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Target Date Funds and Portfolio Choice
in 401(k) Plans

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Target Date Funds and Portfolio Choice in 401(k) Plans

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Abstract

Target date funds in corporate retirement plans grew from \$5B in 2000 to \$734B in 2018, partly because federal regulation sanctioned these as default investments in automatic enrollment plans. We show that adopters delegated pension investment decisions to fund managers selected by plan sponsors. Including these funds in retirement saving menus raised equity shares, boosted bond exposures, curtailed cash/company stock holdings, and reduced idiosyncratic risk. The adoption of low-cost target date funds may enhance retirement wealth by as much as 50 percent over a 30-year horizon.

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Target Date Funds and Portfolio Choice in 401(k) Plans

Although plan sponsors are legally responsible for selecting and overseeing investment options in a 401(k) plan, employees have traditionally borne the responsibility for making their own portfolio construction decisions.¹ Indeed, 401(k) plans have anecdotally been described as requiring workers to become their own portfolio managers. One concern with this state of affairs has been that, due to financial illiteracy or behavioral biases, many participants appear to be ill-equipped to make these portfolio decisions, potentially undermining old-age retirement security.²

This paper illustrates how the introduction of target date funds (TDFs) into 401(k) plans has fundamentally altered this decision-making dynamic. A TDF menu consists of a series of fund offerings with portfolio allocations described in terms of an expected year of retirement; usually offered in five-year increments (e.g., a 2015, 2020, etc., fund), a TDF series may include up to a dozen funds. Participants in voluntary choice plans must make active investment decisions among target date and other fund offerings; participants in automatic enrollment plans are initially defaulted into a single TDF based on the employee's current age and assumed retirement date (usually age 65), with the option to move subsequently to other investments. TDF assets in 401(k) plans have grown dramatically over time: from \$5 billion in 2000 to \$734 billion in 2018 (ICI, 2019). This growth was spurred in part by a Department of Labor regulation issued under the 2006 Pension Protection Act designating TDFs as an eligible default investment option for automatic enrollment plans.³ By 2018, 80 percent of 401(k) plans offered these funds (ICI, 2019), and two-

¹ Here we use the term 401(k) plans to refer broadly to private-sector defined contribution plans which can include profit-sharing, money purchase, and 403(b) plans along with 401(k) plans.

² Research on the role of financial illiteracy or behavioral biases in investing and savings decisions includes Bekaert, Hoyem, Hu, and Ravina (2017); Benartzi and Thaler (2001, 2002); Beshears, Choi, Laibson and Madrian (2018); Goda, Levy, Manchester, Sojourner and Tasoff (2019); Lusardi and Mitchell (2007, 2011, 2104); Mitchell and Lusardi (2011); Mottola and Utkus (2008); and van Rooij, Lusardi, and Alessie (2011).

³ The Department of Labor regulations were effective December 24, 2007. 72 Fed. Reg. 60451. Eligible "qualified default investment alternatives" (QDIAs) include TDFs, traditional balanced funds, and managed account advice

thirds of 401(k) new plan entrants were automatically enrolled, with target funds the dominant choice for default investments by plan sponsors (Vanguard, 2019). This greater U.S. reliance on automatic enrollment and default portfolio choice is consistent with the global move toward default portfolio choice in defined contribution systems (OECD, 2015).

Compared to other multi-asset class portfolios, such as traditional balanced funds or risk-based lifecycle funds, TDFs offer two unique advice-related features. First, each fund is identified with an anticipated retirement year, which serves as an implicit recommendation regarding which types of investors should hold each fund. When investors must make their own portfolio choices, the date labeling transforms a potentially complex decision about how to assemble a portfolio with the available funds on the menu into a simpler decision heuristic, namely portfolio allocation based on an anticipated retirement date. Second, target date risk levels are automatically rebalanced over time by a fund manager who follows an “equity glide path,” reducing risk as participants near their target dates. Prior to the advent of TDFs, no investment fund provided age-related rebalancing in 401(k) plans.⁴

This paper evaluates how the introduction of TDFs into 401(k) investment menus reshapes portfolio choice decisions by participants, drawing on an anonymized, restricted-access longitudinal dataset from Vanguard, a major 401(k) plan administrator and investment manager. The TDFs in our sample are almost exclusively indexed portfolios, diversified across global equity and fixed asset classes, with management fees of below 20 basis points. As of 2020, indexed strategies were the dominant target data strategy in the marketplace, representing just over half of

services. QDIA regulations provide sponsors so-called 404(c) protection for participant portfolio choices, meaning there is a presumption that employers are not liable for participant portfolio decisions when participants hold QDIAs. The sponsor retains liability for selecting and monitoring the QDIA itself.

⁴ A declining equity share with age is based on arguments about labor income (e.g., Viceira, 2001; Campbell and Viceira, 2002; Cocco, Gomes, and Maenhout, 2005) but has also been criticized as sub-optimal (e.g., Basu, Byrne and Drew, 2011).

all target data industry assets.⁵ As a result, our dataset represents a real-world benchmark for the provision of low-cost, highly diversified professional portfolio advice to an important group of nonprofessional investors.

Our approach is to estimate participant adoption and portfolio exposures one year after the first appearance of the funds in a 401(k) investment menu; that is, we measure their early impact. In terms of behavioral effects, we estimate that 28.4 percent of new entrants into voluntary enrollment plans adopted TDFs as part of their portfolios, whereas only 10.2 percent of existing employees (workers in the plan prior to the funds' appearance) switched from existing investments to the funds. This difference we describe as an *active choice effect*, reflecting the fact that new entrants in voluntary enrollment plans had to make an active choice to join the 401(k) plan, whereas existing employees faced a discretionary choice of whether to switch to new options.

In contrast, in plans with new-hire automatic enrollment, 78.7 percent of new entrants adopted TDFs, representing a substantial *default effect*. In addition, 21.7 percent of existing employees in these plans invested in the funds, double the rate of existing employees in voluntary choice plans. We take this latter result as a *default-related endorsement effect*: the employer's selection of TDFs as a default investment for new hires influenced existing employees' willingness to switch to the funds. Similar effects are observed for other measures, such as the propensity to be a *pure target date investor* (investing all of one's savings in a single TDF) or a *mixed target date investor* (combining a TDF with other options).

⁵ According to Morningstar (2021), total indexed target date assets amounted to \$1.5 trillion among the top 10 providers in 2020, in both mutual fund and collective trust format, versus total target date assets of \$2.8 trillion. As noted by Balduzzi and Reuter (2019), the industry is characterized by a wide level of heterogeneity in investment approaches. We would anticipate therefore that our results using Vanguard funds will be relevant to participants offered by other index-based providers, though results could differ for people offered higher-cost active strategies. The direction of the difference is unclear, with some participants dissuaded by higher fees and others attracted by active management.

In terms of portfolio effects, adoption of TDFs had sizeable effects on equity share and risk factor exposures. Equity share rose an average of 24 percentage points for pure investors, and by 13 percentage points for mixed investors, both relative to non-target date investors. Pure and mixed target date investors' equity share also declined with age, whereas non-target date investors had a hump-shaped equity share by age. As a result of increased equity and bond market exposures, expected factor returns for pure investors rose by 2.3 percent per year and for mixed investors by 1.7 percent per year, relative to non-target date investors. Holdings were reduced in cash and company stock and, in our sample of indexed TDFs, uncompensated idiosyncratic risk fell.

The use of TDFs signals an important shift away from participants' own-portfolio choice in 401(k) plans to the delegation of critical portfolio decisions by workers to the target date manager selected by the employer. This change has potentially sizeable benefits. We estimate that, for a pure investor in a low-cost target date series, higher returns would raise expected retirement wealth by as much as 50 percent over a 30-year savings horizon.⁶ Given employer and participant selection effects – in particular employers may have introduced the funds in response to concerns over the quality of participant portfolio construction -- we cannot assert that these results are the causal 'treatment effects' of target date lifecycle advice. Yet it is also true that adopters of the funds could have made these changes on their own, and realize these potential benefits – but they chose not to until the arrival of TDFs. Finally, these findings underscore the potential benefits that the provision of scalable low-cost investment advice might offer to other groups of nonprofessional investors.⁷

⁶⁶ Higher exposure to equities also raises wealth volatility, most notably among participants at younger ages. Whether higher expected wealth is ultimately welfare-improving will depend upon a specification of participant's utility function over the lifecycle; this exercise is beyond the scope of this paper.

⁷ For example, besides providing the risk-taking and diversification benefits noted here for target-date funds, low-cost investment advice could potentially reduce heterogeneity of returns and wealth differences among households (Campbell, Ramadorai and Ranish, 2019) or address concerns about bias among traditional commission-based advisers (Inderst and Ottaviani, 2012).

