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The Dynamics of Lifecycle Investing in 401(k) Plans

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The introduction of lifecycle funds into 401(k) plans offers a rich environment in which to assess workers' portfolio allocation decisions. Consistent with behavioral models, employer design decisions strongly influence lifecycle adoption behavior while fundamentally altering portfolio characteristics, both in the cross-section and longitudinally. Yet there are also elements of rational choice by new employees, as well as choice constrained by information costs among workers with low literacy characteristics. We conclude that recent legislation encouraging riskier 401(k) portfolios will modify investment patterns, with the rate of change varying according to whether behavioral or rational elements dominate in a given setting.

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Over the past quarter century, US workers have been increasingly made responsible for the management of their own retirement portfolios. In particular, employees in 401(k) plans today are expected to decide their investment allocations when they enroll in their plans and then proactively manage their accounts thereafter, given the employer-designed investment menu. But recent research has raised concerns about workers' ability to handle pension plan investments, having detected substantial evidence of behavioral biases and inertia, naive portfolio diversification, excessive reliance on conservative investment options, and financial illiteracy regarding basic investment concepts. These findings, in turn, stimulated an important shift in US retirement policy embodied in the 2006 Pension Protection Act (PPA). Specifically, the PPA now permits firms to offer workers professionally-managed but "default" investment funds within 401(k) plans, rather than having workers be responsible for actively managing their retirement accounts.

Among the options authorized for such default investment as so-called target-maturity date (TM) lifecycle funds. In such funds, a worker must simply select the fund targeted to his expected retirement date (e.g. a 2030 fund).[1] Thereafter, the fund manager takes over all responsibility for selecting asset holdings and rebalancing the portfolio over time. Typical TM funds invest more in equities for younger employees, and as the target date nears, the TM fund's equity holdings are gradually reduced toward a more conservative mix in what is known as the "equity glide path." TM funds, like other PPA-recommended default options, are notably riskier than the cash default investments previously observed in US 401(k) plans. While a relatively

new type of investment option, TM funds have become extraordinarily popular very quickly, growing to $114 billion in assets (year-end 2006; ICI, 2007).

The introduction of lifecycle funds into 401(k) plans offers a rich decision-making environment in which to assess the role of rational and behavioral elements in worker portfolio allocations, as well as to evaluate the impact of federal policy encouraging the use of riskier default portfolios. To assess these questions, this paper provides an empirical assessment of how over a quarter million 401(k) participants responded to the introduction of TM funds in over 250 plans over the 2003-2005 period, using a unique longitudinal dataset from Vanguard.

The 401(k) plans in our data set allow us to observe substantial heterogeneity in the types of decision-making environments influencing portfolio decisions. In some cases, the TM new funds were simply added to existing menus, allowing us to observe workers' active portfolio choices. In other cases, the funds were designed as the plan's default investment option for participants not making active investment choices.[2] And in still other cases, participants were automatically switched or "mapped" into the TM funds from prior risk-based or static allocation (SA) lifecycle funds. The result is a robust combination of employer-designated default options, plan menu changes, and active choice by workers.

Three key findings emerge from our analysis. First, consistent with behavioral models of portfolio choice, employers do shape adoption patterns of new 401(k) investment funds through mapping effects and default fund designations. Sponsor decisions influence not only the adoption rate, but also whether participants tend to be "pure" adopters who hold only lifecycle funds, or "mixed" adopters holding them in conjunction with other funds. "Choice architecture" (Benartzi, Peleg and Thaler, 2007) does matter. However, second, not all participants are as passive as suggested by behavioral models. There are elements of rational choice by new plan

entrants, who encounter the TM options for the first time upon entering the plan. And there are elements of constrained rational choice as TM funds are voluntarily selected by existing employees with low financial literacy characteristics. Menu and default effects do not explain all portfolio allocation decisions. Third, participants who adopt lifecycle funds have their retirement saving portfolios change in measurable ways, even though the TM funds do not add new asset classes to the plan menu. Thus adding TM funds reshapes the age distribution of equity exposure, eliminates extreme zero- or all-equity positions, and alters the portfolio share of idiosyncratic versus systematic risk in adopters' portfolios. These portfolio results are consistent with either behavioral or information cost-constrained models of decision-making.

Our results imply that PPA-like regulation permitting plan sponsors to offer workers professionally-managed default investment funds will modify 401(k) investment patterns, but the rate of change will depend on how the funds are introduced. Offering lifecycle funds on a voluntary basis will gradually change investment behavior, as new hires elect them and as less financially literate employees are drawn to this investment solution. A more substantial impact will be obtained if lifecycle funds are designated as the plan default. And adoption rates will be still higher, and the rate of change in portfolios more dramatic, if the employer actively maps or shifts employees to the new default fund from other plan investments.

In what follows, we first briefly review relevant literature on 401(k) investment decision-making, and elicit several testable hypotheses from that literature. Next we describe our dataset and summarize the methodological approach. Subsequently we discuss who adopts life cycle funds and what impact lifecycle adoption has on savers' portfolio characteristics. A final section concludes.

Related Studies and Hypotheses

Why would participants adopt TM funds when they are introduced into 401(k) plan menus? Previous studies on 401(k) portfolio choice suggest three models of adoption behavior, including a rational agents' hypothesis, a behavioral or employer menu hypothesis, and a information-cost-constrained or financial illiteracy hypothesis. In this section, we explore the implications of each of these hypotheses.

There is some controversy in the theoretical and empirical literature about whether rational investors should adopt age-based portfolio allocation patterns. Early theoretical models argued against changing equity portfolio allocations with investor age. For instance, Samuelson (1969) and Merton (1969) point out that constant lifetime equity exposure is optimal, given standard risk aversion and iid asset returns. By contrast, more recent work by Viceira (2001) and others indicate that equity allocations should optimally decline with age, if one allows for illiquid human capital and borrowing constraints.[3] Empirical studies on actual equity allocations by age come to mixed conclusions. Ameriks and Zeldes (2004) discern little age-based variation in equity exposure in a sample of relatively highly-paid educators. Meanwhile, Agnew, Balduzi and Sunden (2003) find that equity allocations decline by about one percent per year of age, in their study of a single corporate-sector 401(k) plan.

If participants were rational agents in the Samuelson or Merton sense, they would not be expected to adopt TM funds at all, given the funds' age-based pattern of equity exposure. Conceivably, participants might still use the funds as part of their portfolio if the funds included previously unavailable asset classes. However, in our dataset, to be described in more detail below, the newly introduced TM funds only included asset classes previously offered to participants as individual 401(k) fund choices. Thus, the remaining rational agents' argument for

adopting TM funds is that investors do have a preference for age-based rebalancing, and that the type of rebalancing on offer matches their own preferences for such a feature. For such investors, holding a TM fund would be expected to reduce portfolio transaction costs – in our case, the time and effort associated with ongoing rebalancing. Thus, all other things equal, TM fund adopters would be more likely to be high-income participants, given the opportunity costs associated with their time and effort.[4] A corollary is that rational agents adopting TM Funds would experience no change in portfolio risk and return characteristics, inasmuch as the specific appeal of the funds is due solely to the convenience of age-based rebalancing, and not to their unique underlying investments.

