the predicted values from a regression of equity share on indicator variables for age and either cohort or time. We obtain the predicted values by adding the median cohort or year coefficient to each age coefficient. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. The sample comprises our set of retirement investors (RIs) who own at least some equity. (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com))

from 1989 to 1999, with our own version of Figure 9 based on SCF data from 2007 to 2016 (Internet Appendix Figure IA.8). We find the same changes as between the two administrative data sets, but to a slightly lesser degree.³⁰ Specifically, equity shares have risen in the SCF relative to the time-frame studied in Ameriks and Zeldes (2004), and there is now a life-cycle pattern of rebalancing out of equity with age rather than an increasing equity exposure with age.

III. Pension Regulation, TDFs, and Portfolio Allocations

This section provides evidence that the rapid rise of TDFs following the PPA of 2006 contributed to both of the main new facts that we document: equity shares are high earlier in life and decline steadily over the second half of an investor's working life.

The PPA 2006 permitted TDFs to be QDIA in employer-sponsored, defined-contribution retirement plans. The Act provided a "safe harbor provision" that clarified that the use of a TDF as the default investment vehicle in a plan was consistent with the fiduciary responsibilities of the plan sponsor (the employer) and the plan administrator.³¹ Prior to this provision, both employers and administrators faced potential legal liability for replacing existing default options—primarily safe money market funds—with TDFs. Following the PPA, plans increasingly adopted TDFs as the default, which moved employees who passively accepted or chose the default investment out of very safe, low-return funds and into largely equity funds. Following the PPA, the availability, adoption, and use of TDFs accelerated rapidly in the United States Figure 4 depicts the increase in adoption in our data. Overall, TDFs (and related funds) grew from managing less than \$8 billion in 2000 to managing almost \$6 trillion in 2021 (see the discussion in Parker and Sun, 2023).

A. The Short-Run Effect of PPA of 2006 on Portfolios

To identify the effect of TDFs on investors' portfolio allocations, we compare the life-cycle investment behavior of workers hired by a given firm just before and after 2006 at firms that switched their default investment at this time to a TDF. This analysis identifies the exogenous effect of the PPA on investors' portfolios assuming that people (employees) did not endogenously change jobs due to the introduction of the PPA or their (potential) employer's response to it. This assumption seems reasonable since employees typically are not aware of these regulatory changes and base their employment decision on many other factors. Employees who joined their employer before 2006 almost always entered into plans that did not have a TDF as a default option, since without

³⁰ This smaller magnitude is consistent with the gap in equity shares observed between our sample and the SCF, as we discuss in relation to Table III's evidence that equity shares decline with age more in our data than in the SCF.

³¹ See <https://www.dol.gov/agencies/ebsa/about-ebsa/our-activities/resource-center/fact-sheets/default-investment-alternatives-under-participant-directed-individual-account-plans>.

the safe harbor provision of the PPA, employers found it very risky to use this option. After 2006, many employers adopted TDFs as the default option and employees joining the firm after this change then saw a different default investment vehicle when they enrolled.

We first analyze the short-term (two-year) effect of the adoption of a TDF as the default investment fund. We examine the sample of employees who start a new job between 2005 and 2008. The specification is

$$y_{ift} = \beta_1 \times D_{treated} + \beta_2 \times D_{treated} \times AgeEnrolled_i + \beta_3 \times AgeEnrolled_i + \lambda_f + \epsilon_{it}, \quad (2)$$

where t now indexes years since enrollment, and y_{ift} is the portfolio equity share of individual i starting at firm f in year $t = 0$. We include all investors who enrolled between 2005 to 2008, including only the first two years that we observe them in the sample. The variable $D_{treated}$ is an indicator equal to one if an investor starts at a retirement plan that switched to a TDF default immediately after the PPA, in 2007 or 2008. The control group includes those who enrolled in 2005 to 2006.³² The parameter λ_f is an employer fixed effect, included so that our analysis compares individuals enrolling before the Act (in 2005 or 2006) to those at the same employer enrolling after (in 2007 or 2008). Since TDFs by definition change their target allocation for people of different ages, $AgeEnrolled$ is a set of categorical variables for 10-year age groups at enrollment, which are included alone and interacted with the treatment variable to measure the effect of interest. These regressions include only firm-level fixed effects and not individual-level fixed effects since we estimate the effect of the PPA by comparing across investors who enrolled just before and after 2006.

Note that this approach conditions on individuals who newly enroll in a retirement plan during the time period we study. Several provisions of the PPA were designed to increase enrollment, such as allowing autoenrollment. Thus, there may have been an effect on average participation rates in plans (see Beshears et al. (2010)), which raises the possibility of some change in the type of workers who enroll before versus after the PPA. Since we do not have information on nonparticipants that would allow us to directly address this concern, we instead control for the key observable characteristics that we observe, such as income and age. Moreover, previously nonparticipating employees are possibly the most likely to accept the default asset choice of TDFs (Choi et al. (2004)), so that prior to the PPA, they might have been defaulted into investing in safe assets.

Table IV shows the estimation results of equation (2) restricting the sample to the two years after enrollment for each new employee. Column (1) shows that someone aged 25 to 35 who is enrolled into a plan with a TDF default in the two years after the Act (compared to those enrolled in the two years prior to the Act in the same firm) has a 5.5% higher equity share during the first two years of their employment (the coefficient on the *treated* indicator

³² Note there is no time fixed effect, as it would be collinear with the treatment.

Table IV
Regressions of Equity Share on Automated Investment Allocation: Average Effect Two Years after Entering Sample

This table presents regression coefficients of annual household portfolio equity shares on a treatment dummy for being enrolled into a plan with a target date fund (TDF) as the default after the Pension Protection Act of 2006. We set this treatment dummy equal to one for those enrolled in their firm's retirement plan in 2007 or 2008 when that plan had a TDF as a default and zero for those enrolled in 2005 or 2006. Columns (1) and (2) show the results for the first two years of data after the individual enters our sample. Columns (3) and (4) repeat column (1) for those in the lowest and highest tercile of initial income, respectively. Columns (5) and (6) repeat columns (1) and (2) including only individuals who had no prior retirement wealth before enrollment and no rollover assets of any kind. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. Log income, when included, is the log deviation of the individual's current income from the average income of the retirement investor (RI) sample. The sample is our set of RIs who enrolled in their plan from 2005 to 2008. Standard errors, in parentheses, are clustered at the household level.

	Portfolio Equity Share					
	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	Bottom Income Tercile	Top Income Tercile	No Prior Nonretirement Wealth + No Rollover Assets	No Prior Nonretirement Wealth + No Rollover Assets
Treated	0.0552 (0.0007)	0.0533 (0.0008)	0.0599 (0.0011)	0.0186 (0.0024)	0.0578 (0.0007)	0.0555 (0.0008)
Age 35 to 44	-0.0134 (0.0006)	-0.0271 (0.0007)	-0.0339 (0.0013)	-0.0112 (0.0012)	-0.0140 (0.0006)	-0.0272 (0.0007)
Age 45 to 54	-0.0700 (0.0007)	-0.0875 (0.0008)	-0.1011 (0.0015)	-0.0627 (0.0014)	-0.0720 (0.0007)	-0.0887 (0.0009)
Age 55 to 65	-0.1325 (0.0012)	-0.1502 (0.0014)	-0.1658 (0.0026)	-0.1254 (0.0023)	-0.1352 (0.0013)	-0.1520 (0.0015)
Age 35 to 44 × Treatment	-0.0581 (0.0014)	-0.0542 (0.0016)	-0.0508 (0.0024)	-0.0366 (0.0041)	-0.0600 (0.0015)	-0.0549 (0.0017)
Age 45 to 54 × Treatment	-0.1029 (0.0018)	-0.0885 (0.0021)	-0.0717 (0.0030)	-0.0809 (0.0050)	-0.1042 (0.0018)	-0.0895 (0.0021)
Age 55 to 65 × Treatment	-0.1479 (0.0032)	-0.1314 (0.0038)	-0.1235 (0.0055)	-0.1173 (0.0091)	-0.1495 (0.0033)	-0.1322 (0.0038)