Our paper is related to an extensive literature examining how default arrangements influence employee savings and investment decisions.⁸ A related body of research has asked whether individual portfolio choice is influenced by investment illiteracy or behavioral biases.⁹ Our research is linked to those studies as well as analyses showing that retirement investment menus can shape, or “frame,” portfolio allocation patterns due to inertia or naïveté,¹⁰ or in reaction to excessive complexity (also known as “choice overload”).¹¹ As target-date funds have increased their presence in 401(k) plans, there is also an emerging body of work on their differing strategies, relative performance, and equilibrium effects on stock and bond prices.¹² Our contribution is to show how introducing TDFs into the 401(k) investment set substantially altered portfolio outcomes across a diverse set of firms in voluntary choice and automatic enrollment settings.

In what follows, we describe how plan choice architecture shaped participant portfolio outcomes. We then turn to an empirical analysis of adoption behavior and the change in portfolio composition. We conclude with a discussion of implications of our findings for household finance and for the potential benefits that scalable, low-cost investment advice can provide.

401(k) Choice Architecture and Participant Portfolio Choice

⁸ On the savings side, see Carroll, Choi, Laibson, Madrian, and Metrick (2009); Choi, Laibson, and Madrian (2004); Choi, Laibson, Madrian, and Metrick (2003, 2004, 2006); Clark and Young (2018); and Madrian and Shea (2001). On portfolio allocation, see Agnew, Balduzzi and Sunden (2003); Ameriks and Zeldes (2004); Benartzi (2001); Benartzi and Thaler (2001, 2002); Benartzi, Peleg and Thaler (2007); Calvet, Campbell, and Sodini (2009); Mitchell, Mottola, Utkus and Yamaguchi (2006a, 2006b); and O’Donoghue and Rabin (1999; 2001).

⁹ See Barber and Odean (2001); Bekaert, Hoyem, Hu, and Ravina (2017); Benartzi and Thaler (2001, 2002); Beshears, Choi, Laibson and Madrian (2018); Goda, Levy, Manchester, Sojourner and Tasoff (2019); Lusardi and Mitchell (2007, 2011, 2014); Mottola and Utkus (2008); and Mitchell and Lusardi (2011); and van Rooij, Lusardi, and Alessie (2011).

¹⁰ Examples include Agnew and Szykman (2005); Elton, Gruber and Blake (2007); Huberman and Jiang (2006); Brown, Liang and Weisbenner (2007); McDonald, Richardson† and Rietz (2019); Thaler and Sunstein (2008); Tang, Mitchell, Mottola, and Utkus (2010); and Pool, Sialm and Stefanescu (2016).

¹¹ See for example Iyengar, Huberman, and Jiang (2004); and Iyengar and Kamenica (2010).

¹² Balduzzi and Reuter (2019), Brown and Davies (2020), Massa, Moussawi and Simonov (2020), Parker, Schoar and Sun (2020), and Shoven and Walton (2020).

Our analysis draws on administrative records for 880 defined contribution plans that introduced TDFs between January 2003 and June 2015 (a period of 12.5 years or 150 months). These data were provided by Vanguard, a leading US 401(k) recordkeeper, on an anonymous, restricted-access basis. All TDFs in the sample offered were Vanguard-managed. Table 1 illustrates how the TDFs relate to their target maturity dates, and it also indicates how each fund utilizes a different mix of passively-managed U.S. equity (including large-, mid- and small-capitalization stocks), international equity (both developed and emerging markets), and high-quality domestic bonds.¹³ For instance, total equity exposure in the funds for young participants (the third column in Table 1) averaged 90 percent (in the 2040 through 2055 Funds), versus 30 percent for participants in the Income Fund (intended for retirees).¹⁴

Table 1 here

To analyze TDF portfolio choice, we selected a research sample of over 1.2 million active participants from the 880 plans introducing TDFs between January 2003 and June 2015.¹⁵ Both adoption and portfolio composition statistics were gathered for each plan 12 months following the first appearance of TDFs in the investment menu. Plan participants in the firm prior to the adoption of TDFs and still in the plan one year later were classified as *existing participants*; those entering

¹³ In February 2013 the funds added an allocation of international bonds. We illustrate the allocations at the end of 2010 because they were typical of the period we study.

¹⁴ The Vanguard funds are all indexed except for holdings of inflation-indexed bonds which were available to only a small fraction of retired participant portfolios; accordingly we refer to the funds as indexed. Fees for the funds were below 0.20% during the 2003-15 period (at the end of our analysis period, even lower-cost versions of the TDFs were introduced in a handful of large plans). During 2010, a number of TDFs offered by other investment managers were introduced into the sample, but these accounted for under 1% of sample participants.

¹⁵ Active 401(k) participants are those who are currently contributing to their employer's retirement plan. We only include plans for which we observe plan and participant records both prior to and subsequent to the introduction of the TDFs. Plans transferring to the Vanguard recordkeeping service for the first time during our sample period and adopting TDFs at that point are excluded from our sample because we cannot observe plan holdings prior to the funds' introduction.

the plan after the TDF introduction date and still in the plan at the 12-month window were classified as *new entrants*.

This distinction is important for understanding portfolio choice decisions. When TDFs first arrive in the menu, existing participants must decide whether they would switch their portfolio allocations from funds previously selected. Factors influencing their decisions could include the appeal of the key features of TDFs, namely their labeling as a form of investment advice and their automatic age-based rebalancing feature. Behavioral elements, such as inertia and procrastination, as well as an endowment effect (whereby funds already owned may appear to be more valuable than those not yet owned), may hinder adoption. By contrast, new entrants are likely to be more strongly influenced by a plan's choice architecture. In voluntary choice plans, new entrants making investment decisions must possess some degree of financial literacy to navigate through the entire plan investment menu, compare TDFs relative to other options, and construct their portfolios on their own. Auto-enrolled new entrants, by contrast, are directly invested in a single target date. Their choice is to take no action and remain in the single TDF assigned to them, or undertake a decision to switch to some another portfolio with other characteristics.

Table 2 illustrates how the data can be grouped by plan and individual characteristics, using period average statistics.¹⁶ Two key (0,1) variables indicate the plan choice architecture shaping participant choices: *TDFDefault*, indicating that the target date series was designated as the plan's default option; and *New-hire auto enrollment*, indicating that the plan automatically enrolled new hires, regardless of the type of default fund used by the plan.¹⁷ The first column in Panel A reveals

¹⁶ Our statistics are averages over the period for plan-specific 12-month windows, not end-of-period characteristics. Appendix Table 1 provides more detail on TDF patterns by year.

¹⁷ Under new-hire automatic enrollment, newly eligible participants have contributions deducted automatically from their first eligible pay (with the right to opt out); their contributions are invested in the plan's designated default fund. Our automatic enrollment indicator is for new hires only. Some employers have "swept" (i.e., automatically enrolled) existing eligible non-participants, because our dataset does not include an indicator for such "sweeps." Accordingly our estimates should be viewed as lower bounds.

that 52 percent of participants were in plans where TDFs were the plan default.¹⁸ One-third (32.9 percent) of participants were in plans where new hires were automatically enrolled in the firm's plan, regardless of the type of default fund used. Panel A also indicates that 24.7 percent of participants became target date investors with the advent of the new funds on the menu.¹⁹ Two-thirds of these (15.7 percent) were pure target date investors, contributing only to one TDF, while the remaining one-third (9 percent) were mixed investors, combined a TDF with other funds. The right side of Table 2 reports the percentage of pure, mixed, and non-target date investors having the plan features indicated. For instance, 72.1 percent of pure investors were in plans where the TDFs were the default, and 49.5 percent of pure investors were in plans where new hires were auto-enrolled. By contrast, fewer participants holding mixed portfolios (64.9 percent) and only 46.3 percent of non-TDF investors were in plans where TDFs were the default. As also noted, plan menus averaged 25.6 funds in size, 48.4 percent of participants were offered employer stock as an investment option, and most employees (88.4 percent) had access to plan loans.

Table 2 here

Turning to Panel B of Table 2, we see that 19.7 percent of participants were new entrants who joined their plans after TDF introduction, within the 12-month observation period.^{20,21} Other participant information included 401(k) account balances and contribution patterns, plan investments, and participant characteristics such as age, sex, household income, job tenure, and

¹⁸ A plan may designate a fund as a default for several purposes, including automatic enrollment or as a fund for depositing administrative corrections.

¹⁹ Consistent with prior studies of participant investment behavior, we measure portfolio allocations using contribution designations rather than existing portfolio holdings, as the former better reflect forward-looking intentions.

²⁰ Not all new entrants are new hires: while most plans do allow new hires to become immediately eligible to contribute, a few impose a 6- or 12-month waiting period.