A second hypothesis regarding lifecycle fund adoption, resulting from a behavioral economics perspective, posits that workers' portfolio choices are driven by employer menu decisions. Prior studies have suggested that participants spread their money evenly among 401(k) plan fund offerings using a "1/n" heuristic (Benartzi and Thaler, 2001) or across a subset of funds using a "conditional 1/n" rule (Huberman and Jiang, 2006). The fraction of the menu in specific types of assets, such as equities or high-cost active equity funds, also appears to shape participant asset allocations (Bernartzi and Thaler, 2001; Brown, Liang and Weisbenner, 2006).[5] More broadly, participant decisions are influenced by the "choice architecture" implicit in the design of a 401(k) plan (Benartzi, Peleg and Thaler, 2007). A possible explanation for these menu-based effects is inertia, which has been noted in retirement planning generally (O'Donoghue and Rabin, 1999 and 2001), in 401(k) investment choice (Madrian and Shea, 2001), and in ongoing rebalancing of portfolios (Ameriks and Zeldes, 2004; Agnew, Balduzzi, and Sunden, 2003, and Mitchell, Mottola, Utkus, and Yamaguchi, 2006a and 2006b).

Participants appear to "go with the flow" and often fail to make active investment choices in 401(k) plans.

These studies suggest a second hypothesis, namely that introducing lifecycle funds will reshape portfolios purely due to sponsor menu effects - in our case, when employers map workers into TM funds from prior SA funds, or when they designate TM funds as a plan default. Evidence supportive of this hypothesis would include finding that mapping and default effects would influence not only lifecycle plan adoption, but also alter fundamental risk and/return characteristics of the portfolios.

A third hypothesis regarding lifecycle fund adoption arises from the literature on financial illiteracy and participant decision-making, which suggests a model of rational choice subject to information costs. 401(k) participants readily admit they are inexperienced in making investment decisions (Fontaine, 2006; Vanguard, 2003), they are unfamiliar with common financial concepts (Lusardi and Mitchell, 2007), and they regularly misunderstand investments, believing, for instance, that money market funds include stock investments or that employer stock is safer than a diversified equity portfolio (John Hancock, 2002). More broadly, many lower-income and lower-wealth households fail to hold any equity at all although economic models predict they would be better off with at least a small equity position (Campbell 2006).[6] Evidence in favor of this hypothesis would include the finding that TM adopters are most likely to be young, low wage, low wealth and female, where low levels of financial literacy are most concentrated.[7]

Data Set and Descriptive Statistics

To assess whether the introduction of lifecycle funds alters investment patterns, we investigate a unique panel dataset covering 258 defined contribution plans drawn from Vanguard's 401(k) recordkeeping system. Our full sample includes over 252,000 active participants in plans that introduced TM funds during 2003-05[8]; all participants entering and leaving the plans due to normal workforce turnover are included. The dataset is thus far richer than other research studies which have relied on experimental findings, aggregate plan flows, small plan samples, or cross-sectional-only data. Our full data set allows us to analyze adoption patterns when the TM funds are first introduced. As well we utilize a subset of around 25,000 TM adopters to assess the impact of TM funds on portfolio characteristics. This TM adopter sample includes participants who elected at least one TM fund and whom we observe both one month prior to and six months after the fund is introduced.[9]

Variables available for empirical analysis include a wealth of detail on participant 401(k) account balances, investment holdings and account contributions[10], as well as key socioeconomic characteristics including age, sex, household income, and non-retirement financial wealth.[11] Also available are important features about each plan's offered investment menu, including the number and types of investment funds offered and other plan design details. In addition our data set includes monthly returns for all investments offered in our plans over an eight-year period (including the three-year period under analysis as well as the five years preceding it).

Table I summarizes sample characteristics. Across the 258 plans, there is substantial diversity by age, income, 401(k) account balance, and non-retirement financial wealth. TM adopters are younger, more female, and earn less than the full sample; they also have lower 401(k) balances (Columns 1 and 2). Nearly one in five participants in the full sample is a new

entrant to the plan. Forty-four percent of those selecting TM funds are "pure" adopters, directing their entire contributions to TM funds; the remaining 56 percent are "mixed" adopters and contribute to TM funds along with other investment options (Columns 3 and 4).[12] On a purely descriptive basis, before controlling on other factors, pure adopters are again younger and more female, compared to mixed adopters, and again they have lower 401(k) balances and non-retirement financial wealth. Conversely, mixed adopters tend to be older, more affluent males.

Table I here

Panel A of Table II summarizes the attributes of the lifecycle funds introduced by employers in our dataset over the period under study. As indicated, each fund is named according to its target maturity date, and each involves different mixes of passively-managed US equity, international equity (both developed and emerging markets), and US high-quality bond funds. Total equity exposure in the funds is 89% for younger participants in the 2035 and 2035 Funds, versus 29% for older participants in the Income Fund (intended for those in their 60s nearing or in retirement). The underlying investments offered through the TM funds did not represent new asset classes or investment styles offered by the plans in our sample.[13]

Table II here

In our sample TM funds were introduced into 401(k) plans in different ways. For some plans, TM funds were the first type of lifecycle fund ever offered to participants. As indicated in Panel B of Table II, almost half (45%) of the full sample was introduced to TM funds *de novo*, while only 14% of the TM adopters were in this class. A large number of plans also previously offered static allocation (SA) or risk-based lifecycle funds, and sponsors varied in how they subsequently added TM funds. Some portion of our sample was offered TM funds on top of pre-existing SA funds (39% for the full sample; 51% for adopters), while the rest were switched or

"mapped" by their employer from SA to TM funds (16% v. 35%).[14] In the case of mapping from SA to TM funds, sponsors could either switch all participant SA balances and contributions into the new TM funds, or allow existing balances to remain undisturbed, while switching future contributions into TM funds. In either case, the new TM allocations would reflect the sponsor's decision to move the money rather than representing an active employee election. Finally, in some cases the employer designated the new TM funds as the plan default. The default option would influence those participants, principally new hires, who were either automatically enrolled, or who enrolled on a voluntary basis but refused to make an active investment choice.

Portfolio Characteristics

Table III describes the investment characteristics of TM adopters' portfolios "before" and "after" the TM funds were added to the menu—specifically, one month prior to adoption (time *t-1)* and six months later (time *t+6*). Panel A summaries the allocation of participant contributions by major asset class, including cash (money market or guaranteed investment contracts), bonds, balanced or lifecycle funds, US equities, employer stock, and international equities. The most notable feature is that many TM adopters contributed to balanced or SA lifecycle funds before the new menus were introduced; these funds accounted for 79% of pure adopters' and 35% of mixed adopters' contributions. This statistic again points to the importance of controlling on the prior presence of the pre-existing menu design in order to evaluate the impact of TM funds on participant behavior.

Table III here

Panel B of Table III reports mean values for three portfolio attributes measured for TM adopters, again on a before and after basis. The first attribute we examine is the percent of the

portfolio held in equity.[15] Before the change, our mean TM adopter held two-thirds of his contributions going to equities; six months later, equity allocations rose by 1.4% for all adopters before controlling on other factors. Pure adopters devoted somewhat less and mixed somewhat more to equity before the change. With the advent of TM funds, pure adopters changed their equity allocations slightly less (1.0% versus 1.8%), again before controlling on other factors.