(Continued)

Table IV—Continued

	Portfolio Equity Share				
	(1) All	(2) All	(3) Bottom Income Tercile	(4) Top Income Tercile	(6) No Prior Nonretirement Wealth + No Rollover Assets
Log income		0.1031 (0.0012)			0.1072 (0.0013)
Constant	0.7352 (0.0003)	0.7476 (0.0004)	0.7180 (0.0006)	0.7353 (0.0003)	0.7468 (0.0004)
Firm Fixed Effect?	Y	Y	Y	Y	Y
% of Total Sample	1.3	0.9	0.3	0.3	0.9
% of Sample Enrolled 2005 to 2008	18.1	12.8	5.0	3.9	12.2
R ²	0.1543	0.1502	0.2266	0.1044	0.1565

variable). The effect is statistically significant and economically large relative to the change in average equity over the life cycle.³³

The coefficients on the interaction terms show that the effect of a TDF default on older individuals is to decrease their equity shares. For example, while those aged 55 to 65 at enrollment have 13% lower equity shares than those aged 25 to 34 (row 4), those treated by the change in default have equity shares that are lower by an additional 15% (row 7). This age pattern in the treatment effect of TDFs—from positive when young to negative when old—is consistent with the change in overall behavior documented in Section II: relative to the low and (roughly) age-invariant equity profiles of the 1990s, TDFs raise the allocation to stock for younger workers and lower it for older workers. Controlling for income (column (2)), the effect on young investors declines only slightly and the life-cycle pattern remains quite similar.

For younger investors, the effect of a TDF default is generally larger for lower-income investors than for higher-income investors. In columns (3) and (4) of Table IV, we repeat the analysis from column (1) for the subsamples of people with the lowest and highest initial income. Column (3) shows that the initial impact on equity share at young ages is almost 6%, compared to 5.5% in the full sample. The effect on those in the bottom income tercile is similar for the older age groups as in the full sample. For the highest income tercile (column (4)), the treatment effects are significantly muted. For the youngest group (age 25 to 35), the magnitude of the treatment effect on equity share is less than 2%.

The small effect for higher-income investors may be due to the fact that even in the control group, young higher-income investors have high equity shares. Second, higher-income investors may make more active decisions and thus make less use of TDFs. Consistent with the latter, the rebalancing effect of enrolling with a TDF default is much less pronounced for the highest income tercile.

These results are not driven by differences in investors' preexisting portfolio allocations or their experience with assets or asset managers prior to enrolling with their new employer. Columns (5) and (6) display the results of the same analysis as in columns (1) and (2), but focusing only on those individuals who have no other retirement assets or rollover funds prior to enrollment at our institution. It turns out that this sample restriction drops very few investors. As a result, the results are virtually unchanged from those in the first two columns, even for older new employees.

B. Medium-Run Impact and Convergence

To analyze the impact of the PPA on the investment dynamics and persistence of portfolio allocation over the medium term, we now repeat the analysis above but track individuals for five years after enrollment in a retirement plan.

³³ Internet Appendix Table IA.XVII shows the same specification with standard errors clustered by employer rather than by individual. The results continue to be statistically significant.

We expand our specification to

$$y_{it} = \beta_1 \times D_{treated} + \beta_2 \times D_{treated} \times AgeEnrolled_i + \beta_3 \times AgeEnrolled_i + \beta_4 \times D_{treated} \times \lambda_t + \beta_5 \times \lambda_t + \lambda_f + \epsilon_{it}, \quad (3)$$

where the notation is the same as in equation (2) and we have added year fixed effects, λ_t , and their interaction with the treatment indicator. In this specification, to study differences by age, we run separate regressions using different age groups rather than include the full set of age fixed effects and interactions.

Column (1) of Table V confirms that the effect of the PPA on equity shares is positive even averaged over the first five years after enrollment and based on the full sample enrolled in 2005 to 2008.³⁴ This dynamic analysis shows that the difference between the treated and control group portfolios declines over time. As before, the positive effect of the PPA is much larger for the low-income group than the high-income group (columns (2) and (3)), but this difference shrinks to nearly zero five years after treatment.

In addition, we see that TDFs tend to raise equity shares for the young and reduce equity shares for those near retirement. Column (4) shows that for those aged 25 to 34 at enrollment, the change to a TDF default increases equity share by 1.5% on average the year of the change and rises to almost 4% in the following two years. In the last two years, we see some convergence between the treatment and control groups, but at the end of the five-year period, the treated individuals still have equity shares that are nearly 3% higher than those of the control group.

Table V shows for the older age groups, the effect is the opposite: the PPA decreases equity shares immediately following treatment, which is in line with the prescribed glide path of TDFs. As with the youngest group, this difference tends to decrease over time as the two groups converge. For those aged 55 to 65, the difference is persistent, with the treated group's equity shares still being 2% lower than that of the control group five years after treatment.

The PPA also played a role in the convergence of portfolio allocations between income groups, particularly for those that were enrolled at a young age. Figure 10 plots the predicted equity shares of treatment and control groups broken out by age and income tercile.³⁵ Looking first at the youngest age group (25 to 34) in Figure 10, Panel A, the adoption of a TDF default significantly increased equity shares for the low-income group, similar to the overall pattern in the previous section that the lowest income group increases their equity share more as they age than does the highest income group before age 40 (Figure 6). In addition, we see that the control group converges

³⁴ Internet Appendix Table IA.XVIII repeats the results using only those who enrolled in the plan in 2007 as the control group. This minimizes possible spurious correlation due to the financial crisis, as those enrolled in 2007 had at least one full year to contribute and invest prior to the financial crisis starting.

³⁵ These are estimated in by repeating columns (4) and (7) from Table V on the income subsamples.

Table V
Regressions of Equity Share on Automated Investment Allocation: Long-Run Effect

This table presents regression coefficients of annual household portfolio equity shares on being treated with the Pension Protection Act (PPA) of 2006. “Year of” refers to the year the individual enrolled in their retirement plan and “x years after” is x years after they enrolled in the plan. Each column includes year dummies for each year after enrollment and interactions of these dummies with the treatment dummy. The treatment dummy is equal to one if the individual enrolled in 2007 or 2008 to a plan that switched to having a target date fund (TDF) as the default following the PPA and zero if they enrolled in 2005 or 2006. The full sample is those enrolled from 2005 to 2008 who otherwise meet the retirement investor (RI) sample criteria. The bottom (top) income tercile includes those whose initial income is in the lowest (highest) tercile. Columns (4) to (7) separate the results for all individuals enrolled from 2005 to 2008 by age at enrollment. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. Log income, when included, is the log deviation of the individual’s current income from the average income of the RI sample. Standard errors, in parentheses, are clustered at the household level.