²¹ The mean new entrant enrolled in his or her 401(k) plan after 5.8 months and the median after 6 months, while 94% of new entrants enrolled by month 11. In other words, most new entrants had a month or more to revisit initial investment decisions, particularly new entrants automatically enrolled into TDFs.

non-retirement financial wealth.²² In terms of target date investor patterns, it is clear that pure target date investors were younger and more likely to be female, had lower or moderate incomes, and held smaller account balances (second column, Table 2). Mixed TDF investors had the opposite characteristics and above-average balances (third column). Because the panel spanned by our data included the 2008-9 financial crisis period, we also include a variable indicating whether the 12-month plan window occurred during that period.

Adoption of Target Date Funds

To assess the distinct impacts of default versus active choice on participants' portfolio selection, we estimate three multivariate models of TDF adoption. Each model relates a distinct measure of target date adoption to default, participant, plan, and other factors, as in equation (1):

$$TDFAdoption_{i,j,t} = \alpha DEFAULT_{j,t} + \beta PLAN_{j,t} + \gamma PARTICIPANT_{i,t} + v_j + \tau_t + w_j + \varepsilon_{i,j,t} \quad (1)$$

Here $TDFAdoption_{i,j,t}$ indicates whether employee i adopted a TDF in plan j in month t , measured using total contributions to the TDF (from both the employee and employer). Model A examines the extensive margin of target date adoption by estimating a Probit specification. Here the dependent variable takes a value of 1 if the participant had contributed to a TDF a year after the introduction of TDFs in the plan menu (0 otherwise). The mean value of this time-weighted adoption rate was 24.7 percent over the 2003-15 period. Model B measures the intensive margin of adoption, where the dependent variable in the OLS equation is the fraction of the employees' contributions directed to the TDF; the mean time-weighted value for our sample was 18.9 percent

²² Household income and non-retirement wealth were provided to Vanguard by Acxiom; amounts are imputed using zip code (zip+4) averages.

(which includes non-target date investors).²³ Model C uses a multinomial Logit framework where the dependent variable is equal to zero if the participant was a non-target date investor (the reference category); 1 if the participant was a “mixed” TDF investor (directing 1-99 percent of contributions to one or more TDFs); or 2 if the participant was a “pure” TDF investor (directing all contributions to a single TDF). In Model C, the mean time-weighted proportion of pure investors was 15.7 percent, and of mixed investors, 9.0 percent.

All three models use the dataset summarized in Table 2 which includes all active participants in the 401(k) sample: a single monthly observation is available for each participant 12 months following the first appearance of TDF in the plan menu. Explanatory variables in equation (1) include attributes of the plan default architecture, *DEFAULT*, discussed above, plus a *PLAN* vector of other characteristics such as the size of the plan menu, the availability of plan loans, and a comprehensive set of participant characteristics, *PARTICIPANT*, including age, sex, income, 401(k) account wealth, and a measure of non-retirement-account financial wealth.²⁴

Rather than elaborate on each estimated coefficient separately (all are reported in Appendix Table 2), Table 3 uses these estimates to derive marginal effects for existing employees and new entrants under both voluntary choice and automatic enrollment architectures, holding all other explanatory variables at their sample means. The overall probability of adopting TDFs after one year averaged 24.7 percent. In voluntary enrollment plans, 10.2 percent of existing employees adopted these funds, versus a new entrant adoption rate nearly three times as large (28.4 percent). This sizeable difference is due to the fact that new plan entrants needed to make active choices in voluntary enrollment plans: they had to actively select investments to enroll in the plan, versus

²³ This figure includes both those holding TDFs and those with zero holdings.

²⁴ The models also control for plan-level heteroskedasticity by clustering standard errors at the plan level (v_j), time fixed effects (τ_t), and industry fixed effects, along with missing data dummies. All models also include a financial crisis control, defined here as the period September 2008-June 2009.

existing employees who had already enrolled and only needed to decide to make the switch to the new funds.

Within automatic enrollment plans, 21.7 percent of existing employees adopted the funds, and 78.7 percent of auto-enrolled new entrants. The former result we interpret as due to the endorsement effect, whereby the employer's decision to choose the TDF as a default investment for new entrants influenced the willingness of existing employees to switch. It is more than twice as large as the adoption rate by existing employees in voluntary enrollment plans. The latter represents a very strong default effect. Panel 3 of Table 3 summarizes the relative sizes of these outcomes.

Table 3 here

The second column of Table 3 addresses the fraction of contributions that employees direct to TDFs. The effects are similar in direction and magnitude to column the first column. The third column shows that automatic enrollment was especially powerful in influencing participants to become *pure* target date investors, another measure of the intensive adoption margin. Again, the same three effects are at work. In terms of the active choice effect, 3.9 percent of existing employees in voluntary choice plans switched all of their contributions to a single TDF when the funds were first introduced, while this figure rose to 14.5 percent for new enrollees. In terms of the default effect, 74.9 percent of automatically enrolled new entrants were pure target investors, more than five times the voluntary enrollment new entrant rate. And finally, in terms of the endorsement effect, only 3.9 percent of existing employees in voluntary plans switched to become pure investors, but this rate rose to 14.1 percent for existing employees in automatic enrollment plans.

Comparing the third and fourth columns also provides another lesson regarding the impact of plan choice architecture on portfolio choice. Specifically, new entrants to voluntary enrollment plans were roughly equally likely to be either pure (14.5 percent) or mixed (13.2 percent) TDF investors, whereas new entrants to automatic enrollment plans were five times more likely to be pure versus mixed investors (74.9 versus 17.2 percent).²⁵ One potential explanation for this difference is that employers who defaulted their participants into TDFs under automatic enrollment may have done so anticipating employee preferences for the age-based labeling or age-related rebalancing features unique to TDFs. An alternative explanation, consistent with the household finance literature on inertia and malleable preferences in financial decision-making, is that the default effect is very strong and overrides participant demand for mixed investments.

Our default-related adoption effects across 880 firms are similar in magnitude to prior individual company case studies of automatic enrollment (Madrian and Shea, 2001; Choi, Laibson, Madrian and Metrick, 2004, 2005), where automatically enrolled new entrants remained entirely in the default fund, at rates ranging from 46 to 90 percent. Their results differ from ours due to firm-specific design factors, different methods of measurement, and, in most cases, the fact that default funds tended to be low-risk money market funds. Other results on voluntary choice are not directly comparable to ours as these case studies measured the effects of a default fund that had previously been included in the menu as a voluntary enrollment option, unlike in our setting where we focus on the first appearance of TDFs in the menu. Our measured endorsement effects are meaningfully higher than other reported results. For example, Benartzi (2001) found that

²⁵ Both Agnew et al. (2012) and Ameriks et al. (2011) have reported that some participants elect a mixed strategy, believing that this enhances diversification; in other words they fail to recognize that each TDF is already a highly-diversified multi-asset-class fund. This view may reflect a naïve understanding of diversification or a desire to diversify across multiple managers. Pagliaro and Utkus (2017a) demonstrate how different types of mixed investors diversify their portfolios, including those who alter risk levels and active/passive share.

employees were over one-and-a-half times more likely to invest their own contributions in employer stock when the employer match to their account was in stock rather than cash (29 versus 18 percent).²⁶ In our results, the endorsement effect is associated with a two to nearly four times higher propensity to hold TDFs by existing employees, depending on the exact measure. Moreover, the endorsement effect we measure comes from a default designation affecting employees' co-workers rather than defaulted employees' own accounts.

We have demonstrated that plan choice architecture clearly has a potent impact on target date use, but other factors correlated with the outcomes are also worth mentioning (for details see Appendix Table 2). Target date adoption was highest among low-balance participants, falling for those with higher balances. Younger participants (under age 35) were also more likely to adopt TDFs, either as pure or mixed investors, even after controlling for effects of new hire auto enrollment. This suggests that, earlier in their life cycles, workers were either less financially sophisticated or more willing to adopt novel strategies or technologies; hence they were more attracted to TDFs even aside from default effects. We also note that target date portfolio choice decisions did not change significantly during the 2008-2009 financial crisis, indicating that the sharp decline in stock prices during the financial crisis did not alter participant demand.

Portfolio Effects from Adoption of Target Date Funds

Having examined how plan architecture influenced retirement savers' portfolios, we next assess how the arrival of TDFs in the fund menu shaped adopters' portfolio risk and return characteristics. To this end, we compare pure and mixed TDF investors with their non-TDF

²⁶ Evidence of an 'endorsement effect' resulting from an employer's designation of employer stock as the default for matching contributions was provided by Benartzi (2001), Brown, Liang, and Weisbenner (2007), and Choi, Laibson, and Madrian (2004).

counterparts in terms of equity shares, portfolio return and risk, Sharpe ratios, and nonsystematic or idiosyncratic portfolio risk or variance (reported as a share of total variance, or NSR/TV). We further compare factor risk exposures of each participant subgroup.