The second portfolio attribute reported in Panel B of Table III shows how the participants' portfolios changed in terms of the overall systematic or risk-adjusted return. Systematic returns refer to the sum of the risk-free rate during the period, r_f, and each participant's factor return, or $r_{i,t}^e$. Factor returns are computed using a three-factor model based on US equities, US bonds and international equities because, as noted earlier, the TM funds in our dataset are composed of index-based funds mirroring these three asset classes. To calculate portfolio returns, we first construct a risk-loading matrix for all *k* investment options in our dataset. Specifically, we regress the excess return (over Treasury bill returns) for each of the *k* assets in our universe on three market indices: the value-weighted CRSP portfolio, the Lehman Brothers Aggregate Bond Index (LBA), and the Morgan Stanley Capital International (MSCI) Europe, Australia and Far East (EAFE) Index.[16] The systematic return for each 401(k) investment option is simply its factor exposure times the average factor returns over the period; the participant's factor return is simply the weighted average return of his or her factor exposures over the period.[17] The risk-free rate is added to the participant's factor return (and annualized) to arrive at the returns shown in column 2 of Panel B (Table III).

Two features stand out about the return calculations. One is that the returns rise across the board, for all adopters as well as for pure and mixed adopters, before controlling for other factors, particularly time effects. Second, the difference in returns between pure and mixed

adopters is small. For example, on a "before" basis, mixed adopters held 15% more equity than pure adopters' (70.7% is 15% higher than 61.4%), but their returns were only 2% higher (6.52% is 2% higher than 6.38%). This suggests that those who later became pure TM investors had, probably through SA and balanced fund holdings, successfully constructed more efficient portfolios with lower equity exposure but similar expected returns.[18]

The third portfolio attribute reported in Table III is the ratio of idiosyncratic portfolio risk as a fraction of total portfolio variance, $NSR/TV_{i,t}$.[19] This measure describes how much of portfolio variance is explained by nonsystematic or non-market factors. By definition, nonsystematic risk should be zero when all of a participant's contributions are directed to index-based TM funds. Not surprisingly, this measure of risk falls in Table III for all lifecycle plan adopters: it is eliminated for pure TM adopters, and it falls for mixed adopters.

Who Adopts TM Funds? A Multivariate Analysis

To explore the "treatment effect" associated with TM fund introduction, we estimate the probability of lifecycle adoption, $LCAdopter_{i,j,t}$ which refers to the probability that the *i*th participant holds a TM fund in the *j*th plan in month *t.* The multivariate model is as follows:

$$LCAdopter_{i,j,t} = \alpha PARTICIPANT + \beta PLAN + \gamma TREATMENT + \upsilon_i + \tau_t + \omega_j + \varepsilon_{i,j,t} \qquad (1)$$

where the dependent variable $LCAdopter_{i,j,t}$ takes a value of 1 if the participant invests in a TM fund in month *t*, and 0 otherwise. The mean value of this variable is 15.1%.[20]

The model includes controls on key socioeconomic characteristics including age, income, sex, and non-retirement financial wealth. The *PARTICIPANT* vector also includes a new plan entrant identifier, *New Entrant,* equal to 1 if the participant entered the plan after the TM funds were offered (0 otherwise).[21] To control on cross-plan differences, the *PLAN* vector includes the

number of fund choices available in each plan, a dummy indicating company stock is available in the 401(k) plan, and an indicator of loan availability. The *TREATMENT* vector captures several factors associated with the particular way in which TM funds were introduced. The *Time Count* variable (and that same variable squared) indicates how many months had elapsed since the TM funds were introduced. For reasons noted above, we also control on *SA_Before* which indicates whether static allocation funds had been previously offered; and a *Default* indicator indicates whether the new TM funds had been designated as the default investment option. The econometric models also correct for plan-level heteroskedasticity (ν_i), time fixed effects (τ_t), and industry fixed effects, along with missing data controls.

Table IV provides estimates of a multivariate Probit model comparing TM adopters with other participants, to determine what factors are linked to life cycle fund adoption. We first observe that sponsor-driven menu changes profoundly influence participation adoption, consistent with a behaviorally-motivated employer menu hypothesis. The largest marginal effects are associated with the prior availability of SA funds in the plan menu; the presence of such funds, whether through mapping by the sponsor or awareness of such funds by participants, raises TM adoption by more than double (16.9% versus the dependent variable mean of 15%). When an employer designates TM funds as the default investment, this boosts the likelihood that participants will adopt TM by 11.4%, or three-quarters the pre-TM mean. We term this the "PPA effect," indicative of how much participation in TM funds may increase as a result of sponsor decisions to select a TM default fund under the Pension Protection Act. The time since the menu was enhanced is also a related factor as indicated by *Time Count*, the number of months since the funds were introduced. Participation rises by 2% after 10 months of having the TM funds on offer.

Table IV here

While sponsor decisions are important, there is also strong evidence of participants making active portfolio choices. One group displaying active decision-making are new plan entrants, who are 7.1% more likely to adopt TM funds after controlling for sponsor-driven menu and default effects. New entrants appear closest to rational agents making independent portfolio choices upon encountering the 401(k) menu for the first time. Our finding on new entrants is consistent with other studies that have reported that new plan entrants tend to change portfolio behavior more in light of current financial market conditions or adopt new 401(k) plan features (Vanguard, 2003 and 2006). Table IV also demonstrates that TM funds are more likely to be adopted by participants with characteristics typically associated with low levels of financial literacy. These include young, lower paid, and female participants, as well as those with low 401(k) balances and low levels of non-financial retirement wealth. These findings are supportive of our financial literacy hypothesis, of rational agents constrained by information costs. TM funds, by their very simple design, eliminate such information constraints and replace all portfolio choices with the selection of a single expected retirement year. Our findings are also inconsistent with our rational agents' hypothesis, which suggested that higher-income participants would select these funds due to the opportunity costs associated with rebalancing. Interestingly, offering more funds in the 401(k) menu slightly reduces participation in TM funds. The effect is small (having 10 additional funds means a 2% lower chance of holding TM funds) but it does offer some modest support for the finding from the prior literature that participant holdings are influenced the fraction of the plan investment menu represented by a given fund option.

Next we separately analyze the differences between pure versus mixed lifecycle adopters. Table V reports results from a multinomial Logit model where $LCAdopter_{i,j,t}$ is equal to 1 if the participant is a mixed adopter; 2 if he is a pure adopter; and 0 if he is a nonadopter (the reference group). Empirical results are reported as marginal effects. As before, there are potent effects of sponsor menu and default fund selections, and again new entrants are particularly likely to be TM adopters. The differences in estimated coefficient magnitudes between the two types of investors are also revealing. If SA funds were previously offered, this is more likely to result in mixed adoption than in pure adoption (5.1% v. 3.7%). One possible explanation is that participants were more likely to adopt SA funds rather than TM funds on a mixed basis. We also see, unsurprisingly, that defaulting workers into TM funds is more likely to lead to pure rather than mixed adoption.

Table V here

There are also interesting demographic differences between pure and mixed adopters. Pure adopters are more likely to be new plan entrants, and also more likely to be female, younger, lower income, and have lower 401(k) and non-retirement wealth, than participants who do not adopt TM funds. This pattern seems consistent with the conclusion that this group is most in need of professional financial advice, perhaps because of low financial literacy. Mixed adopters are also likely to be younger and female, but they tend to be middle income and middle-wealth participants, compared with non-adopters. The mixed adopters results are therefore subject to conflicting explanations. On the one hand, mixed adopters may be engaged in naïve diversification by allocating only a portion of their portfolio to a "portfolio in one fund" solution. On the other hand, mixed adopters are more affluent, and so are more likely to be more financially literate. Mixed adoption could be evidence of a more sophisticated approach to

investing.[22] To determine how TM funds fit into mixed investors' portfolios, more research is required into actual investment intentions.