	Portfolio Equity Share						
	(1) Full Sample	(2) Bottom Income Tercile	(3) Top Income Tercile	(4) Age Enrolled 25 to 34	(5) Age Enrolled 35-44	(6) Age Enrolled 45-54	(7) Age Enrolled 55-65
Year of × Treatment	0.0198 (0.0023)	0.0463 (0.0036)	0.0071 (0.0051)	0.0161 (0.0022)	-0.0263 (0.0066)	-0.0584 (0.0092)	-0.0618 (0.0171)
1 Year After × Treatment	0.0430 (0.0011)	0.0655 (0.0015)	-0.0065 (0.0029)	0.0295 (0.0011)	-0.0154 (0.0036)	-0.0750 (0.0068)	-0.1321 (0.0097)
2 Years After × Treatment	0.0683 (0.0009)	0.0861 (0.0013)	0.0287 (0.0025)	0.0363 (0.0011)	0.0186 (0.0028)	-0.0181 (0.0050)	-0.0515 (0.0116)
3 Years After × Treatment	0.0032 (0.0010)	0.0254 (0.0015)	-0.0269 (0.0021)	0.0005 (0.0013)	-0.0261 (0.0018)	-0.0268 (0.0025)	-0.0524 (0.0046)
4 Years After × Treatment	-0.0244 (0.0010)	-0.0185 (0.0015)	-0.0292 (0.0019)	0.0003 (0.0013)	-0.0173 (0.0014)	-0.0274 (0.0020)	-0.0410 (0.0039)
5 Years After × Treatment	0.0036 (0.0010)	0.0104 (0.0015)	-0.0055 (0.0023)	0.0257 (0.0014)	0.0099 (0.0016)	-0.0060 (0.0022)	-0.0201 (0.0043)
1 Year After	0.0087 (0.0009)	0.0209 (0.0018)	0.0126 (0.0013)	0.0136 (0.0012)	0.0133 (0.0014)	0.0096 (0.0016)	0.0088 (0.0026)
2 Years After	-0.0194 (0.0010)	0.0022 (0.0019)	-0.0201 (0.0014)	0.0067 (0.0012)	-0.0207 (0.0015)	-0.0445 (0.0017)	-0.0564 (0.0029)

(Continued)

Table V—Continued

	Portfolio Equity Share						
	(1) Full Sample	(2) Bottom Income Tercile	(3) Top Income Tercile	(4) Age Enrolled 25 to 34	(5) Age Enrolled 35-44	(6) Age Enrolled 45-54	(7) Age Enrolled 55-65
3 Years After	-0.0272 (0.0010)	0.0046 (0.0019)	-0.0383 (0.0015)	0.0142 (0.0013)	-0.0282 (0.0016)	-0.0675 (0.0018)	-0.0876 (0.0030)
4 Years After	-0.0221 (0.0010)	0.0074 (0.0019)	-0.0334 (0.0015)	0.0243 (0.0013)	-0.0209 (0.0016)	-0.0629 (0.0018)	-0.0810 (0.0031)
5 Years After	-0.0348 (0.0011)	-0.0091 (0.0020)	-0.0459 (0.0016)	0.0134 (0.0014)	-0.0373 (0.0017)	-0.0824 (0.0019)	-0.0955 (0.0034)
Log income	0.0487 (0.0012)						
Constant	0.7279 (0.0010)	0.6751 (0.0020)	0.7473 (0.0014)	0.7255 (0.0013)	0.7432 (0.0015)	0.7059 (0.0017)	0.6374 (0.0028)
Firm Fixed Effect?	Y	Y	Y	Y	Y	Y	Y
% of RI Sample	1.6	0.5	0.5	0.8	0.6	0.4	0.1
% of Sample Enrolled 2005 to 2008	22.4	7.8	7.1	11.9	8.2	5.8	1.9
R ²	0.0969	0.1727	0.0716	0.1537	0.1013	0.0942	0.1181

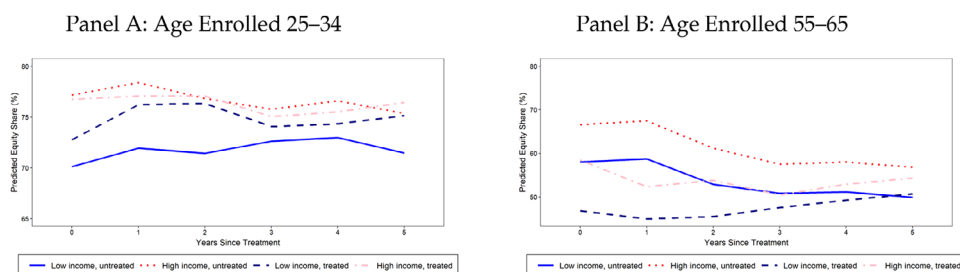


Figure 10. Predicted equity share: Pension Protection Act. This figure shows the predicted equity share for those treated by the Pension Protection Act of 2006 and those not treated by the act, split out by age and income groups. Panel A shows the results for those aged 25 to 34 when enrolled. Panel B shows the results for those aged 55 to 65 when enrolled. The portfolio equity share is defined as the sum of equity securities, pure equity funds, and the equity portion of hybrid funds, relative to total portfolio assets. The sample comprises our set of retirement investors (RIs) who were enrolled between 2005 to 2008. (Color figure can be viewed at wileyonlinelibrary.com)

partially to the treatment group over time. In contrast, the effect on equity shares for the high-income group is positive but much smaller.

Figure 10, Panel B, shows the results for those enrolled from age 55 to 65 for high-income investors and for low-income investors. The PPA significantly decreased equity shares for both groups. Over time, the two treated groups become more similar when compared to the two untreated groups, implying a similar convergence effect of the changes in defaults facilitated by the PPA.

Finally, we examine the role that TDFs play in accounting for the aggregate shift in the life-cycle portfolio allocation over our sample period. While the regressions using PPA variation show some catch-up over time even for those who are not defaulted into TDFs, we want to understand how important this effect is in the aggregate (in an accounting sense). To do so, we separate financial wealth invested in TDFs from financial wealth invested in other non-TDF funds or directly invested in underlying assets. We find that the share of wealth allocated to equities is much less humped-shaped over the life cycle for financial wealth that is not invested in TDFs compared to wealth that is invested in TDFs (pictured in Internet Appendix Figure IA.9). Non-TDF wealth comes from two types of investors: RIs who allocate part of their savings to TDFs but part of their savings outside of TDFs, and RIs who never participate in TDFs at all. Non-TDF wealth from each type of investor exhibits this flatter life-cycle pattern. Finally, non-TDF assets on average also have a lower fraction invested in equity.

In conclusion, middle- and upper-middle class working-age American investors with retirement wealth now hold a large share of their financial wealth in equity and reduce this share as they age, following a concave rather than a linear life-cycle pattern. This is relatively new behavior that was not visible prior to 2000. This large change appears to be due to the combination of industry development and regulatory approval of TDFs as default options in retirement saving plans. The new portfolio behavior follows the prescription

embedded in TDFs' investment strategies, that is, to invest mostly in stocks when young and to decrease this share significantly in the second half of one's working life as retirement approaches.

IV. Contribution Rates

In this section, we analyze the average contribution rates that investors make to their retirement plans over their working lives.³⁶ The analysis, which mirrors our analysis of portfolio composition, shows three main results. First, contribution rates increase linearly with age, increasing by 4% to 6% over one's working life. Second, and more importantly, unlike portfolio behavior, this behavior has been relatively stable over time, with the exception that the youngest cohort saves slightly more than the rest. Third, the economic response of average contribution rates to the PPA of 2006 was minimal, and point estimates suggest that changes in plan features shortly after the Act actually decreased saving slightly. Thus, we conclude that investors' own contribution rates were less sensitive than equity shares to the changing regulatory environment (and to investment trends) over time.

A. Realized Contribution Rates

We measure the realized contribution rate as the percentage of an individual's annual income that has been invested into a retirement account over the previous year, not including employer contributions, calculated at the end of each calendar year.