As with adoption behavior, we measure several aspects of participants' portfolio allocations one year after the first appearance of TDFs in the plan menu. Equity allocations refer to the fraction of participants' portfolios held in equities in that month,²⁷ and risk and return characteristics are estimated using a six-factor asset pricing model over the prior 60 months drawing on monthly returns data for plan menu investments over a 17.5 year period (including the 150 month period under analysis, and the preceding five years). For example, if TDFs first appeared in a plan in September 2005, savers' equity allocations were observed a year later, in September 2006, and risk and return characteristics were estimated for the 60 months preceding and then predicted for September 2006. Factor returns were calculated using six factors: the market, size, value, and momentum factors for equities, and term and default factors for bonds.²⁸ All returns are net of all investment management fees.²⁹

We note that over the analysis period of January 1998 through June 2015, the mean market factor return (the return of the equity market less the risk-free rate) was 5.95 percent, with a standard deviation of 16.1 percent over the period, while the mean term premium for bonds (the return of long-dated government bonds less the risk-free rate) was 5.41 percent, with a standard

²⁷ Equity share is the percentage of employer and employee contributions directed to U.S. and international equity funds, company stock, and a percentage of balanced and TDFs. The equity percentage for balanced and TDFs was calculated based on each fund's holdings; it varies from fund to fund.

²⁸ To calculate portfolio returns over a given 60-month period, we construct a risk-loading matrix for all k investment options in a given plan by regressing the excess return (over Treasury bill returns) for each of the k assets on the six factors. The factor return for each 401(k) investment option in the predicted month is simply its factor exposure in that month times the average factor returns over the prior 60-month period; the participant's factor return is simply the weighted average return of his or her factor exposures over the period.

²⁹ Return calculations do not include the effect of recordkeeping fees (e.g., per capita fees such as \$10 per quarter), which are charged by some plans and are assessed regardless of the assets in the account.

deviation of 10.5 percent. In other words, over our time period, the risk premium from equities over long-dated government bonds was small, and long-dated government bonds had a superior Sharpe ratio to equities. Our results should be interpreted in light of how future return and risk characteristics might resemble, or deviate from, these historical data.

Figure 1 summarizes equity share by age for four categories of investors: pure, mixed, non-target date investors, and all participants. Most notable is the higher equity allocation at virtually all ages for pure and mixed target date investors versus non-target date investors. In addition, pure and mixed investors followed a distinctive age-based gradient or glidepath, whereas variation in equity share among non-target date investors was hump-shaped in age.

Figure 1 here

Table 4 summarizes portfolio characteristics for our three groups of interest and the entire sample. Panel A shows the allocation of total contributions (employer and employee) by major asset class, including cash or principal-guaranteed funds (including money market and guaranteed investment contract funds), bonds, balanced or TDFs (including traditional balanced funds and static allocation or risk-based funds), U.S. equity funds, international equity funds, and employer stock. Panel B indicates equity shares, monthly systematic returns, and portfolio risk, Sharpe ratios, and nonsystematic risk.³⁰ Panel C summarizes portfolio risk exposures.

Table 4 here

³⁰ Specifically, $NSR / TV_{i,t} = \hat{\Sigma}_i^{idio} / \hat{\Sigma}_i$. We estimate the variance-covariance matrix for all assets $\hat{\Sigma}$, which in turn is used to estimate the total portfolio variance for the i th participant, $\hat{\Sigma}_i$. $\hat{\Sigma} = \hat{B}' \hat{\Sigma}_f \hat{B} + \hat{D}$, where \hat{D} is a diagonal matrix with elements computed as the square of the $\hat{\epsilon}_k$ estimated in equation (2). The asset variance can be decomposed into systematic risk, $\hat{\Sigma}^{sys} = \hat{B}' \hat{\Sigma}_f \hat{B}$ and idiosyncratic risk \hat{D}^{idio} . Individual portfolio variance is then decomposed into its systematic and idiosyncratic components: $\hat{\Sigma}_i = \omega'_{i,k,t} \hat{\Sigma} \omega_{i,k,t} = \omega'_{i,k,t} (\hat{\Sigma}^{sys} + \hat{D}^{idio}) \omega_{i,k,t} = \hat{\Sigma}_i^{sys} + \hat{\Sigma}_i^{idio}$.

Contribution allocations in Panel A indicate that non-target date investors held 22.3 percent of their portfolios in cash (i.e., money market instruments and guaranteed investment contracts), while Panel B shows they held an average of 63 percent in equities. By contrast, TDF investors invested substantially more equity: 80.8 percent for pure investors, and 76.1 percent for mixed investors. This difference produces higher market risk exposures in Panel C: 61.6 percent for non-target date investors, 68.9 percent for pure, and 71 percent for mixed, investors. Panel B also indicates that, before controlling on other observables, TDF portfolios yielded higher monthly systematic returns (60 to 70 basis points versus 36 basis points for non-TDF investors), slightly higher monthly volatility (2.8-3.1 versus 2.7 percent), lower monthly Sharpe ratios (13.1-15.5 versus 16.7), and substantially lower idiosyncratic or uncompensated risk (3.6-12.1 versus 25.3 percent). The most notable result in Panel C, besides the market risk increase already reported, is the sharply higher bond market term and default premia, particularly for pure investors, where these exposures doubled (e.g., for the default premium, 0.201 for pure investors versus 0.096 for non-target date investors).

We also seek to determine how these portfolio metrics vary when controlling for observable differences in plan choice architecture and participant characteristics. Accordingly, we estimate a multivariate model of the following form:

$$\begin{aligned}
 &PORTFOLIO_{i,j,t} \\
 &= \alpha INVESTORS_{i,t} + \beta PLAN_{j,t} + \gamma PARTICIPANT_{i,t} + v + \tau_t + w_j + \varepsilon_{i,j,t} \quad (2)
 \end{aligned}$$

where $PORTFOLIO_{i,j,t}$ is a vector of the five outcome measures of interest—equity share, return and risk, nonsystematic risk and Sharpe ratio—and $INVESTORS$ is a matrix representing the type of TDF investor (pure or mixed, reference non-target date) and type of employee (new entrant,

reference existing employee). *PLAN* and *PARTICIPANT* characteristics are also included as above in Equation (1).³¹

Table 5 presents marginal effects for equity share, where Model 1 is as in equation (2), and Model 2 adds age interactions with target date behavior. Results in Model 1 indicate that, on average, pure TDF adopters held 24 percentage points more equity compared to non-target date investors, while mixed target date investors held 13 percentage points more. Model 2 indicates that young pure investors (those under age 35) had an equity share averaging 34 percent points above the reference category, while older pure investors (those over age 55) had an equity share 7 percentage points higher; this implies an increase in the difference of 26 points. This result demonstrates a fundamental feature of TDFs, namely their intentional age gradient. For example, for non-target date investors, the equity share was one point higher for young investors and 10 points lower among the older age group, a difference of only 11 points.

Table 5 here

Table 6 presents estimated marginal effects for other portfolio characteristics of interest. Monthly factor returns for pure TDF investors were 19 basis points per month higher (equivalent to 2.3 percent on an annualized basis), while mixed investors were 14 basis points per month higher (1.7 percent annualized). These are sizeable increases relative to the mean factor return of 44 basis points per month in our dataset (5.4 percent annualized). Given their higher equity allocations, it is also not surprising that pure (mixed) target date investors experienced larger portfolio standard deviations by 32 (29) basis points. Also of interest is that predicted Sharpe ratios were statistically insignificantly different for target date investors compared to non-target date investors. This

³¹ As in Equation (1), our models also control for plan-level heteroskedasticity (ν_i) by clustering errors at the plan level, time fixed effects (τ_t), and industry fixed effects, along with missing data dummies. All models also include a financial crisis control.

suggests that target date adoption moved participants up the efficient frontier compared to non-target date investors, in that they were exposed to more equity, higher expected returns, and more risk. Yet non-target date investors – who principally owned diversified mutual fund portfolios and cash equivalents, as noted in Table 4 – were also on the efficient frontier but at a lower risk/return point.³²

Table 6 here

One other remarkable lesson from Table 6 is the impact of TDFs on nonsystematic risk as a percentage of total variance. Idiosyncratic risk overall was around 21 percent of total variance across the entire sample. For pure investors, diversifiable risk was essentially eliminated, with an estimated marginal reduction of 27 percentage points; for mixed investors, it was substantially lower, by 13 percentage points. These results reflect the index nature of the TDFs offered to sample participants.