In sum the evidence reveals two influences in 401(k) plan investment patterns. Clearly employer-driven menu and default patterns help shape participant choice of lifecycle funds, confirming the behavioral hypothesis. We find little support for the pure rational agent hypothesis that affluent participants facing large opportunity costs from rebalancing will be most likely to adopt lifecycle funds. Yet there is also a substantial group of participants actively selecting the new funds, mainly new entrants and participants who appear to be less financially literate. Finally, while pure adopters seem to be perceive lifecycle funds as suitable for their needs, mixed adopters appear to have more complex motivations.

Portfolio Effects of Adding Lifecycle Funds

Next we turn on an assessment of how lifecycle fund adopters' portfolios change when lifecycle funds are introduced into their portfolios. Using a difference-in-difference approach, each participant is observed one month before and six months after adopting the TM fund. Three dependent variables are of particular interest, namely the participant's percentage allocation to equities, his portfolio's systematic returns, and his share of nonsystematic risk as a percent of total portfolio variance (NSR/TV). Each of these dependent variables, summarized in a vector we term $PORTFOLIO_{i,j,t}$, taking the following form:

$$PORTFOLIO_{i,j,t} = \alpha PARTICIPANT + \beta PLAN + \gamma TREATMENT + \upsilon_i + \tau_t + \omega_j + \varepsilon_{i,j,t}. \qquad (2)$$

Model A includes just these terms; Model B adds interaction terms (*INTERACTION*) to test whether specific groups display differential treatment patterns when lifecycle funds are introduced. For example, *LC_Treat*Young* allows us to examine the differential impact of TM

treatment on participants under age 35. For this difference-in-difference approach we must exclude the *DEFAULT* and *NEW ENTRANT* treatment variables: all participants are observed both before and after the lifecycle treatment effect, so we cannot observe either true default effects or the entry of new hires into the plan.

Table VI summarizes estimates for the equity allocation models, differentiating results for pure and mixed adopters. The variable *LC_Treat* in Model A captures the simple change in equity allocation after controlling for differences in participant and plan features, timing and industry fixed effects, and plan-level heteroskedasticity. In Model A, all else constant, pure adopters devote less to equity (1.8 percent) but no change is seen for mixed adopters. Model B adds treatment interactions for participant and plan characteristics, the most important of which is with respect to age. Now it is clear that for pure and mixed adopters, younger workers invest more in equity after TM funds are introduced (*LC_Treat* + *LC_Treat*Young*), while middle-aged and older people reduce their equity share. Figure 1 summarizes the age effects; the old-young difference increases by 8-10 percentage points. It is worth noting that the changes in equity shares by age remains meaningful for mixed adopters, who on average direct one-third of their portfolio contributions to TM funds.

Table VI and Figure 1 here

Not only does the overall allocation to equity change when TM funds are introduced, but the distribution also becomes less dispersed as shown in Figure 2 for both plans offering TM funds *de novo* (top panel) and those offering SA funds previously (bottom panel). (Corresponding statistics measuring the dispersion of equity allocations are presented in Table A1 in the Appendix.) When TM funds are offered *de novo,* participants had previously clumped their equity holdings at two focal points, namely 0 and 100%, with another group holding a mid-

range of equities (61-65%, a typical allocation in many balanced funds). After the new funds are offered, adopters' portfolios now concentrate around the five key target percentages embodied in the main TM fund offerings. (Of the six funds offered, two had near-identical asset allocations.) In fact, the cross-sectional standard deviation of equity allocations among pure adopters falls by half, from 34 to 16 percent, after TM funds are offered. For mixed adopters, here too, the zero and all-equity allocations are mostly eliminated, though the changes are attenuated. Overall, the standard deviation of equity allocation distributions for adopters falls by one-quarter.[23]

Figure 2 here

Next we analyze expected returns and risk characteristics before and after TM funds are offered. Table VII reports results for Models A and B, similar to those in Table VI. The first two columns show that pure adopters can expect returns to rise by 19-21 basis points per year when they shift to an all-TM portfolio. Also interesting are the changes by age, with young pure adopters seeing expected returns rise by an annualized 13 basis points (.0019-.0013). By contrast, older pure adopters can expect lower returns by 25 basis points (.0019-.0011) per year, partly due to their having more cash at older ages.[24] For mixed adopters, depicted in the next two columns of Table VII, changes in returns are not statistically significant.

Table VII here

The second half of Table VII indicates how portfolios nonsystematic risk share (NSR) changes when TM funds are introduced. Not surprisingly, it virtually disappears for pure adopters, who move all of their contributions to an all-index life cycle fund. Specifically for pure adopters, nonsystematic risk is 6 percent of total variance before TM fund adoption; the marginal effect of shifting to TM funds is a negative 5.1 percent. The NSR share falls less for younger participants (-2.9%) than for older participants (-5.2%). Changes for mixed adopters are

more notable: after investing in TM funds, their NSR risk share declines by over 40% (a marginal effect of -8.3% on a mean of 19.9%). Accordingly, even affluent mixed adopters who use TM funds for only part of their portfolios can experience a meaningful reduction in nonsystematic risk exposure.

These results, we believe, are inconsistent with the pure rational agent model of TM fund adoption, and strengthen the behavioral and information-cost or literacy hypotheses. Introducing lifecycle funds in our sample does not expand the range of capital market assets that plan participants could elect. Yet they result in marked changes to portfolio and return characteristics. That is, equity allocations change materially by age as a result of sponsor menu changes, for both pure and mixed TM adopters. Pure adopters see systematic returns rise; both pure and mixed adopters see a large decline in the portfolio share of idiosyncratic risk. These findings suggest that these funds help those laboring under financial illiteracy constraints, perhaps by eliciting or making more obvious the notion of age-based equity variation. They also confirm behavioral menu-driven effects where introducing new lifecycle funds triggers changes in the risk and return characteristics of participants' portfolios.

Discussion and Conclusions

In recent years, sponsors have expanded their use of lifecycle funds within 401(k) plans in an effort to improve 401(k) portfolio outcomes. At the same time, federal retirement policy, through the 2006 Pension Protection Act, is likely to encourage greater reliance on risky default investments for participants, including TM lifecycle funds. TM-type funds have been proposed for the Federal Thrift Savings Plan for federal government employees, some state defined contribution schemes, and even a defined contribution model under the US Social Security

system. Other countries including Chile already offer target maturity-type funds in their national defined contribution systems.

The introduction of such funds into 401(k) plans allows us to assess worker portfolio allocations in a rich decision-making environment, including sponsor-initiated default choices, menu changes, and active choice by workers. This paper demonstrates that while behavioral models of decision-making do dominate explanations of 401(k) portfolio allocations, there are also elements of rational and information cost-constrained choice. First, sponsor-initiated menu changes have a powerful effect on investor behavior, particularly when the TM funds are designated as the default, or when the sponsor chooses to map participants from other options to the TM funds. These sponsor decisions not only influence adoption rates, but they also influence whether participants hold lifecycle funds as pure adopters or combine them with other funds in a mixed strategy. These results are consistent with a behavioral hypothesis regarding the effect of menu design and employer decisions on participant portfolios. Second, at the same time, many plan participants do make active choices about their pension investments, so menu and default effects are an incomplete explanation for 401(k) allocation choices. Specifically, new entrants to 401(k) plans making active choices are more likely to adopt TM funds. In addition, a particular subset of existing workers – younger, less affluent, and female participants – appear to elect lifecycle funds because of their essential simplicity, consistent with a model of choice constrained by information costs.