Figure 11, Panel A, presents the coefficients from estimation of equation (1) with realized contribution rates as the dependent variable.³⁷ The baseline specification shows that, in the cross section, contribution rates increase monotonically with age, from about 4.6% at age 25 to 8.5% at age 65. The remaining lines show that contribution rates increase by a similar 4% over the working life when controlling for income in two different ways. First, the coefficient on current log-income deviation from the average implies that each 1% deviation in income from the average is associated with a nearly two percentage point increase in reported contribution rate. Instead, looking across initial income groups, those in the highest income group save nearly 2% more, on average, than those in the lowest income group at every age. The increases over the life cycle, however, are parallel: each group increases its total saving rate by about 3.5% from ages 25 to 65.

The average behavior of investors as they age similarly increases steadily with age but at a faster rate. Figure 11, Panel B, shows the regression coefficients of the realized contribution rate on age-group indicators, including

³⁶ The measure of contribution rates includes only the employee's own saving, not employer contributions.

³⁷ Internet Appendix Tables IA.XIX, IA.XXI, and IA.XXII report the regression results that are plotted in the figures and discussed in this subsection. Internet Appendix Table IA.XX shows cross-sectional results split by cohort and TDF ownership group.

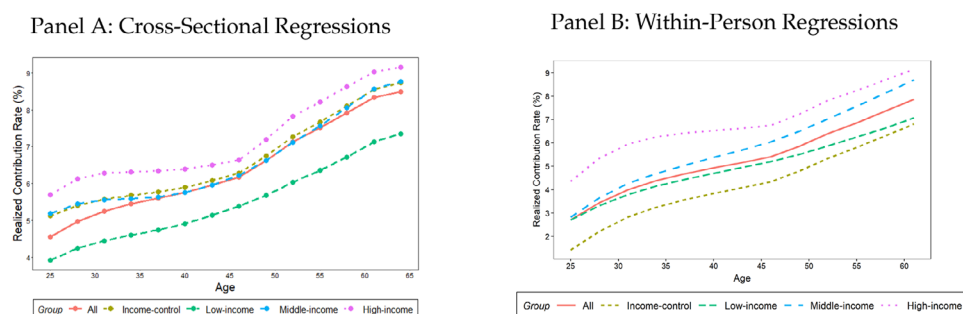


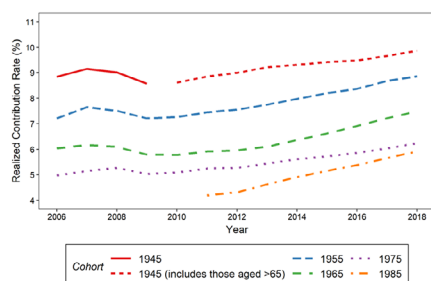
Figure 11. Regression coefficients of the realized contribution rate on age, full sample, and by income terciles. This figure plots the regression coefficients of the realized contribution rate on a set of demographic controls. The realized contribution rate is the percentage of an individual's annual income that has been invested in a retirement account over the previous year, calculated at the end of each calendar year. Panel A shows the coefficients for cross-sectional regressions. The baseline specification, "All," shows the coefficients for the regression of the realized contribution rate on age group dummies. We then add a control for the log of income in the current year, measured as the individual's log deviation from the average income in the RI sample. The other lines show results of the baseline specification for the first (lowest) through third tercile of initial income. Initial income is based on the income observed in the first (or second, if first is not available) year that we observe the individual. Panel B includes person fixed effects. The age-group coefficients are normalized by adding the average fixed effect back to the estimated coefficients. The excluded age group is those aged 64 to 65. The sample comprises our full set of retirement investors (RIs) from 2006 to 2018. (Color figure can be viewed at wileyonlinelibrary.com)

person fixed effects that effectively include cohort effects. In the baseline results, contribution rates increase by just over 5% over the life cycle, an increase of the same magnitude as in the cross-sectional age pattern. We then add a control for log income, which does little to change the age effects or the regression R^2 . These results confirm that when controlling for person fixed effects, income is less important for determining contribution rates and increasing savings rates with age are unlikely to be due to income profiles.

Splitting investors by initial income, all income groups also show a similar life-cycle pattern, although those with higher incomes have higher contribution rates overall. Comparing the highest to lowest income group, we see parallel increases of 4.6% and 5.1% over the working life in average contribution rates. The average contribution rate of the middle initial income group increases by a slightly larger 6.2%. These differences in contribution rates across cohorts relate in part to contribution limits set by the Internal Revenue Service (IRS), as we analyze in the next subsection.

Turning to changes in behavior across cohorts, while younger cohorts contribute less than older cohorts at every age, each cohort contributes roughly the same amount as the previous cohort at the same age (Figures 12, Panels A and B). The one exception is the youngest cohort, which is on a slightly higher saving trajectory than all of the older cohorts. Thus, relative to the portfolio changes characterized in the previous section, contribution rates are relatively stable over time and do not exhibit the differences and gaps in the share of

Panel A: Cohort Realized Contribution Rate by Year



Panel B: Cohort Realized Contribution Rate by Age

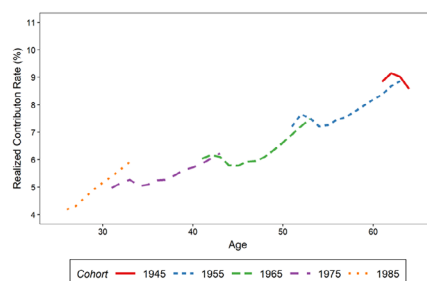
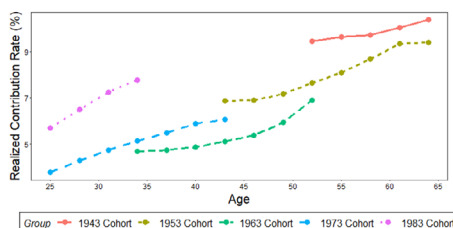


Figure 12. Realized contribution rate by birth cohort. This figure shows the realized contribution rate averaged by birth year cohorts. Panel A shows the averages by year over our sample period. We include only years during which each member of the cohort is aged 25 to 65, unless otherwise indicated. Panel B shows the averages by age, where age is the median age of the cohort. The realized contribution rate is the percentage of an individual's annual income that has been invested in a retirement account over the previous year, calculated at the end of each calendar year. A cohort is defined as having been born in the three-year period centered around the year indicated. The sample comprises our full set of retirement investors (RIs). (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com))

Panel A: By Cohort



Panel B: By TDF Share

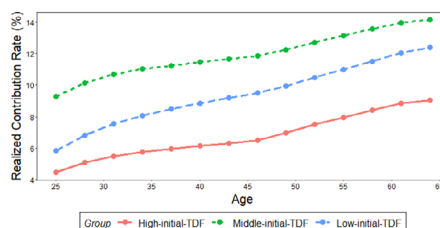


Figure 13. Regression coefficients from within-person regressions of realized contribution rate on age. This figure plots the regression coefficients of annual individual realized contribution rate on a set of demographic controls. The realized contribution rate is the percentage of an individual's annual income that has been invested in a retirement account over the previous year, calculated at the end of each calendar year. Panel A shows the results including age-group controls and a control for log income, broken out by birth cohort groups. A cohort is defined as having been born in the 10-year period beginning with the year indicated. Panel B shows the results for different groups based on the initial share of their portfolio that is invested in target date funds (TDFs). All regressions include person fixed effects. The age-group coefficients are normalized by adding the average fixed effect back to the estimated coefficients. The excluded age group is those aged 64 to 65. The sample comprises our full set of retirement investors (RIs) from 2006 to 2018. (Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com))

investable wealth invested in the stock market that Figure 7, Panel B, shows across cohorts.