Finally, Table 7 compares factor risk exposures across types of participants. Given that plan investment menus were dominated by diversified equity funds prior to the arrival of TDFs, mean market exposure was already 64 percent. Pure (mixed) target date adoption raised this further, by 14 (9) percentage points. The second most sizeable equity factor was value (HML), at 8 percent, and both the pure and mixed target date options raised the value exposure of adopters materially, relative to that 8 percent. Another striking difference was the increase in exposure to bonds among target date versus non-target date investors. For example, pure investors had nearly double the exposure to the default factor (10 percentage point increase on a mean of 12 percent) and the term premium (7 point increase on a mean of 8 percent), and similar-sized effects are

³² 80 percent of the assets of all investors were held in low-cost Vanguard mutual funds and trusts, including both active and passive strategies, and the remainder in a range of non-Vanguard funds or trusts.

relevant to the term factor. Accordingly, TDFs extended participants out the yield curve and boosted their exposure to corporate debt, while reducing their cash holdings.³³

Table 7 here

These changes reflect an important development in 401(k) portfolio plans : adopters shift from a model of own-portfolio choice to a model of portfolio choice overseen by the TDF manager and the employer. To illustrate the potential benefits of target date adoption, a hypothetical 30-year-old participant earning \$35,000 per year and saving 10% of wages would generate retirement wealth of nearly \$300,000 over a 30-year period, assuming the mean excess return of 5.4% experienced in our data. That retirement nest egg would be 50 percent higher for pure investors and one third higher for mixed investors at the end of that same period, assuming use of a low-cost, widely diversified target date series as in our sample.³⁴

These are potentially substantial effects from target date adoption by participants. We cannot attribute these results solely as the causal treatment effect of TDFs because of employer and participant self-selection. As noted at the outset, some employers may have introduced the funds or designated them as defaults under automatic enrollment because they felt that participants needed remedial portfolio help – for example, they held too much cash, invested too little in bonds, were under-diversified, and or failed to rebalance with age. In voluntary enrollment settings, participants might have selected the TDFs due to the retirement-date labeling, which acts as an implicit advice feature, or the convenience of the age-based rebalancing.

³³ This is consistent with anecdotal observations about inexperienced investors and their relative lack of understanding of, and exposure to, the bond market (a bond market participation problem).

³⁴ We use the mean return changes for pure and mixed target-date investors, respectively 2.4% and 1.7% annualized, from Table 5. We assumed 1% real wage growth, and importantly no leakage from retirement accounts over the period. The calculations assume an end-of-period convention, and they are available from the authors.

Nonetheless, among adopters, TDFs are clearly associated with sizeable shifts in portfolio risk factors and potential increases in future retirement wealth, relative to non-target date investors. These are benefits adopters could have realized on their own at any time – but they did not take place until arrival of TDFs in the plan menu.³⁵ Moreover, beyond these results signal that the provision of scalable low-cost advice can have important consequences for nonprofessional investors in domains other than 401(k) plans – in terms of risk-taking and portfolio diversification.

Conclusions and Discussion

Portfolio choice in U.S. defined contribution plans is gradually shifting from an own-portfolio choice model to a regime where participant portfolio choice is delegated to a TDF manager selected by the employer. Our paper illustrates how the introduction of TDFs, either in voluntary choice or automatic enrollment plans, has led to this fundamental change. We examine 880 retirement plans covering 1.2 million participants to demonstrate the importance of key behavioral mechanisms in target date adoption, and in turn, how TDF adoption resulted in substantive change in portfolio risk factors among adopters.

We identify three distinct behavioral effects influencing adoption when TDFs were introduced in voluntary or automatic enrollment environments. One is an active choice effect: in voluntary enrollment plans, 28.4 percent of new entrants adopted TDFs in their 401(k) portfolios, compared to only 10.2 percent of existing employees. A second is a substantial default effect: 78.7 percent of new entrants in plans with new-hire automatic enrollment adopted TDFs, versus 28.4 percent in voluntary plans. Third is a default-related endorsement effect: in new-hire automatic enrollment plans, 21.7 percent of existing employees not subject to auto-enrollment invested in

³⁵ Tang, Mitchell, Mottola, and Utkus (2010) show that virtually all employees could have “rolled their own” portfolios to mimic the age-relevant TDF mix using funds available prior to the inclusion of the TDFs on the menu.

the funds, double the rate of existing employees in voluntary choice plans. Similar effects play out in terms of pure versus mixed target date investors.

Our second set of findings relates to portfolio outcomes. Target date adoption leads to a sizeable change in portfolio risk-taking. For example, pure investors adopting a single fund had a higher equity share (+24 percentage points), a sharper age equity share gradient (+26 points), and higher factor returns (+2.3% annualized), versus non-target date holders. Besides boosting equity shares for pure and mixed investors, TDFs also produced a distinctive age-based gradient in risk-taking, compared to a hump-shaped equity allocation among non-target date investors. As our factor analysis shows, target date participants took on the factor exposures embedded in the target date series offered by the fund manager and selected by the employer. In our sample of indexed, broadly diversified TDFs, that meant greater market risk exposure, higher exposures to term and default premia, and reduced risk.³⁶

In other words, target date investors take greater risks across the lifecycle, follow a lifecycle-based age gradient, and enhance their exposure to factors embedded in the funds designed by the portfolio manager. These changes could be welfare-enhancing under the joint assumptions that the target date design represents an efficient portfolio frontier (selected by the sponsor and fund manager), and that workers without TDFs would fail to construct efficient portfolios, or would choose suboptimal points on that frontier, due to either investment literacy problems or behavioral biases. One illustration of the potential welfare benefits is the potential impact of higher equity exposure on long-term retirement wealth accumulation. We estimate that pure target date investors in a low-cost broadly diversified target date series might realize retirement wealth that is up to 50 percent higher relative to non-target date investors. For mixed investors, it is up to 30

³⁶ A similar result is reported by Keim and Mitchell (2018) who analyzed TDF introduction at a single firm.

percent. We recognize, of course, that target date adopters are taking more risk, particularly at younger ages. Whether this proves to be welfare-enhancing will ultimately depend on a specification of investors' utility functions over the lifecycle, an exercise which is beyond the scope of this paper.

If these are reasonable estimates of potential benefits, a related question is whether plan sponsors and policymakers could increase target date adoption among existing 401(k) participants. One approach might be to use 'reenrollment,' whereby U.S. plan sponsors could transfer existing employees' investments into age-specific TDFs (or any other default fund), with advance notification to the employee and with the right by the employee to opt out of the move. In view of our results, reenrollment could lead to similar changes as outlined here for existing non-target date investors.³⁷

Finally, our results point to the potential effects of providing low-cost, scalable investment advice more broadly. TDFs differ from other balanced funds since they tailor their recommendations based on a single factor, age. Similar to TDFs, low-cost lifecycle investment algorithms incorporating age and other personal characteristics might also help reduce portfolio construction deficiencies in other settings, such as retail investment accounts or personal pensions. This is particularly important given our evidence that there is a sharp divergence between portfolio construction decisions made by nonprofessional investors such as 401(k) investors versus advice provided by professional advisers. Mechanisms like low-fee TDFs or robo-advice services³⁸ have the potential to reduce this "advice gap" and improve outcomes for other groups of nonprofessional

³⁷ For more on reenrollment, see Pagliaro and Utkus (2016, 2017b)

³⁸ See Agnew and Mitchell (2019) and Rossi and Utkus (2020).

investors, including potentially reducing the heterogeneity of returns across households or addressing biases in traditional professional advice.³⁹

³⁹ See Campbell, Ramadorai and Ranish (2019) and Inderst and Ottaviani (2012).

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Table 1. Target Date Fund Characteristics

TDF Fund	Participant Age in 2010	Equity allocation (%)	U.S. stocks (%)	Non-U.S. stocks (%)	U.S. nominal bonds (%)	U.S. inflation- protected bonds (%)	Cash (%)
2055	20	90	63.0	27.0	10.0	0.0	0.0
2050	25	90	63.0	27.0	10.0	0.0	0.0
2045	30	90	63.0	27.0	10.0	0.0	0.0
2040	35	90	63.0	27.0	10.0	0.0	0.0
2035	40	89	62.5	26.8	10.8	0.0	0.0
2030	45	82	57.2	24.5	18.3	0.0	0.0
2025	50	74	52.0	22.3	25.8	0.0	0.0
2020	55	67	46.7	20.0	33.3	0.0	0.0
2015	60	59	41.3	17.7	40.0	1.0	0.0
2010	65	49	34.0	14.6	40.4	10.7	0.4
2005	70	34	24.0	10.3	43.9	17.9	3.9
Income	75	30	21.0	9.0	45.0	20.0	5.0

Note: Fund asset mix measured as of December 2010. Source: Authors' tabulations using Vanguard data; see text.