Third, among existing participants switching to lifecycle funds from other portfolios, lifecycle fund adoption does materially change portfolio characteristics. Specifically, it narrows the distribution of equity exposure, eliminating 100% and zero-equity portfolios, while enhancing the age distribution of equity exposure. Further, it reduces participants' portfolio

idiosyncratic risk. These results further strengthen the diagnosis of both behavioral and information-cost or literacy-constrained models among TM fund adopters. The results undermine the narrowly rational agent argument for adoption based on the notion of convenient age-based rebalancing, and the opportunity costs incurred by high-wage workers in engaging in such portfolio activity.

Ultimately, our results suggest that strategies for improving portfolio allocations, such as default fund rules proposed under the Pension Protection Act, will vary in efficacy and speed depending on the path taken. How quickly 401(k) participant investment patterns over time will depend on how the funds are introduced, and also the composition of each firm's workforce. Providing TM funds on a voluntary basis alone changes plan investment behavior only gradually, via new plan entrants (where the rate of change will depend on workforce turnover), and via low-literacy participants drawn voluntarily to this new investment solution. If an employer designates lifecycle funds as a default, it will further raise adoption. And if the employer shifts or maps participants from their existing portfolios to something like an age-based lifecycle fund, this will result in the largest and most rapid change in portfolio characteristics.[25]

Ultimately, our findings underscore the fact that even with sponsor-driven menu effects and default decisions, active decision-making by workers remains important as well. While the US 401(k) system is gradually shifting toward greater reliance on default investment choices, it remains the case that many millions of existing participants make investment choices on their own. In the end, it will be their behavior over time, not solely sponsor choices, that will determine how quickly 401(k) portfolio allocations change in response to the introduction of a novel investment feature like lifecycle funds.

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Table I. Characteristics of the Full Sample Offered Target Maturity [TM] Funds and the Subsample of TM Adopters

			Subset of TM Adopters	
	Full Sample (Offered TM) *1*	**Adopter Sample** (Adopted TM) *2*	**Pure TM Adopters** *3*	**Mixed TM Adopters** *4*
Sample size				
Number of plans	258	251	228	234
Number of participant accounts	252,980	24,612	10,750	13,862
Age				
Young (< 35)	25.4%	27.8%	32.7%	24.1%
Middle (35 to 55)	59.0%	59.2%	55.1%	62.5%
Old (> 55)	15.6%	12.9%	12.3%	13.5%
Sex				
Male	45.3%	41.3%	31.3%	49.1%
Female	26.1%	30.3%	32.6%	28.5%
Missing	28.7%	28.4%	36.1%	22.5%
Income				
Low (< $62.5K)	19.4%	22.8%	25.3%	20.9%
Medium ($62.5-$87.5K)	39.1%	39.4%	44.2%	35.7%
High (> $87.5K)	41.5%	37.7%	30.4%	43.4%
Job tenure				
% new entrants	18.3%	na	na	na
401(k) balance (mean)	$ 64,065	$ 50,032	34,289	62,240
Non-retirement financial wealth				
Poor (< $7.3K)	42.3%	41.3%	44.2%	39.1%
Average ($7.3-$61K)	34.9%	36.7%	35.6%	37.6%
Rich (> $61K)	22.8%	21.9%	20.2%	23.3%
Plan design features (% of participants)				
Company stock offered	30.8%	26.4%	na	na
Loan offered	66.9%	61.9%	na	na
No. of funds offered (mean)	34.2	33.0	na	na

Note: Participant characteristics measured at 12/05 for full sample and six months after TM introduction for Adopter sample.

Table II. Lifecycle Funds Overview

A. Lifecycle Funds Offered*

	% US equities	% inter-national equities	% domestic bonds	TOTAL	*% total equities*
2045 Fund	71%	18%	11%	100%	*89%*
2035 Fund	71%	18%	11%	100%	*89%*
2025 Fund	63%	16%	21%	100%	*79%*
2015 Fund	50%	13%	37%	100%	*63%*
2005 Fund	35%	9%	56%	100%	*44%*
Income Fund	24%	5%	71%	100%	*29%*

*As of 9/07

B. Lifecycle Funds Treatments

	PLANS		Participants		TM adopters	
	No.	%	No.	%	No.	%
1. Introduction of TM *de novo*	117	45%	113,560	45%	3,541	14%
2. Addition of TM to SA	83	32%	99,201	39%	12,509	51%
3. Switch from SA to TM	58	22%	40,219	16%	8,562	35%
Total TM offered	258	100%	252,980	100%	24,612	100%

Table III. Contribution Allocations and Portfolio Risk/Return Characteristics Before and After the Introduction of TM Funds: All Adopters, Pure TM Adopters, and Mixed TM Adopters

A. Contribution Allocations

		Cash (MM, GIC)	*Bond*	*Balanced & Life Cycle*	*US Equity*	*Company Stock*	*International Equity*
All TM Adopters	Before	7.1%	5.2%	54.2%	27.9%	2.7%	2.9%
	After	3.7%	3.6%	66.1%	21.7%	2.3%	2.7%
	Change	-3.4%	-1.7%	11.9%	-6.2%	-0.4%	-0.3%
Pure TM Adopters	Before	4.9%	2.9%	79.4%	11.3%	0.5%	0.9%
	After	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
	Change	-4.9%	-2.9%	20.6%	-11.3%	-0.5%	-0.9%
Mixed TM Adopters	Before	8.7%	7.0%	34.7%	40.8%	4.3%	4.5%
	After	6.5%	6.3%	39.8%	38.6%	4.0%	4.8%
	Change	-2.2%	-0.7%	5.1%	-2.2%	-0.3%	0.2%

B. Portfolio Risk/Return Characteristics

		Equity Allocations	*Systematic Returns*	*NSR/TV**
All TM Adopters	Before	66.6%	6.46%	13.8%
	After	68.1%	6.70%	10.0%
	Change	1.4%	0.24%	-3.8%
Pure TM Adopters	Before	61.4%	6.38%	6.0%
	After	62.4%	6.63%	0.9%
	Change	1.0%	0.25%	-5.0%
Mixed TM Adopters	Before	70.7%	6.52%	19.9%
	After	72.5%	6.76%	17.1%
	Change	1.8%	0.24%	-2.8%

Note: * NSR/TV refers to portfolio nonsystematic risk as a percent of total variance; see text.

Table IV. Multivariate Probit Analysis of the Probability of Being a TM Adopter
(Dependent variable = 1 if TM Adopter, 0 Else)

	Mean	Coefficient		Marginal Effect
Socioeconomic Factors				
Young	23%	0.120	***	2.3%
Old	16%	-0.102	***	-2.0%
Male	45%	-0.066	***	-1.3%
Low_Income	20%	-0.029	***	-0.6%
High_Income	40%	-0.004		-0.1%
Poor_Wealth	38%	0.035	***	0.7%
Rich_Wealth	26%	-0.092	***	-1.8%
Log Balance	$ 9.8	-0.063	***	-1.2%
New Entrant	11%	0.368	***	7.1%
Plan Design				
Company Stock Offered	26%	0.101	***	1.9%
Loan Offered	59%	-0.030		-0.6%
Number of funds	38.9	-0.011	***	-0.2%
Lifecycle Treatment				
SA_Before	61%	0.878	***	16.9%
Default	11%	0.592	***	11.4%
Time Count	9.3	0.011	***	0.2%
Time Count Squared	120.7	0.000	***	0.0%
Participant Clustering		Yes		
Time Fixed Effect		Yes		
Industry Fixed Effect		Yes		
Observations		3,178,373		
Number of Clusters		252,980		
-2LogL		2,300,773		
Pseudo-R Squared		11.60%		

Notes: ** Significant at the .05 level; *** Significant at the .01 level. Reference category for income is middle; for wealth is medium; for sex is female (missing also controlled). Mean of dependent variable 15.1 percent.