As we did for portfolios (in Figure 8), we run regressions that control for income broken out by cohort. Figure 13, Panel A, confirms that each cohort

increases its savings rate with age, but younger cohorts increase their contribution rate at a slightly faster pace than older cohorts. These regressions control for income and are plotted for the average income of all RIs, which (artificially) raises the level of the saving rates of the youngest and oldest cohorts, but allows us to measure how the saving rate increases within each cohort as they age, controlling for income. For example, comparing the 1983 to 1973 cohort, we see that 28 to 30 year-olds born from 1983 to 1992 increase their contribution rate by 0.81%, relative to 25 to 27 year-olds, while 28 to 30 year-olds born from 1973 to 1982 increase their contribution rate by 0.52%. A similar pattern holds when differencing across ages for the other age groups that are common to multiple cohorts. In summary, although older cohorts start at a higher saving rate due to age, the younger cohorts increase their rate slightly faster as they age, even when controlling for income.

Finally, the stable pattern of saving behavior holds regardless of the share of TDFs initially held by the investor, although investors with large initial investments in TDFs increase their saving rates by more than other investors. Figure 13, Panel B, breaks out the within-person results by initial TDF share. Investors with intermediate investments in TDFs have the highest contribution rates. Investors with TDF shares below of 25% increase their contribution rates over their working lives by a large amount, 6.6%, or about 1.5% to 2% more than the 4.9% to 4.6% increase of the two other groups that start with a larger allocation to TDFs.

Thus far, we have limited our discussion of contribution rates to *realized* contribution rates, which is the percentage of income that is actually saved for retirement ex-post (on a year-by-year basis). However, there is a distinction between the realized rate of savings and the designated or *reported* rate of savings that investors decide upon ex-ante. The difference between reported and realized contribution rates is the result of retirement contribution limits set by the IRS.³⁸ Depending on their income and reported contribution rate, some people will hit their maximum contribution before the end of the year, and thus their actual realized contribution will be less than what they designated at the beginning of the year. This may occur if an individual has a very high income, or if they set a very high contribution rate.

We address this discrepancy using two analyses, both of which confirm our main results. First, we condition our analysis on an indicator variable equal to one if an individual hits their (age-dependent) contribution limit in that year. We find that 6% to 9% of our sample with available income data max out their contribution in a given year (Internet Appendix Table IA.XXIII). Our second method of addressing the discrepancy between realized and reported contribution rates is to simply repeat our analysis on the reported contribution rate rather than the realized rate. Each approach largely confirms our results using realized rates, as we show in Internet Appendix III.

³⁸ See <https://www.irs.gov/newsroom/401k-contribution-limit-increases-to-19500-for-2020-catch-up-limit-rises-to-6500>.

B. The Effect of the Pension Protection Act of 2006

Our results so far suggest that the PPA of 2006, which included several provisions designed to encourage savings in retirement funds (Beshears et al., 2010), had only a modest impact on actual retirement saving rates by age or across cohorts of savers.³⁹ In this subsection, we present evidence that the immediate effects of the PPA on retirement saving rates were, if anything, negative.

We replicate the difference-in-difference analysis of Section III.A but compare the retirement saving rates of new enrollees at the same employer in the two years before and after the PPA. Unlike in our analysis of portfolios, we designate anyone enrolled during 2007 to 2008 as a treated investor, regardless of whether their plan's default investment allocation changed, and we estimate equations (2) and (3) with the reported contribution rate as the dependent variable.⁴⁰

First, as shown in column (1) of Table VI, those enrolling at an employer after PPA have lower contribution rates in the two years following enrollment. The effect starts at a large -0.43% of income for age 25 to 35, and becomes increasingly negative with age, reaching -1.2% for those age 55 to 65. The negative sign, magnitude, and pattern are similar when controlling for income (column (2)) and across income groups (columns (3) and (4)). Finally, this decrease in saving is similar for those with no other retirement assets at the institution prior to enrollment, as shown in columns (5) and (6). This result implies that our finding is not driven by those who have some wealth at the institution prior to enrolling in a new plan.

Tracing out the effect over the five years following enrollment, the PPA had only a transitory negative effect on average contribution rates and is largest for the oldest investors. We repeat our analysis tracking investors for five years after they enroll and including interactions of individual indicator variables for each year after treatment with an indicator for being treated by the PPA (enrolled in 2007 or 2008, versus 2005 or 2006). As shown in Table VII, column (1), the PPA has a negative initial effect on contribution rates, but the magnitude decreases over time and is essentially zero five years after treatment. Column (3) shows that the decrease in retirement contribution rates is slightly more persistent for investors with higher (initial) income. Splitting the result by age group, columns (4) to (7) show that the effect is

³⁹ Note that we only look at employee saving, not employer matching, and thus, we do not measure the impact that the PPA may have had on employer matching incentives. It is possible that the PPA had a larger effect on saving levels inclusive of employer matching.

⁴⁰ In our analysis of portfolios equity shares, only those who were enrolled in a plan that changed its default investment to a TDF after the PPA are considered treated. In that case, we measured the effect of TDF default allocation, induced by the PPA on portfolio allocation. In the case of contribution rates, we want to measure the overall impact of the PPA. The PPA had a significant number of provisions intended to increase savings rates, but we are not able to isolate those plan features in our regressions due to data limitations. Hence, we simply designate anyone enrolled in a plan from 2007 to 2008 as a treated investor, regardless of which plan features changed following the PPA.

Table VI
Regressions of Reported Contribution Rate on the Pension Protection Act: Average Effect Two Years after Entering Sample

This table presents regression coefficients of reported contribution rate on a treatment dummy for being enrolled into a plan following the Pension Protection Act (PPA) of 2006. We set this treatment dummy equal to one for those enrolled in their firm's retirement plan in 2007 or 2008 and zero for those enrolled in 2005 or 2006. Columns (1) to (2) show the results for the first two years that we observe the individual in our sample. Columns (3) to (4) repeat column (1) for those in the lowest and highest tercile of initial income, respectively. Columns (5) to (6) repeat columns (1) to (2) including only individuals who had no prior retirement wealth before enrollment and no rollover assets of any kind. The reported contribution rate is the percentage of their income that an individual designates to be allocated into their retirement accounts at the beginning of each calendar year. Log income, when included, is the log deviation of the individual's current income from the average income of the RI sample. The sample is our set of retirement investors (RIs) who enrolled in their plan from 2005 to 2008. Standard errors, in parentheses, are clustered at the household level.

	Reported Contribution Rate					
	(1) All	(2) All	(3) Bottom Income Tercile	(4) Top Income Tercile	(5) No Prior Nonretirement Wealth + No Rollover Assets	(6) No Prior Nonretirement Wealth + No Rollover Assets
Treated	-0.0043 (0.0001)	-0.0034 (0.0001)	-0.0028 (0.0001)	-0.0073 (0.0003)	-0.0042 (0.0001)	-0.0034 (0.0001)
Age 35 to 44	0.0117 (0.0001)	0.0084 (0.0001)	0.0103 (0.0002)	0.0077 (0.0003)	0.0112 (0.0001)	0.0082 (0.0001)
Age 45 to 54	0.0239 (0.0001)	0.0203 (0.0002)	0.0204 (0.0003)	0.0211 (0.0003)	0.0229 (0.0002)	0.0196 (0.0002)
Age 55 to 65	0.0406 (0.0003)	0.0367 (0.0003)	0.0339 (0.0005)	0.0406 (0.0005)	0.0389 (0.0003)	0.0354 (0.0003)
Age 35 to 44 × Treatment	-0.0023 (0.0002)	-0.0026 (0.0002)	-0.0015 (0.0003)	-0.0002 (0.0004)	-0.0021 (0.0002)	-0.0024 (0.0002)
Age 45 to 54 × Treatment	-0.0045 (0.0002)	-0.0047 (0.0002)	-0.0028 (0.0004)	-0.0029 (0.0004)	-0.0038 (0.0002)	-0.0042 (0.0002)
Age 55 to 65 × Treatment	-0.0077 (0.0004)	-0.0083 (0.0004)	-0.0058 (0.0007)	-0.0078 (0.0008)	-0.0067 (0.0004)	-0.0075 (0.0004)