Table 2. Descriptive Characteristics of Plans and Participants

A. Plan Features and Participant Outcomes (% of accounts)

	All	Pure TDF Investors	Mixed TDF Investors	Non-TDF Investors
Choice architecture features				
TDF Default	52.0	72.1	64.9	46.3
New-hire auto enrollment	32.9	49.5	27.4	30.1
TDF adoption				
TDF investor	24.7	100.0	100.0	0.0
Pure TDF investor	15.7	100.0	0.0	0.0
Mixed TDF investor	9.0	0.0	100.0	0.0
Other plan features				
N Funds offered (mean)	25.6	24.5	24.4	26.0
Employer stock offered	48.4	46.6	53.0	48.3
Loans offered	88.4	88.0	92.8	87.9
N plans	880	852	824	880
N unique accounts	1,262,506	198,242	114,161	950,103

B. Participant Attributes (% of accounts)

	All	Pure TDF Investors	Mixed TDF Investors	Non-TDF Investors
New entrants	19.7	54.5	24.2	11.8
Log account balance (2015\$)	9.9	8.1	10.1	10.2
Job tenure (years)	10.0	5.0	8.7	11.3
Young (% <35)	25.1	41.3	28.2	21.4
Middle (% 35-55)	59.6	49.3	59.2	61.9
Old (% >55)	15.2	9.4	12.6	16.8
Male (%)	69.4	65.7	69.3	70.2
Low HH income (% <\$62.5K)	31.0	37.9	27.0	30.0
Mid. HH income (% \$62.5-\$87.5K)	26.7	28.9	26.9	26.2
High HH income (% >\$87.5K)	42.3	33.1	46.0	43.7
Low non-ret. fin. wealth (% <\$7.3K)	17.9	28.2	17.4	15.9
Mid. non-ret. fin. wealth (% \$7.3K-\$61.2K)	32.2	39.0	34.2	30.6
High non-ret. fin. wealth (% >\$61.2K)	49.9	32.8	48.4	53.6
Financial crisis (% of year)	8.1	8.6	10.1	7.8

Note: Post-TDF adoption sample; each individual observed 12 months after TDF introduction.

Source: Authors' tabulations using Vanguard data; see text and Appendix Table 3.

Table 3. Summary of Marginal Effects of Plan Choice Architecture on Target Date Fund Adoption

<i>In percent</i>	Probability of TDF Adoption (1)	Total Contributions to TDFs (2)	Probability of Pure TDF (3)	Probability of Mixed TDF (4)
Sample mean	24.7	18.9	15.7	9.0
Choice Architecture				
I. Voluntary choice				
A. Existing employees	10.2 (1.2)	7.6 (1.2)	3.9 (0.6)	5.6 (0.6)
B. New entrants	28.4 (2.9)	27.4 (2.9)	14.5 (2.2)	13.2 (1.7)
II. Auto enroll of new entrants to TDF				
A. Existing employees	21.7 (3.0)	18.7 (2.3)	14.1 (2.6)	7.9 (1.4)
B. New entrants	78.7 (5.8)	73.2 (4.4)	74.9 (6.8)	17.2 (2.5)
III. Summary of effects				
Active choice effect (IB v. IA)	2.8	3.6	3.8	2.3
Endorsement effect (IIA v. IA)	2.1	2.5	3.6	1.4
Default effect (IIB v. IB)	2.8	2.7	5.2	1.3

Note: Marginal effects derived from model estimates appearing in Appendix Table 2 (Probit model of probability of adoption; OLS model of total employer and employee contributions; and a multinomial Logit model of pure versus mixed versus non-target date adopters), with all other variables held at sample means. Standard errors of marginal effects from fitted models in parentheses. ‘New entrants’ are participants who enrolled with TDFs available in the investment menu; ‘existing participants’ are those who enrolled prior to TDFs being introduced in the menu. Adoption effects are measured one year after first TDF appearance in menu. Source: Authors’ tabulations using Vanguard data; see text and Appendix Table 3.

Table 4. Contribution Allocations and Portfolio Characteristics of Participants in Plans Adopting Target Date Funds

A. Contribution allocations (%)						
	Cash	Bonds	Balanced/ TDF	U.S. Equities	Internation al Equities	Company Stock
All investors	17.3	6.4	29.6	34.3	6.6	5.7
Non TDF investors	22.3	7.7	13.7	41.9	7.7	6.8
Pure TDF investors	0.0	0.0	100.0	0.0	0.0	0.0
Mixed TDF investors	5.9	7.2	39.9	31.1	9.3	6.5

B. Portfolio characteristics (%)					
	Six-factor CAPM, Predicted				
	Equity share	Monthly Returns	Monthly Risk (σ)	Sharpe Ratio	NSR/TV
All investors	67.0	0.44	2.75	16.2	20.7
Non TDF investors	63.0	0.36	2.71	16.7	25.3
Pure TDF investors	80.8	0.70	2.77	15.5	3.6
Mixed TDF investors	76.1	0.60	3.07	13.1	12.1

C. Portfolio risk exposures							
	β (Mkt)	β (SMB)	β (HML)	β (UMD)	β (Default)	β (Term)	β (RMSE)
All investors	0.636	-0.011	0.084	-0.008	0.117	0.080	0.010
New entrants	0.621	-0.024	0.086	-0.002	0.150	0.099	0.008
Existing employees	0.640	-0.008	0.083	-0.010	0.109	0.075	0.010
Non TDF investors	0.616	0.001	0.079	-0.011	0.096	0.065	0.010
Pure TDF investors	0.689	-0.073	0.099	0.005	0.201	0.138	0.007
Mixed TDF investors	0.710	-0.006	0.093	-0.005	0.151	0.103	0.011

Note: The following β differences are significant at the 1% level: new entrants versus existing employees; pure versus mixed investors; pure versus non-TDF; and mixed versus non-TDF investors. Source: Authors' computations using Vanguard data; see text and Appendix Table 3 for variable definitions.

Table 5. Marginal Effects of Equity Share and Target Date Treatment

	Mean	Equity Share (1)		Equity Share (2)	
TDF investors (%)					
Pure TDF Investors	15.7	0.240	**	0.212	**
Mixed TDF Investors	9.0	0.126	**	0.116	**
Young*Pure TDF Investors (%)	6.5			0.125	**
Old*Pure TDF Investors (%)	1.5			-0.139	**
Young*Mixed TDF Investors (%)	2.6			0.062	**
Old*Mixed TDF Investors (%)	1.1			-0.043	**
Choice architecture					
New-hire auto enrollment (%)	32.9	-0.017		-0.018	
New entrants	19.7	-0.016		-0.022	
Participant characteristics					
Log balance (mean 2015\$)	9.9	0.024	**	0.024	**
Job tenure (years)	10.0	-0.002	**	-0.002	**
Young (% <35)	25.1	0.046	**	0.010	*
Old (% >55)	15.2	-0.117	**	-0.100	**
Male (%)	69.4	0.032	**	0.032	**
HH income low (% <\$62.5K)	31.0	-0.026	**	-0.027	**
HH income high (% >\$87.5K)	42.3	0.015	**	0.015	**
Wealth low (% <\$7.3K)	17.9	-0.028	**	-0.029	**
Wealth high (% >\$61.2K)	49.9	0.025	**	0.024	**
Financial crisis (% months)	8.1	-0.012		-0.010	
Intercept		0.445	**	0.458	**
Controls		Yes			
Observations		1,262,50			
		6			
Number of clusters (plans)		880			
R-squared		0.151		0.158	
Mean of dependent variable		67.0%		67.0%	

Note: Equity share refers to the percentage of participant contributions directed to stock market investments. Controls include plan-level indicators of the number of funds, employer stock, and loans offered. Standard errors clustered at the plan level. * Significant at 5%, *** significant at 1%. Source: Authors' computations using Vanguard data; see text and Appendix Table 3 for variable definitions.