Table V. Marginal Effects from Multivariate Logit Model of the Probability of Being a Pure or Mixed TM Adopter (Reference Group: Non adopter)

		Pure Adopter	**Mixed Adopter**
Dependent variable mean		8.58%	7.69%
	Mean	*Marginal Effect*	*Marginal Effect*
Socioeconomic Characteristics			
Young	24%	0.9% ***	0.5% ***
Old	16%	-0.5% ***	-0.7% ***
Male	43%	-0.8% ***	-0.2% ***
Low_Income	20%	0.2% **	-0.3% ***
High_Income	39%	-0.2%	0.0%
Poor_Wealth	38%	0.5% ***	0.0%
Rich_Wealth	25%	-0.8% ***	-0.4% ***
Log Balance	$ 9.8	-0.7% ***	0.0% **
New Entrant	11%	2.4% ***	1.3% ***
Plan Design			
Company Stock Offered	31%	-1.6% ***	1.2% ***
Loan Offered	61%	-1.2% ***	0.4% ***
Number of funds	37.6	-0.1% ***	0.0% ***
Lifecycle Treatment			
SA_Before	57%	3.7% ***	5.1% ***
Default	10%	5.4% ***	1.5% ***
Time Count	8.6	0.4% ***	-0.1% ***
Time Count Squared	120.7	0.0% ***	0.0% ***
Participant Clustering		Yes	Yes
Time Fixed Effect		Yes	Yes
Industry Fixed Effext		Yes	Yes
Observations		3,178,373	3,178,373
Number of Cluster		252,980	252,980
-2LogL		3,354,106	3,354,106
Psuedo-R Squared		15.10%	15.10%

Note: See Table 3.

Table VI. Marginal Effects from Multivariate Model of TM Treatment Effects on Portfolio Equity Allocation: Pure and Mixed TM Adopters

	Pure Adopters		Mixed Adopters	
Dependent variable means	Model A	Model B	Model A	Model B
Before treatment	61.4%		70.7%	
After treatment	62.4%		72.5%	
Unadjusted difference	1.0%		1.8%	
Socioeconomic Factors				
Young	0.006 ***	0.022 ***	0.052 ***	0.031 ***
Old	-0.105 ***	-0.085 ***	-0.078 ***	-0.060 ***
Male	0.010 **	0.019 ***	0.019 ***	0.023 ***
Low_Income	0.004	0.004	-0.015 ***	-0.017 ***
High_Income	0.001	0.004	0.006	0.007
Poor_Wealth	0.007	-0.005	-0.012 ***	-0.016 ***
Rich_Wealth	0.010 **	0.013 **	0.005	0.001
Log Balance	0.006 ***	0.005 ***	0.016 ***	0.016 ***
Plan Design				
CS_Offer	-0.006	-0.004	0.022 ***	0.022 ***
Loan_Offer	0.074 ***	0.074 ***	0.011	0.011
Nfund	0.005 ***	0.005 ***	0.000	0.000
SA_Before	-0.061 ***	-0.062 ***	0.005	0.004
Treatment				
LC_treat	-0.018 ***	-0.032 ***	-0.006	-0.013 **
Interactions				
LC_treat*Young		0.064 ***		0.043 ***
LC_treat*Old		-0.040 ***		-0.035 ***
LC_treat*Low_Income		0.000		0.004
LC_treat*High_Income		-0.004		0.000
LC_treat*Male		-0.016 ***		-0.008 ***
LC_treat*Poor_Wealth		0.019 ***		0.007
LC_treat*Rich_Wealth		-0.008		0.008
Clustering at Participant-level	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effext	Yes	Yes	Yes	Yes
Observations	21,500	21,500	27,724	27,724
# of Participants	10,750	10,750	13,862	13,862
R Squared	19.3%	20.2%	5.7%	6.0%

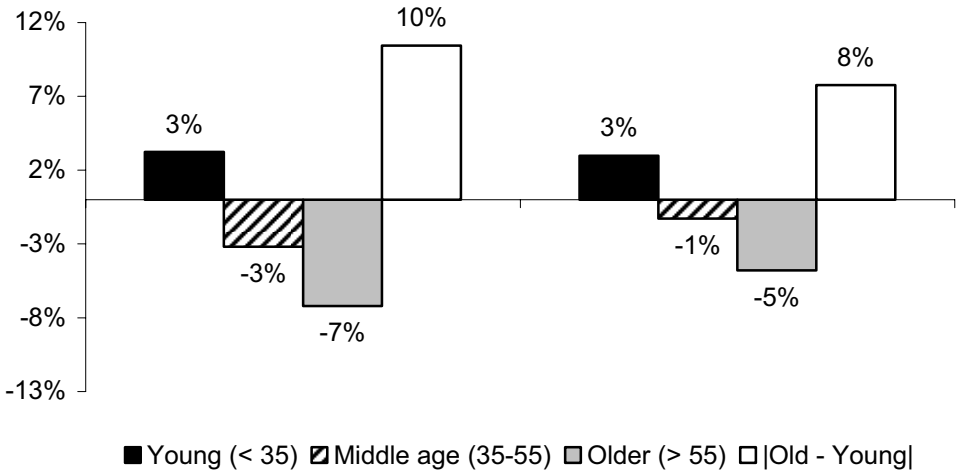
Note: See Table 3

Table VII. Marginal Effects of Multivariate Model of TM Treatment Effects on Portfolio Risk and Returns: Pure and Mixed TM Adopters