(Continued)

Table VI—Continued

	Reported Contribution Rate					
	(1) All	(2) All	(3) Bottom Income Tercile	(4) Top Income Tercile	(5) No Prior Nonretirement Wealth + No Rollover Assets	(6) No Prior Nonretirement Wealth + No Rollover Assets
Log income		0.0314 (0.0002)				0.0307 (0.0002)
Constant	0.0619 (0.0001)	0.0623 (0.0001)	0.0508 (0.0001)	0.0705 (0.0001)	0.0613 (0.0001)	0.0621 (0.0001)
Firm Fixed Effect?	Y	Y	Y	Y	Y	Y
% of Total Sample	1.9	1.4	0.6	0.4	1.8	1.3
% of Sample Enrolled	27.5	20.3	7.9	6.1	25.9	19.3
2005 to 2008						
R-squared	0.1737	0.1915	0.1718	0.1242	0.1726	0.1888

Table VII
Regressions of Reported Contribution Rate on the Pension Protection Act: Long-Run Effect

This table presents regression coefficients of the reported contribution rate on being treated with the Pension Protection Act (PPA) of 2006. "Year of" refers to the year the individual enrolled in their retirement plan and "x years after" is x years after they enrolled in the plan. Each column includes year dummies for each year after enrollment and interactions of these dummies with the treatment dummy. The treatment dummy is equal to one if the individual enrolled in 2007 or 2008, after the PPA, and zero if they enrolled in 2005 or 2006. The full sample is those enrolled from 2005 to 2008 who otherwise meet the retirement investor (RI) sample criteria. The bottom (top) income tercile includes those whose initial income is in the lowest (highest) tercile. Columns (4) to (7) separate the results for all individuals enrolled from 2005 to 2008 by age at enrollment. The reported contribution rate is the percentage of their income that an individual designates to be allocated into their retirement account at the beginning of each calendar year. Log income, when included, is the log deviation of the individual's current income from the average income of the RI sample. Standard errors, in parentheses, are clustered at the household level.

	Reported Contribution Rate						
	(1) Full Sample	(2) Bottom Income Tercile	(3) Top Income Tercile	(4) Age Enrolled 25 to 34	(5) Age Enrolled 35 to 44	(6) Age Enrolled 45 to 54	(7) Age Enrolled 55 to 65
Year of × Treatment	−0.0085 (0.0002)	−0.0092 (0.0004)	−0.0092 (0.0004)	−0.0069 (0.0003)	−0.0088 (0.0004)	−0.0093 (0.0005)	−0.0127 (0.0009)
1 Year After × Treatment	−0.0116 (0.0001)	−0.0098 (0.0002)	−0.0140 (0.0002)	−0.0087 (0.0001)	−0.0119 (0.0002)	−0.0143 (0.0003)	−0.0167 (0.0006)
2 Years After × Treatment	−0.0072 (0.0001)	−0.0074 (0.0002)	−0.0091 (0.0002)	−0.0055 (0.0001)	−0.0071 (0.0002)	−0.0101 (0.0003)	−0.0124 (0.0005)
3 Years After × Treatment	−0.0026 (0.0001)	−0.0034 (0.0001)	−0.0033 (0.0002)	−0.0014 (0.0001)	−0.0029 (0.0002)	−0.0056 (0.0003)	−0.0071 (0.0005)
4 Years After × Treatment	−0.0012 (0.0001)	−0.0016 (0.0002)	−0.0026 (0.0003)	−0.0007 (0.0001)	−0.0025 (0.0002)	−0.0054 (0.0003)	−0.0072 (0.0006)
5 Years After × Treatment	−0.0003 (0.0001)	0.0001 (0.0002)	−0.0028 (0.0003)	−0.0009 (0.0002)	−0.0023 (0.0002)	−0.0042 (0.0003)	−0.0051 (0.0007)
1 Year After	−0.0041 (0.0002)	−0.0064 (0.0003)	−0.0036 (0.0003)	−0.0062 (0.0002)	−0.0034 (0.0003)	0.0029 (0.0004)	0.0017 (0.0006)
2 Years After	−0.0092 (0.0002)	−0.0093 (0.0003)	−0.0093 (0.0003)	−0.0094 (0.0002)	−0.0114 (0.0003)	−0.0050 (0.0004)	−0.0075 (0.0007)

(Continued)

Table VII—Continued

	(1) Full Sample	Reported Contribution Rate					(7) Age Enrolled 55 to 65
		(2) Bottom Income Tercile	(3) Top Income Tercile	(4) Age Enrolled 25 to 34	(5) Age Enrolled 35 to 44	(6) Age Enrolled 45 to 54	
3 Years After	−0.0126 (0.0002)	−0.0125 (0.0003)	−0.0123 (0.0003)	−0.0116 (0.0002)	−0.0156 (0.0003)	−0.0104 (0.0004)	−0.0142 (0.0007)
4 Years After	−0.0130 (0.0002)	−0.0135 (0.0003)	−0.0117 (0.0004)	−0.0112 (0.0002)	−0.0163 (0.0003)	−0.0113 (0.0004)	−0.0149 (0.0007)
5 Years After	−0.0133 (0.0002)	−0.0145 (0.0003)	−0.0111 (0.0004)	−0.0113 (0.0002)	−0.0170 (0.0003)	−0.0127 (0.0004)	−0.0171 (0.0008)
Log income	0.0424 (0.0002)						
Constant	0.0806 (0.0002)	0.0698 (0.0003)	0.0982 (0.0003)	0.0706 (0.0002)	0.0826 (0.0003)	0.0891 (0.0004)	0.1047 (0.0003)
Firm Fixed Effect?	Y	Y	Y	Y	Y	Y	Y
% of RI Sample	2.5	0.9	0.8	1.3	0.9	0.6	0.2
% of Sample Enrolled 2005 to 2008	35.7	12.7	11.3	18.7	12.6	8.7	2.9
R-squared	0.1509	0.1169	0.0846	0.1367	0.1201	0.1096	0.1423

negative for each age group, and largest in magnitude and most persistent for the older age groups. For example, those aged 55 to 65 when enrolling after PPA have contribution rates that are 1.3% lower than those enrolling before PPA during the year they enroll, a difference that declines to 0.5% after five years. In contrast, those aged 25 to 34 enrolling after PPA contributed only -0.7% less of their income the year of enrollment and -0.1% five years after enrollment relative to those that enrolled just before PPA.

It is possible that the interaction terms are picking up some of the differences in year fixed effects and that saving rates are lower for the treatment group due to the timing of the financial crisis. However, Internet Appendix Table [IA.XXIV](#) shows that the results are similar if we include only those enrolled in 2007, rather than 2007 to 2008. This result alleviates some concern about possible spurious effects on saving rates due to the financial crisis, as those enrolled in 2007 had at least one full year to contribute and invest (compared to two to three full years for the control group) prior to the start of the financial crisis. Moreover, the income control in column (1) indicates that the results hold even for those who did not experience significant changes in income due to the financial crisis.

Figure [14](#) shows the predicted contribution rates for those in the youngest and oldest age groups, split out by those in the lowest and highest income terciles.⁴¹ Looking first at those aged 25 to 34 in Figure [14](#), Panel A, the PPA decreased contribution rates significantly for both income groups, initially by about 0.7 to 0.9 percentage points.⁴² However, the difference between the treated and control groups converges to zero over time.