Table 6. Marginal Effects of Portfolio Outcomes and Target Date Treatment

	Mean	Monthly Return	Monthly Risk (σ)	Sharpe Ratio	NSR/TV
TDF investors (%)					
Pure TDF Investors	15.7	0.0019 *	0.0032 **	-0.0687	-0.2703 **
Mixed TDF Investors	9.0	0.0014 *	0.0029 **	-0.0348	-0.1344 **
Choice architecture					
New-hire auto enrollment (%)	32.9	-0.0014	-0.0010	-0.0722	0.0051
New entrants	19.7	-0.0006	-0.0012 **	-0.0209	0.0225
Participant characteristics					
Log balance (mean 2015\$)	9.9	0.0004	0.0008 **	-0.0015	-0.0165 **
Job tenure (years)	10.0	0.0000	-0.0001 **	0.0022 **	0.0015 **
Young (% <35)	25.1	0.0002	0.0013 **	-0.0079	-0.0019
Old (% >55)	15.2	-0.0006	-0.0041 **	0.0401 **	0.0440 **
Male (%)	69.4	0.0003	0.0013 **	0.0089	-0.0033
HH income low (% <\$62.5K)	31.0	-0.0004 **	-0.0011 **	0.0028	0.0182 **
HH income high (% >\$87.5K)	42.3	-0.0001	0.0005 **	-0.0111 *	-0.0080 **
Wealth low (% <\$7.3K)	17.9	0.0001	-0.0009 **	0.0250 *	0.0224 **
Wealth high (% >\$61.2K)	49.9	-0.0002	0.0009 **	-0.0182 **	-0.0148 **
Financial crisis (% months)	8.1	-0.0528 **	0.0006	-1.3855 **	0.0385 *
Intercept		0.0320 **	0.0286 **	1.0203 **	0.3548 **
Controls				Yes	
Observations				1,262,506	
Number of clusters (plans)				880	
R-squared		0.514	0.247	0.447	0.179
Mean of dependent variable		0.0044	0.0275	0.1621	0.2069

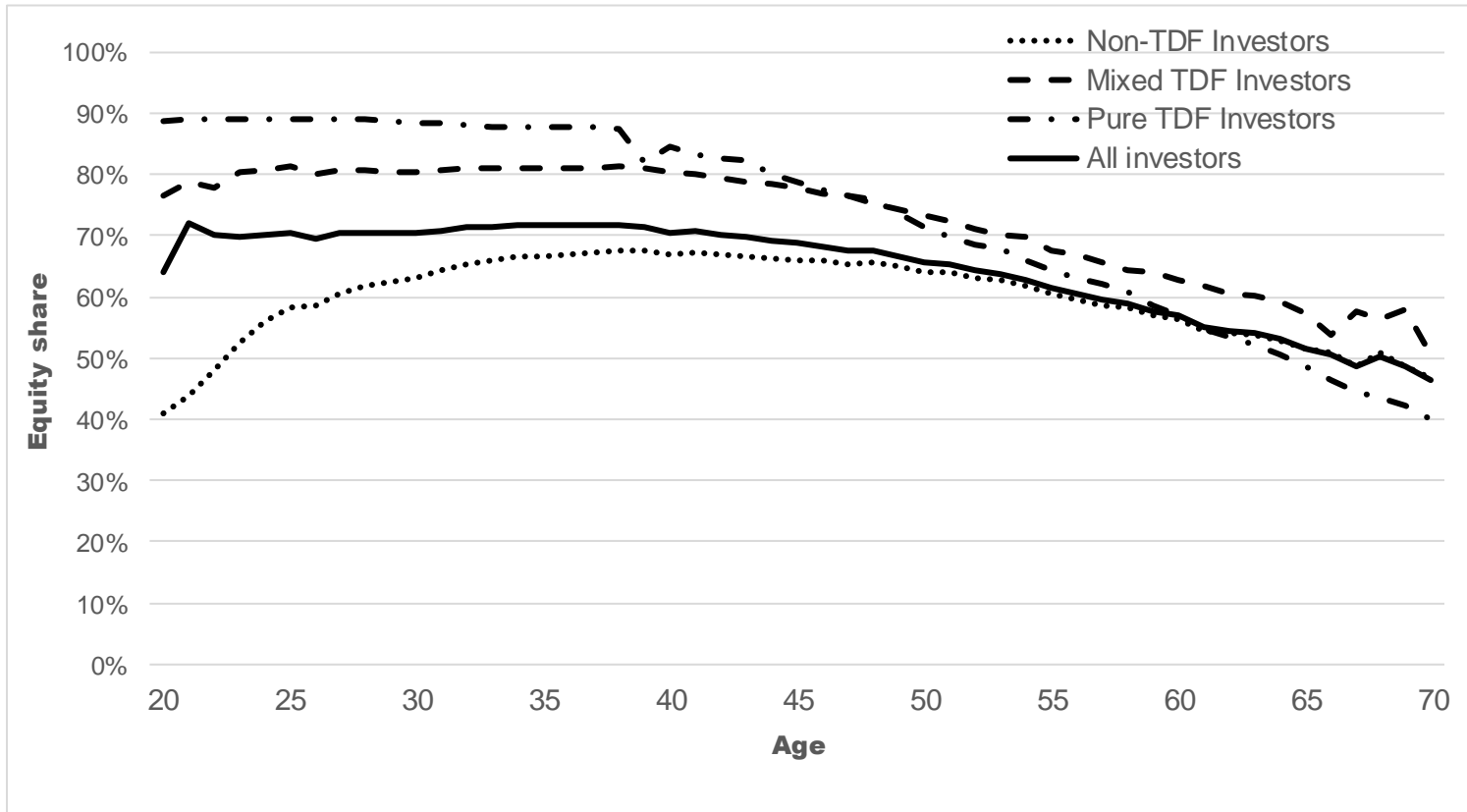
Note: See text for definition of dependent variables. Controls include plan-level indicators for number of funds, employer stock, and loans offered. Standard errors clustered at the plan level. * Significant at 5%, ** significant at 1%. Source: Authors' computations using Vanguard data; see text and Appendix Table 3 for variable definitions.

Table 7. Marginal Effects of Portfolio Risk Exposures and Target Date Treatment

	Mean	β (Mkt)		β (SM B)		β (HML)		β (UMD)		β (Default)		β (Term)		β (RMSE)	
TDF investors (%)															
Pure TDF Investors	15.7	0.135	**	-0.084	**	0.026	**	0.012	**	0.101	**	0.072	**	-0.002	**
Mixed TDF Investors	9.0	0.090	**	-0.015	**	0.013	**	0.004	**	0.050	**	0.040	**	0.001	*
Choice architecture															
New-hire auto enrollment (%)	32.9	-0.018		-0.002		-0.011	*	0.002		-0.008		-0.005		-0.001	*
New entrants	19.7	-0.015		0.014	**	0.000		0.003	**	0.001		-0.003		0.000	
Participant characteristics															
Log balance (mean 2015\$)	9.9	0.022	**	0.003	**	0.002	**	0.000		0.002	**	0.000		0.000	**
Job tenure (years)	10.0	-0.002	**	-0.001	**	0.000		0.000	*	-0.001	**	-0.001	**	0.000	*
Young (% <35)	25.1	0.032	**	0.005	**	0.011	**	0.003	**	0.011	**	-0.007	**	0.001	**
Old (% >55)	15.2	-0.100	**	-0.009	**	-0.013	**	-0.001	**	-0.010	**	0.012	**	-0.001	**
Male (%)	69.4	0.028	**	0.006	**	0.001		0.000		0.002		-0.004	**	0.001	**
HH income low (<\$62.5K)	31.0	-0.026	**	-0.003	**	-0.003	**	0.000		-0.003	**	-0.001	*	0.000	**
HH income high (>\$87.5K)	42.3	0.015	**	0.004	**	0.002	**	0.000		0.002	**	0.001		0.000	**
Wealth low (<\$7.3K)	17.9	-0.028	**	-0.002	**	-0.001		0.000		-0.003	*	-0.001	*	0.000	**
Wealth high (>\$61.2K)	49.9	0.024	**	0.003	**	0.000		0.000		0.001		0.000		0.000	**
Financial crisis (% months)	8.1	-0.004		-0.005		0.013		0.003		0.003		0.004		0.001	
Intercept		0.451	**	-0.048	**	0.065	**	-0.022	**	0.027	*	0.053	**	0.007	**
Controls		Yes													
Observations		1,262,506													
Number of clusters (plans)		880													
R-squared		0.111		0.140		0.098		0.111		0.247		0.151		0.151	
Mean of dependent variable		0.636		-0.011		0.084		-0.008		0.117		0.080		0.010	

Note: See text for definition of dependent variables. Controls include plan-level indicators for number of funds, employer stock, and loans offered. Standard errors clustered at the plan level. * Significant at 5%, ** significant at 1%. Source: Authors' computations using Vanguard data; see text and Appendix Table 3 for variable definitions.

Figure 1. Equity Share by Age and Investor Type



Source: Authors' calculations.