	Returns				NSR/TV*			
	Pure Adopters		***Mixed Adopters***		***Pure Adopters***		***Mixed Adopters***	
Variable	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B
Before treatment	6.38%		6.52%		6.0%		19.9%	
After treatment	6.63%		6.76%		0.9%		17.1%	
Unadjusted difference	0.25%		0.24%		-5.0%		-2.8%	
Socioeconomic Factors								
Young	0.0005 ***	0.0008 ***	0.0016 ***	0.0014 ***	0.000	-0.005 ***	0.004	0.004
Old	-0.0195 ***	-0.0023 ***	-0.0017 ***	-0.0012 ***	0.007 ***	0.018 ***	0.005	0.006
Male	0.0001	-0.0004 **	0.0010 ***	0.0010 ***	0.001	0.021 ***	0.002	0.009 **
Low_Income	0.0001	0.0002	-0.0003	-0.0001	-0.002	-0.006 **	0.010 ***	0.008
High_Income	0.0001	0.0001	0.0000	0.0002	-0.003	-0.002	0.004	0.004
Poor_Wealth	0.0002	-0.0001	-0.0006 ***	-0.0007 ***	-0.002	0.003	-0.014 ***	-0.009 **
Rich_Wealth	0.0002 **	0.0005 ***	0.0001	-0.0003	0.001	-0.003	-0.003	-0.005
Log Balance	0.0001 ***	0.0001 ***	0.0004 ***	0.0004 ***	0.003 ***	0.002 ***	0.005 ***	0.005 ***
Plan Design								
CS_Offer	0.0001	0.0001	0.0032 ***	0.0032 ***	0.035 ***	0.034 ***	0.068 ***	0.067 ***
Loan_Offer	0.0011 ***	0.0011 ***	0.0001	0.0001	-0.009 ***	-0.007 ***	-0.006	-0.006
Nfund	0.0001 ***	0.0001 ***	0.0000 **	0.0000	0.000	0.000 **	0.001 ***	0.001 **
SA_Before	0.0011 ***	0.0011 ***	-0.0009 ***	-0.0009 ***	-0.074 ***	-0.075 ***	-0.055 ***	-0.055 ***
Treatment								
LC_treat	0.0021 ***	0.0019 ***	-0.0003	-0.0003	-0.051 ***	-0.039 ***	-0.083 ***	-0.075 ***
Interactions								
LC_treat*Young		-0.0006 ***		0.0002		0.010 ***		-0.002
LC_treat*Old		0.0006 **		-0.0011 **		-0.023 ***		-0.001
LC_treat*Low_Income		-0.0002		-0.0003		0.008 ***		0.005
LC_treat*High_Income		0.0000		-0.0005 **		0.000		0.001
LC_treat*Male		0.0011 ***		0.0000		-0.039 ***		-0.013 ***
LC_treat*Poor_Wealth		0.0005 ***		0.0003		-0.009 ***		-0.011 ***
LC_treat*Rich_Wealth		-0.0007 ***		0.0009 ***		0.009 ***		0.003
Observations	21,500	21,500	27,724	27,724	21,500	21,500	27,724	27,724
# of Participants	10,750	10,750	13,862	13,862	10,750	10,750	13,862	13,862
R Squared	14.4%	14.8%	35.6%	35.6%	27.7%	29.2%	30.9%	31.0%

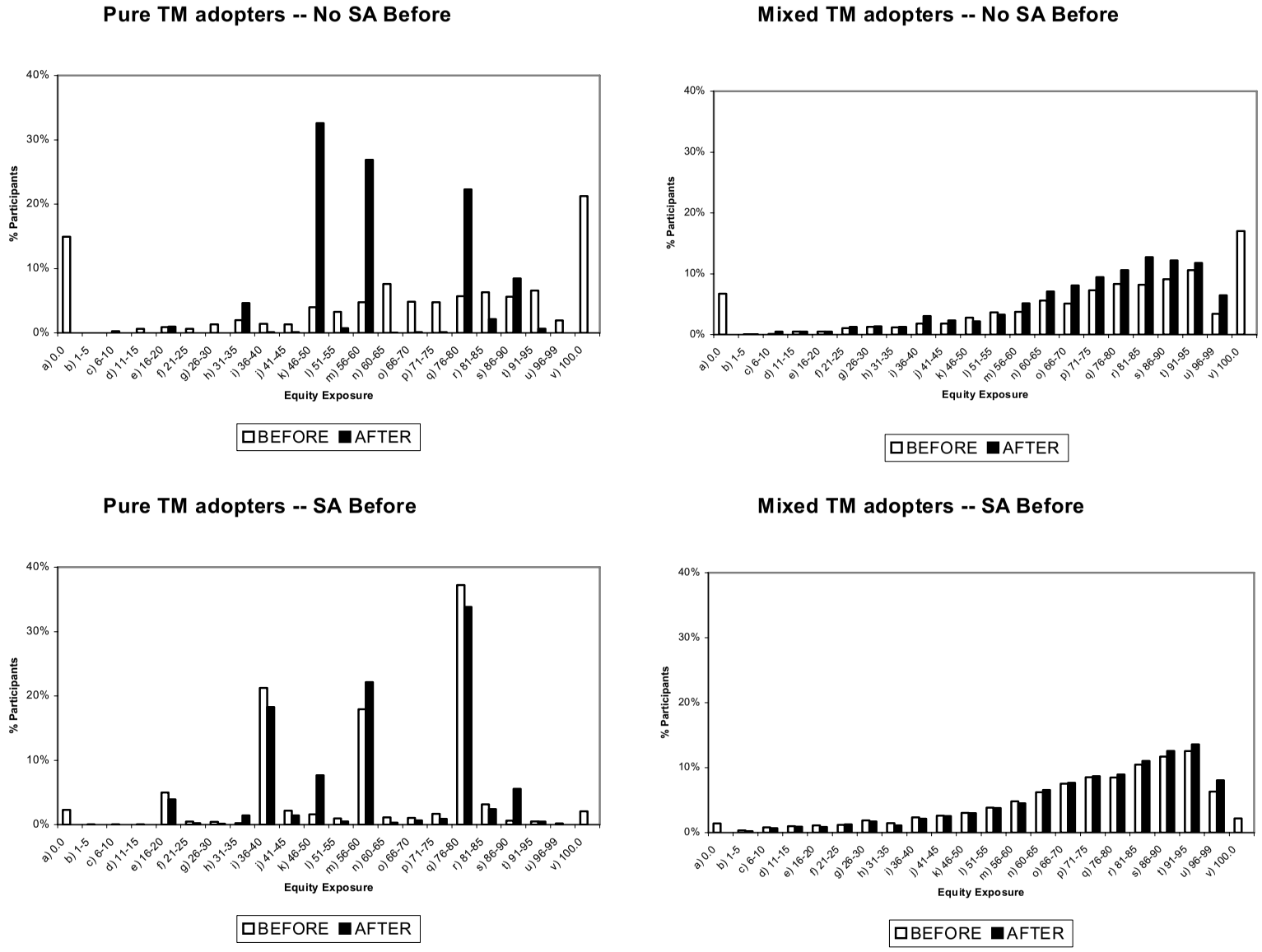
Note: See Table 3

Figure 1. Change in Equity Proportion After TM Fund Introduction: Patterns by Age



Note: Authors' tabulations, see text.

Figure 2. Equity Allocations of TM Adopters: Before and After Adoption



Note: Authors' tabulations, see text

Appendix Table A1. Cross-sectional Variation in Equity Exposure

	Pure adopters		Mixed adopters		All adopters	
	Mean	*St. Dev.*	*Mean*	*St. Dev.*	*Mean*	*St. Dev.*
1. TM adopters / no SA before						
Before	64.2%	0.34	71.8%	0.28	68.0%	0.31
After	62.8%	0.16	72.6%	0.19	67.7%	0.18
% Change	*-2%*	*-53%*	*1%*	*-32%*	*-1%*	*-42%*
2. TM adopters / SA before						
Before	60.9%	0.22	70.6%	0.23	66.4%	0.23
After	62.4%	0.19	72.5%	0.21	68.2%	0.21
% Change	*2%*	*-14%*	*3%*	*-9%*	*3%*	*-9%*
3. All TM adopters						
Before	61.4%	0.24	70.7%	0.24	66.6%	0.24
After	62.4%	0.18	72.5%	0.2	68.1%	0.2
% Change	*2%*	*-25%*	*3%*	*-17%*	*2%*	*-17%*

Endnotes

[1] In this paper we reserve the term "lifecycle fund" for the TM concept. The lifecycle concept is sometimes broadened to include risk-based static allocation (SA) funds, such as conservative, moderate or aggressive funds. SA funds are increasingly referred to as "lifestyle" funds.