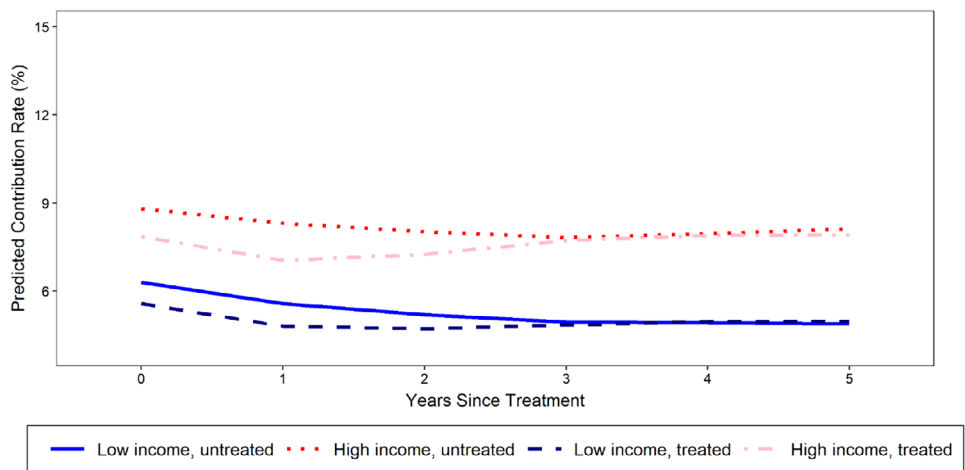
For those enrolled when aged 55 to 65, investors with lower incomes are more affected by the PPA, as shown in Figure [14](#), Panel B. The treated group with high incomes decreases their contribution rate by about 0.7 percentage points following treatment. For the lower-income group, the immediate effect is larger, at 1.3 percentage points. For both income groups, the difference between treated and control after five years is nearly zero.

As in the analysis of asset allocations, we only observe individuals who are enrolled in a retirement plan, and the provisions of the PPA may have changed who enrolled, so that the same caveats that we discussed in Section [III.A](#) apply to this analysis. In particular, the concern is that our controls, including income, may not fully account for the fact that households pushed into participating post-PPA may be those who would be inclined to save less once participating.

⁴¹ These are estimated by repeating columns (4) and (7) from Table [VII](#) on the income subsamples.

⁴² The reason that both the treatment and the control groups decrease their contribution rate over the five-year period following enrollment is that the five-year period that we analyze happens to occur during the Great Recession and its aftermath. This pattern is consistent with the fact that contribution rates increase with age (Internet Appendix Table [IA.XXV](#) (cross section) and [IA.XXVI](#) (within-person)) and at the same time contribution rates decreased uniformly across birth cohorts from 2007 to 2009 (Internet Appendix Figure [IA.10](#)).

Panel A: Age Enrolled 25–34



Panel B: Age Enrolled 55–65

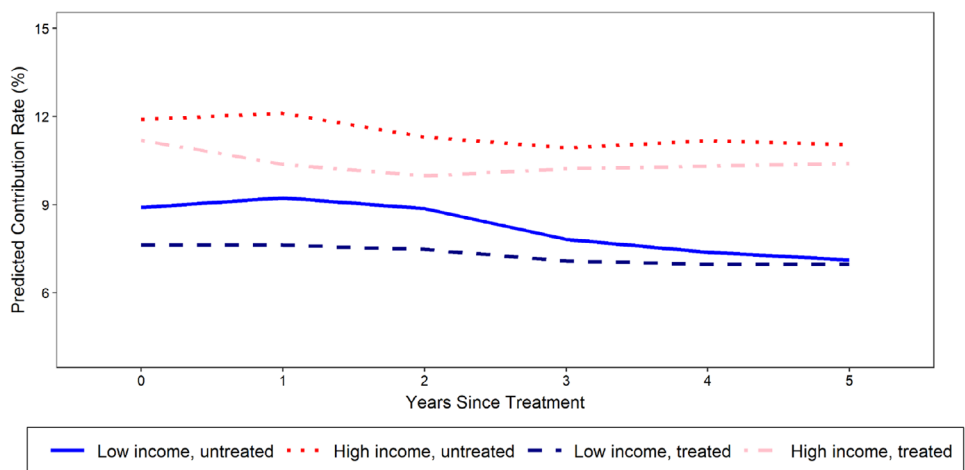


Figure 14. Predicted contribution rate: Pension Protection Act. This figure shows the predicted contribution rate for those treated by the Pension Protection Act of 2006 and those not treated by the Act, split out by age and income groups. Panel A shows the results for those aged 25 to 34 when enrolled. Panel B shows the results for those aged 55 to 65 when enrolled. The reported contribution rate is the percentage of income that an individual designates to be allocated into their retirement accounts at the beginning of each calendar year. The sample comprises our set of retirement investors (RIs) who were enrolled between 2005 and 2008. (Color figure can be viewed at wileyonlinelibrary.com)

V. Conclusion

The results in this paper show that the portfolios of middle and upper-middle class investors with retirement saving in the United States have changed significantly over the last few decades. Investors have increased the share of their investable wealth that they hold in the stock market relative to the 1990s, and they now reduce the share of their portfolio invested in the stock market as they age, when they used to maintain a relatively constant share as they aged. These two changes followed the PPA of 2006, which gave favorable regulatory treatment to the relatively new retirement saving product, the TDF, and were implemented by investors largely through adoption of TDFs. We show that the adoption of TDFs as default investments in employer-sponsored retirement plans has a causal effect on portfolios in the direction of the observed changes in portfolio holdings and rebalancing for workers over the life cycle, particularly those with lower incomes. These causal effects decline significantly over the following five years, however, as individuals in the control group who are not defaulted into TDF start catching up to the treatment group. These patterns suggest that the relative effect of being defaulted into a TDF decayed because TDFs were taken up by other employees, even those that were not subject to the default allocation, potentially due to word of mouth from other employees or because financial advisors felt encouraged to recommend TDFs or the asset allocation underlying these funds.

Did the PPA and the rise of TDFs fundamentally change investor behavior, or would investors have adopted the hump-shaped allocation to risky assets over the life cycle even without the change in regulations? On the one hand, greater dissemination of prescriptive, model-based portfolio advice and a recognition of the equity premium might have led to this shift in investor behavior even absent the PPA. On the other hand, by permitting TDFs as default investment options, the Act appears to have been a critical catalyst in making higher equity allocations acceptable advice for retail investor portfolios. The timing of the effect and initial concentration in employers after they switched to TDFs as defaults is certainly consistent with this second interpretation. In addition, the PPA seems to have led the investment advice industry (many of whom, like retirement plan sponsors, have a fiduciary duty to their investors) to recommend TDF-like investment strategies more broadly. As we show, investors did not reverse the default allocations but rather moved even their active portfolio decisions in the direction of the allocation implied by the TDF glide path. In either case, the adoption of TDFs has quantitatively important implications for retirement preparedness, for who bears macroeconomic risks, and may even have contributed to greater stability in asset-class returns through automatic contrarian rebalancing, as suggested in Parker, Schoar, and Sun (2023).

Finally, we show that the life-cycle pattern of retirement contribution rates has been relatively stable across cohorts, with the exception of the youngest cohort, suggesting that the changes in the design of retirement saving plans permitted under PPA had little effect on retirement contribution rates for most of the population relative to the effects on portfolio choices.