Appendix Table 1. Year-by-Year Target Date Fund Adoption Patterns and Other Trends

	By Year											
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Default architecture												
TDFDefault (%)	0.0	8.0	14.9	29.1	70.5	84.6	66.9	93.5	80.7	80.3	14.7	
New-hire auto enrollment (%)	0.0	0.1	26.5	43.2	38.1	37.7	35.5	45.2	31.9	2.8	11.6	
New entrant (%)	16.1	13.9	22.6	18.2	26.7	13.1	9.1	12.1	22.2	14.5	11.9	
Other plan characteristics												
N funds offered (mean)	69.2	38.5	19.0	22.7	25.8	24.7	27.1	28.5	24.4	29.1	28.9	
Employer stock offered (%)	0.0	7.4	58.7	45.3	56.3	54.0	51.5	14.2	0.0	0.0	84.0	
Loan offered (%)	3.5	56.7	88.7	96.1	94.1	83.8	91.2	98.8	92.7	76.8	97.1	
SA enabled (%)	100.0	60.9	28.8	32.3	63.3	74.0	86.3	81.9	87.7	79.0	11.9	
Participant characteristics												
Log balance (mean 2015\$)	10.1	9.8	10.0	9.9	9.5	10.1	10.3	10.2	9.4	10.4	11.4	
Job tenure (years)	4.6	8.2	11.5	8.8	9.5	11.0	13.0	10.7	8.8	8.9	12.2	
Young (<35, %)	26.4	26.2	23.2	26.5	25.7	25.6	21.4	23.0	23.1	24.7	23.1	
Middle (35-55, %)	62.3	60.5	61.5	59.3	60.7	57.8	57.3	58.3	57.6	59.0	54.3	
Old (>55, %)	11.3	13.3	15.3	14.3	13.6	16.5	21.3	18.7	19.3	16.3	22.6	
Male (%)	30.9	62.6	59.4	72.6	75.6	65.2	71.3	77.9	64.1	60.6	79.6	
HH income low (<\$62.5K, %)	22.0	27.3	33.1	33.8	32.1	29.5	29.2	28.5	32.9	27.3	21.4	
HH income medium (\$62.5-\$87.5K, %)	22.6	26.1	29.3	25.0	26.9	26.2	27.1	26.2	33.9	27.5	22.6	
HH income high (>\$87.5K)	55.4	46.5	37.6	41.2	41.0	44.2	43.7	45.3	33.2	45.2	56.0	
Low (<\$7.3K, %)	3.4	9.1	15.5	19.7	19.7	18.1	18.8	18.9	33.7	20.8	18.7	
Average (\$7.3K-\$61.2K, %)	16.4	23.0	31.9	31.3	34.9	33.2	35.9	32.3	31.3	29.8	26.7	
High (>\$61.2K, %)	80.3	67.9	52.6	49.0	45.4	48.7	45.3	48.8	35.0	49.4	54.6	
Financial Crisis												
Financial crisis (% of year)	0	0	0	0	0	1/3	1/3	0	0	0	0	
TDF adoption (% of accounts)												
TDF investor	1.7	10.1	19.5	25.4	26.5	29.0	21.2	40.3	51.2	50.5	12.2	
Pure TDF investor	1.1	6.8	11.3	16.4	18.0	16.5	13.0	24.1	35.8	40.4	5.8	
Mixed TDF investor	0.6	3.3	8.2	9.0	8.5	12.5	8.2	16.2	15.4	10.1	6.4	
Observations												
N plans	6	93	109	157	168	129	63	48	43	27	22	
N accounts	11,310	87,514	189,648	204,932	403,984	208,196	46,046	42,177	8,224	19,282	37,172	

Source: Authors' computations using Vanguard data; see text and Appendix Table 3 for variable definitions.

Appendix Table 2. Estimated Determinants of Participant Target Date Fund Adoption Patterns

	Mean	Probability of TDF adoption (Probit marginal effects) (1)	Contributions to TDFs (OLS coefficients and standard errors) (2)	Prob. of Pure Investor (Mult. Logit marginal effects) (3)	Mixed Investor (Mult. Logit marginal effects) (4)	
Choice architecture features						
TDFDefault (%)	52.0	15.4 **	0.100 **	0.018	9.0 **	7.7 **
New-hire auto enrollment (%)	32.9	-1.6	0.011	0.023	3.8	-4.4 *
New entrant (%)	19.7	23.0 **	0.199 **	0.026	18.3 **	9.7 **
New-hire auto enrollment*New entrant (%)	8.6	4.0	-0.034	0.087	-2.8	9.6 **
New-hire auto enrollment*New entrant*TDFDefault (%)	5.6	25.9 **	0.381 **	0.095	28.7 **	-5.5 **
Participant characteristics						
Log balance (mean 2015\$)	9.9	-1.8 **	-0.017 **	0.002	-1.9 **	1.2 **
Job tenure (years)	10.0	-0.4 **	-0.003 **	0.001	-0.4 **	-0.2 **
Young (<35, %)	25.1	3.5 **	0.029 **	0.007	2.0 **	1.8 **
Old (>55, %)	15.2	-0.8	0.004	0.004	0.3	-1.1 **
Male (%)	69.4	1.2	0.010	0.010	0.6	0.6
HH income low (<\$62.5K, %)	31.0	-0.6	0.002	0.004	0.4	-1.1 **
HH income high (>\$87.5K, %)	42.3	-0.3	-0.004	0.004	-0.7	0.1
Wealth low (<\$7.3K, %)	17.9	1.0	0.014 *	0.006	0.8 *	-0.1
Wealth high (>\$61.2K, %)	49.9	-1.7 **	-0.013 **	0.005	-1.6 **	-0.6
Financial crisis (%)	8.1	-4.1	-0.034	0.030	-2.8	-1.0
Intercept			0.348 **	0.079		
Controls			Yes			
Observations			1,262,506			
Number of clusters (plans)			880			
-2LogL		1,129,377	N/A		1,438,045	
Pseudo-R squared / R-squared		0.201	0.283		0.263	
Mean of dependent variable		24.7%	18.9%		15.7%	9.0%

Source: Probit model of probability of adoption; OLS model of total contributions which include employer and employee contributions; and a multinomial logit model of pure versus mixed versus non-target date adopters. ‘New entrants’ are participants who enrolled with TDFs available in the investment menu; “existing participants” are those who enrolled prior to TDFs being introduced in the menu. Adoption effects are measured

one year after first TDF appearance in menu. Standard errors are clustered at the plan level. * Significant at 5%, *** significant at 1%. Source: Authors' computations using Vanguard data; see text and Appendix Table 3 for variable definitions.

Appendix Table 3. Variable Descriptions

Variable	Description
TDF adoption (0/1)	=1 if employee contributes to TDF funds, 0 else
Contributions to TDFs (%)	Percentage of monthly contribution invested into TDF funds
Pure TDF Investors	=1 if employee only contributes to TDF funds, 0 else
Mixed TDF Investors	=1 if employee contributes to TDF and non-TDF funds, 0 else
Equity Allocations (%)	Percentage of monthly contribution invested into equity assets
Monthly return (%)	Monthly predicted factor return
Monthly Standard deviation (σ) (%)	Monthly predicted standard deviation of factor return
Nonsystematic risk/total variance (NSR/TV)	Ratio of non-sysmatic risk of total portfolio variance
Sharpe Ratio	Ratio of monthly predicted factor return to monthly predicted standard deviation
β (Mkt)	Weighted estimated coefficient of benchmark Mkt
β (SMB)	Weighted estimated coefficient of benchmark SMB
β (HML)	Weighted estimated coefficient of benchmark HML
β (UMD)	Weighted estimated coefficient of benchmark UMD
β (Defaultprem)	Weighted estimated coefficient of benchmark Defaultprem
β (Termprem)	Weighted estimated coefficient of benchmark Termprem
β (RMSE)	Weighted estimated Root MSE
Default	=1 if TDF fund as default in plan, 0 else
New entrants	=1 if employee began contribution after TDF introduction, = else
New-hire auto enrollment	=1 if the month is after Vanguard TDF auto enrollment date; =0 else
N Funds offered	# funds offered in plan
Employer stock offered	=1 if plan offers company stock; =0 else
Loan offered	=1 if plan offers loan; =0 else
Log balance (mean 2015\$)	Natural logarithm of balance in 2015\$
Job tenure (years)	Years of job tenure
Young (age<35)	=1 if employee's age<35, =0 else
Old (age>55)	=1 if employee's age>55, =0 else
Male	=1 if employee is male, = 0 else
HH income low (<\$62.5K)	=1 if HH income<\$62,500, =0 else
HH income high (>\$87.5K)	=1 if HH income>87,500, =0 else
Wealth low (<\$7.3K)	=1 if HH wealth<\$7.3k, =0 else
Wealth high (>\$61.2K)	=1 if HH wealth>\$61.2k; =0 else
Financial crisis	=1 if month is between 200809 and 200903, =0 else

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