[2] Participant accounts may be invested in a default fund in three ways. First, in a plan with voluntary choice, participants may elect to contribute to the plan, but fail to make an investment election, and so will be invested in the default option. Second, the sponsor may require participants to make a separate investment election for non-matching employer contributions, such as a profit-sharing contribution, to the plan; participants who fail to make an election are invested in the default option. Third, the participant may be automatically enrolled in the plan and invested in the default fund.

[3] Viceira (2007) also notes that the "age-based" approach to investing is most appropriate for workers whose labor earnings volatility is low and relatively uncorrelated with equity. Recent work by Bodie and Treussard (2007) and Horneff et al. (2007) recommends a "hump-shaped" pattern of equity exposure by age due to changes in human capital over the lifetime.

[4] Within the 401(k) plans in our study, participants incur no brokerage commission or other market-related transaction costs (as well as no taxes) when switching among funds, and so transaction costs are related solely to time and effort.

[5] 401(k) menus may also influence participant choices through "choice overload," such that participants offered too many choices either fail to participate or opt for more familiar (i.e., conservative) investments (Iyengar, Huberman and Jiang, 2004; Iyengar and Jiang, 2006).

[6] Adopting too-conservative portfolios can be costly, reducing expected real returns by as much as 350 basis points per year for younger and less affluent participants (Mottola and Utkus, 2007).

[7] A direct test of the role of financial literacy would require actual data on both adopters and nonadopters financial abilities; lacking this, we can indirectly associate literacy with demographic characteristics found in other studies to proxy for financial knowledge and experience.

[8] Active 401(k) participants are those who are currently contributing to their employer's retirement plan.

[9] Because we observe participants six months after TM funds are offered, both the full sample and subset of adopters include only plans which introduced TM funds by June 2005. The TM adopter subset has 7 fewer plans because these had no TM adopters as of December 2005. Of the 252,000 participants in the full dataset, 189,968 were included in their plan both one month before and six months after the TM funds were introduced.

[10] We focus our portfolio analysis on 401(k) contributions rather than fund balances because contributions are more reflective of forward-looking intentions and unbiased by prior holdings.

[11] Household income is imputed based on zip codes as is non-retirement financial wealth, and is provided by the IXI Company.

[12]Over 95% of pure adopters contribute to only one TM fund; mixed adopters contribute to 4.5 funds on average.

[13] Prior to the introduction of TM funds, all of the sample plans offered broad-based US equity index and high-quality US bond index funds; only seven plans did not offer at least one international equity index fund. Tang (forthcoming) shows that all but a handful of the plans in the broad universe from which our plans were drawn were "efficient' in that they spanned eight broad global capital market indexes. The less efficient ones were only modestly so, and did not differ from the others markedly in their plan offerings.

[14] Overall, 86% of the TM adopters were in plans where the employer switched from SA to TM funds.

[15] Equity allocation is equal to the percentage of contributions directed to US equity funds, international equity funds, company stock, and a percentage of balance/lifecycle funds. The equity percentage for balanced/lifecycle funds was calculated based on each fund's investment policies and varies from fund to fund.

[16] This regression function can be written as $r^e_{k,t} = \beta_1 r^e_{CRSP,t} + \beta_2 r^e_{LBA,t} + \beta_3 r^e_{EAFE,t} + \varepsilon_{k,t}$, where $r^e_{k,t}$ is the excess return of fund *k* in month *t* (i.e., the nominal fund return less the risk-free rate in that month), and $r^e_{CRSP,t}$ $r^e_{LBA,t}$ and $r^e_{EAFE,t}$ are the excess monthly returns CRSP, LBA and EAFE indices. β_1, β_2 and β_3 are the regression coefficients or factor loadings; $\varepsilon_{k,t}$ is the error term. The regression is estimated over the 96-month period—five years prior to our sample period and the three years covering our sample. $\hat{B} = (\hat{b}_1,...,\hat{b}_k)'$, where $\hat{b}_k$ is the estimated loading vector of fund *k*, which can be written as $\hat{b}_k = (\hat{\beta}^k_1, \hat{\beta}^k_2, \hat{\beta}^k_3)'$.

[17] The mean returns of our three factors (CRPS, LBA and EAFE) over the 96-month period are given by: $\bar{r}_f = (\bar{r}_{CRSPRF,t}, \bar{r}_{LBARF,t}, \bar{r}_{MSCIRF,t})$. The systematic return associated with the *k*th asset is its factor exposure times the average factor returns over the 96 months, namely: $r^e_k = b'_k \bar{r}_f$. The *i*th participant's excess return reported in Panel B of Table 3 is $r^e_i = \sum_{k=1}^{N} \omega_{k,t} r_k{}^e$, where $\omega_{i,k,t}$ is the weight of the *k*th fund in the *i*th participant's contributions made in month *t*.

[18] Virtually all of the SA funds in our sample included broad exposure to US and international equities, as well as US bonds. Many of the balanced funds did as well, although some were exclusively US-focused.

[19] $NSR/TV_{i,t} = \hat{\Sigma}_i^{idio} / \hat{\Sigma}_i$. 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, $\hat{\Sigma}_i$. $\hat{\Sigma} = \hat{\mathrm{B}}'\hat{\Sigma}_f\hat{\mathrm{B}} + \hat{D}$, where $\hat{D}$ is a diagonal matrix with elements computed as the square of the $\hat{\varepsilon}_k$ estimated in equation (2). The asset variance can be decomposed into systematic risk, $\hat{\Sigma}^{sys} = \hat{\mathrm{B}}'\hat{\Sigma}_f\hat{\mathrm{B}}$ and idiosyncratic risk $\hat{D}^{idio}$. Individual portfolio variance can be decomposed into its systematic and idiosyncratic component:

$\hat{\Sigma}_i = \omega'_{i,k,t}\hat{\Sigma}\omega_{i,k,t} = \omega'_{i,k,t}(\hat{\Sigma}^{sys} + \hat{D}^{idio})\omega_{i,k,t} = \hat{\Sigma}_i^{sys} + \hat{\Sigma}_i^{idio}$.

[20] The mean value of lifecycle adoption is not 10% (in Table 1, 24,612 TM adopters divided by 252,980 participants) because our measure is weighted according to the months in which TM funds were offered. For example, if TM funds were offered in a given plan during 18 months of our analysis period, and a participant in that plan contributed to those funds over nine months, his adoption rate would be 50%.

[21] Not all new entrants are new hires. Many of the plans in our sample allow immediate eligibility for the plan to new hires though a minority imposes a six- or twelve-month waiting period.

[22] For example, mixed adopters may only want to have a portion of their portfolio to be automatically rebalanced, or they may be engaging in a "core/satellite" strategy of having the lifecycle fund as a core holding, supplemented by satellite funds.

[23] Similar results ensue in the case where SA funds had been offered previously, although the results are not surprisingly smaller.

[24] Pure TM investors generally liquidate cash investments and shift their fixed income to bonds. Cash investments have zero excess returns by definition, while over our study period, bonds earned excess returns of 23 basis points per month. Our younger pure adopters moved from a cash exposure of 3% to 0% when moving to TM funds, while older participants moved from 9% to 0%. For mixed adopters, younger participants reduced equity holdings slightly, from 8% to 6%, while older participants moved from 11% to 9%.

[25] Sponsors forfeit so-called optional 404(c) fiduciary protection when undertaking such mapping, though it remains an appropriate strategy if the plan fiduciary judges such a move to be in the best interests of plan participants.