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REFERENCES

- Ameriks, John, Andrew Caplin, Minjoon Lee, Matthew D. Shapiro, and Christopher Tonetti, 2015, The wealth of wealthholders, NBER Working Paper 20972.
- Ameriks, John, Gábor Kézdi, Minjoon Lee, and Matthew D. Shapiro, 2019, Heterogeneity in expectations, risk tolerance, and household stock shares: The attenuation puzzle, *Journal of Business and Economic Statistics* 33, 633–646.
- Ameriks, John, and Stephen Zeldes, 2004, How do household portfolio shares vary with age, Technical Report.
- Benzoni, Luca, Perre Collin-Dufrense, and Robert S. Goldstein, 2007, Portfolio choice over the life-cycle when the stock and labor markets are cointegrated, *Journal of Finance* 62, 2123–2167.
- Beshears, John, James Choi, David Laibson, Brigitte C. Madrian, and Brian Weller, 2010, *Public Policy and Saving for Retirement: The Autosave Features of the Pension Protection Act of 2006* (Harvard University Press, Cambridge).
- Beshears, John, James Choi, David Laibson, and Peter Maxted, 2022, Present bias causes and then dissipates auto-enrollment savings effects, *AEA Papers and Proceedings* 112, 136–141.
- Bricker, Jesse, Alice Henriques, Jacob Krimmel, and John Sabelhaus, 2016, Measuring income and wealth at the top using administrative and survey data, *Brookings Papers on Economic Activity* 1, 261–331.
- Campbell, John Y., 2016, Restoring rational choice: The challenge of consumer financial regulation, *American Economic Review: Papers & Proceedings* 106, 1–30.
- Campbell, John Y., and Luis M. Viceira, 2002, *Strategic Asset Allocation* (Oxford University Press, Oxford).
- Carroll, Christopher, 2000, Portfolios of the rich, NBER Working Paper 7826.
- Choi, James, David Laibson, Brigitte Madrian, Andrew Metrick, and David A. Wise, 2004, For better or for worse: Default effects and 401(k) savings behavior, in *Perspectives on the Economics of Aging* (University of Chicago Press, IL).
- Choukhmane, Taha, 2021, Default options and retirement saving dynamics, Working paper, MIT 6134-20.
- Christelis, Dimitris, Dimitris Georgarakos, and Michael Haliassos, 2013, Differences in portfolios across countries: Economic environment versus household characteristics, *Review of Economics and Statistics* 95, 220–236.
- Curcuru, Stephanie, John Heaton, Deborah Lucas, and Damien Moore, 2010, Heterogeneity and portfolio choice: Theory and evidence, in Yacine Ait-Sahalia, and Lars Peter Hansen, eds.: *Handbook of Financial Econometrics: Tools and Techniques* (North-Holland, London).
- Duarte, Victor, Julia Fonseca, Aaron Goodman, and Jonathan A. Parker, 2021, Simple allocation rules and optimal portfolio choice over the lifecycle, NBER Working Paper w29559.
- Fagereng, Andreas, Charles Gottlieb, and Luigi Guiso, 2017, Asset market participation and portfolio choice over the life-cycle, *Journal of Finance* 72, 705–750.
- Giglio, Stefano, Matteo Maggiori, Johannes Stroebel, and Stephen Utkus, 2021, Five facts about beliefs and portfolios, *American Economic Review* 111, 1481–1522.
- Gomes, Francisco, Kenton Hoyem, Wei-Yin Hu, and Enrichetta Ravina, 2018, Retirement savings adequacy in U.S. defined contribution plans, Working paper 2022-40.
- Gomes, Francisco, Alexander Michaelides, and Yuxin Zhang, 2020, Tactical target date funds, *Management Science* 68, 3047–3070.

- Gomes, Francisco, and Oksana Smirnova, 2021, Stock market participation and portfolio shares over the life-cycle, Working paper 3808350.
- Gourinchas, Pierre-Olivier, and Jonathan A. Parker, 2002, Consumption over the lifecycle, *Econometrica* 70, 47–89.
- Guiso, Luigi, Michael Haliassos, and Tullio Jappelli, 2003a, Household stockholding in Europe: Where do we stand and where do we go?, *Economic Policy* 18, 123–170.
- Guiso, Luigi, Michael Haliassos, and Tullio Jappelli, 2003b, Stockholding: A European comparison, in Luigi Guiso, Michael Haliassos, and Tullio Jappelli, eds., *Stockholding in Europe* (Palgrave Macmillans, Palgrave Macmillans).
- Heaton, John, and Deborah Lucas, 2000, Portfolio choice and asset prices: The importance of entrepreneurial risk, *Journal of Finance* 55, 1163–1198.
- Lusardi, Annamaria, and Olivia S. Mitchell, 2007, Baby boomer retirement security: The roles of planning, financial literacy, and housing wealth, *Journal of Monetary Economics* 54, 205–224.
- Madrian, Brigitte C., and Dennis F. Shea, 2001, The power of suggestion: Inertia in 401(k) participation and savings behavior, *Quarterly Journal of Economics* 116, 1149–1187.
- Malmendier, Ulrike, and Stefan Nagel, 2011, Depression babies: Do macroeconomic experiences affect risk taking?, *Quarterly Journal of Economics* 126, 373–416.
- McDonald, Robert L., David P. Richardson, and Thomas A. Rietz, 2019, The effect of default target date funds on retirement savings allocations, TIAA Institute, Research Dialog No. 150.
- McKenzie, David J., 2006, Disentangling age, cohort and time effects in the additive model, *Oxford Bulletin of Economics and Statistics* 68, 473–495.
- Meeuwis, Maarten, 2019, Wealth fluctuations and risk preferences: Evidence from U.S. investor portfolios, Working Paper 3653324.
- Meeuwis, Maarten, Jonathan A. Parker, Antoinette Schoar, and Duncan Simester, 2022, Belief disagreement and portfolio choice, *Journal of Finance* 77, 3191–3247.
- Merton, Robert C., 1969, Lifetime portfolio selection under uncertainty: The continuous-time case, *Review of Economics and Statistics* 51, 247–257.
- Mitchell, Olivia S., and Stephen P. Utkus, 2022, Target-date funds and portfolio choice in 401(k) plans, *Journal of Pension Economics and Finance* 21, 519–536.
- Parker, Jonathan A., Antoinette Schoar, and Yang Sun, 2023, Retail financial innovation and stock market dynamics: The case of target date funds, *Journal of Finance* 78, 2673–2723.
- Parker, Jonathan A., and Yang Sun, 2023, Target date funds as asset market stabilizers: Evidence from the pandemic, *Journal of Pension Economics and Finance* First View, 1–26.
- Poterba, James, Steven Venti, and David Wise, 2011, The composition and drawdown of wealth in retirement, *Journal of Economic Perspectives* 25, 95–118.
- Poterba, James M., 2014, Retirement security in an aging population, *American Economic Review* 104, 1–30.
- Poterba, James M., and Andrew A. Samwick, 2001, Household portfolio allocation over the life cycle, in Seiritsu Ogura, Toshiaki Tachibanaki, and David A. Wise, eds.: *Aging Issues in the United States and Japan*, 65–104 (University of Chicago Press, Chicago, IL).
- Samuelson, Paul, 1969, Lifetime portfolio selection by dynamic stochastic programming, *Review of Economics and Statistics* 51, 239–246.
- Karl Scholz, John, Ananth Seshadri, and Surachai Khitatrakun, 2006, Are Americans saving “optimally” for retirement?, *Journal of Political Economy* 114, 607–643.
- Storesletten, Kjetil, Chris Telmer, and Amir Yaron, 2007, Asset pricing with idiosyncratic risk and overlapping generations, *Review of Economic Dynamics* 10, 519–548.
- Viceira, Luis M., 2001, Optimal portfolio choice for long-horizon investors with nontradable labor income, *Journal of Finance* 56, 433–470.
- Wachter, Jessica, 2010, Asset allocation, *Annual Reviews of Financial Economics* 2, 175–206.
- Wachter, Jessica A., and Motohiro Yogo, 2010, Why do household portfolio shares rise in wealth?, *Review of Financial Studies* 23, 3929–3965.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.
Replication code.

